Environmental Assessment of the Alaskan Continental Shelf

Program Work Statements

FY 1978

Volume III

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

U.S. DEPARTMENT OF INTERIOR
Bureau of Land Management

1978 Work Statements

Vol. III

June
1978

O UTER

C ONTINENTAL

S HELF

E NVIRONMENTAL

A SSESSMENT

P ROGRAM

WORK STATEMENTS

FOR FISCAL YEAR 1978

(October 1, 1977 - September 30, 1978)

VOLUME III

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ENVIRONMENTAL RESEARCH LABORATORIES

BOULDER, COLORADO 80303

June 1978

DISCLAIMER

The Environmental Research Laboratories do not approve, recommend, or endorse any proprietary product or proprietary material mentioned in this publication. No reference shall be made to the Environmental Research Laboratories or to this publication furnished by the Environmental Research Laboratories in any advertising or sales promotion which would indicate or imply that the Environmental Research Laboratories approve, recommend, or endorse any proprietary product or proprietary material mentioned herein, or which has as its purpose an intent to cause directly or indirectly the advertised product to be used or purchased because of this publication.

CONTENTS

VOLUME III

For information purposes the contents of Volumes I and II are also given.

CONTENTS

VOLUME I

CONTENTS

VOLUME II

Table I

Classification of Research Units as to Tasks

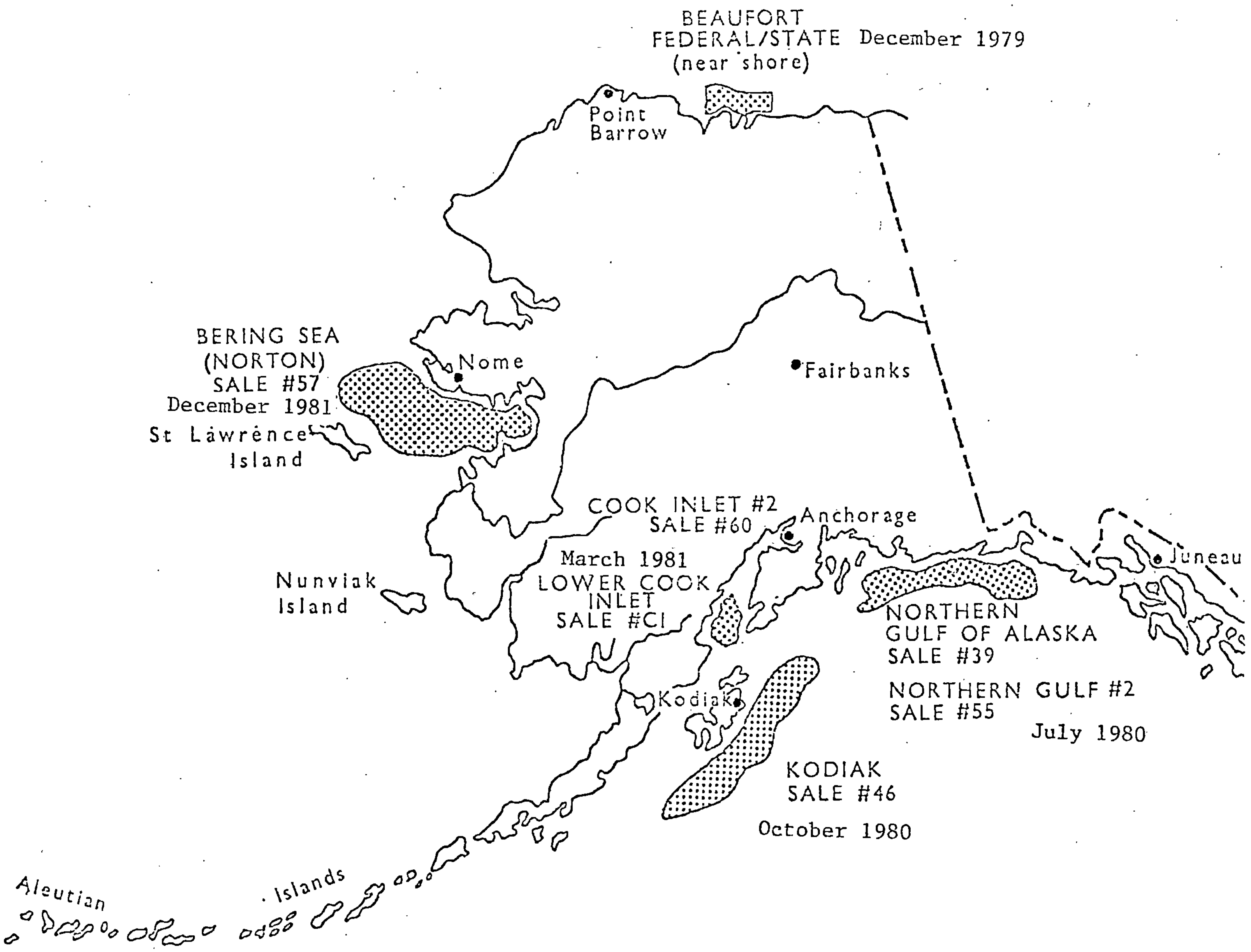
A	C	D	E		F	Data Management
43	16	48	3	232	71	350
152	59	91	5	237	72	351
153	87	138	6	243	73	362
162	88	140	19	248	77	370
275	98	141	29	332	96	468
480	105	208	67	337	389	497
500	204	217	68	341	423	527
506	205	250	69	356	454	545
556	206	257	78	359	460	563
	210	265	83	417	467	
	212	267	108	424		
	251	289	172	425		
	253	367	190	427		
	271	435	194	428		
	290	499	196	481		
	327	519	229	512		
	429	526	230	537		
	430	529				
	431	530				
	473	531				
	483	536				
	516	541				
		549				
		557				

Work Statements are arranged in numerical order according to research unit number, beginning on page 1.

Table II

Distribution of Research Units in Lease Areas

Aleutians	Beaufort	Bristol Bay	Chukchi Sea	Kodiak	Lower Cook Inlet	NEGOA	Norton	St. George	Non-Site Specific
16	6	67	59	5	3	5	5	16	43
67	29	77	69	59	5	68	19	77	71
68	69	141	87	68	29	78	69	83	72
138	87	194	88	78	48	138	87	108	73
217	88	232	172	138	138	140	88	141	96
289	91	248	196	140	152	210	152	194	389
337	98	257	230	194	153	212	153	196	423
	105	267	232	217	162	217	162	206	454
	162	289	248	229	190	229	194	230	499
	172	337	253	243	194	243	196	232	500
	190	435	257	251	229	289	208	248	537
	196	556	267	289	243	337	230	257	549
	204		271	290	251	341	232	289	557
	205		289	327	267	367	237	337	
	230		337	332	275	417	248	427	
	232		356	337	289	481	257	435	
	248		359	341	290		267	556	
	250		427	367	327		275		
	253		460	480	341		289		
	257		473	506	367		290		
	265		483		417		337		
	267		516		424		427		
	271		536		425		429		
	275		541		430		430		
	289				480		431		
	290				512		435		
	337						480		
	341						483		
	356						541		
	359								
	467								
	473								
	516								
	519								
	526								
	529								
	530								
	531								
	536								



ALASKA OUTER CONTINENTAL SHELF

AREAS PRESENTLY SCHEDULED FOR LEASING

Proposal to the National Oceanic and Atmospheric Administration

Title: Influence of Petroleum on Egg Formation and Embryonic Development in Seabirds.

Applicable Research Unit Number: OCSEAP Research Unit 423

Principal Investigators: D. G. Ainley and C. R. Grau

Total Cost of Proposal: $32,993

Period of Work: 1 October 1977 to 30 September 1978

Institutions and Departments: Point Reyes Bird Observatory and Department of Avian Sciences, University of California, Davis

Date of Proposal: June 22, 1977

Signatures:

David G. Ainley
D. G. Ainley

C R Grau
C. R. Grau

Stephen H. Morrell
S. H. Morrell

Address: Point Reyes Bird Observatory, 4990 State Route 1, Stinson Beach, CA 94970

Telephone Number: (415) 868-1221

Required Organization Approval: J. P. Church
J. P. Church
Executive Director
Point Reyes Bird Observatory
4990 State Route 1,
Stinson Beach, CA 94970

Organization Financial Officer: C. R. Wetterman
C. R. Wetterman
Treasurer
General Business Services
25 Juno Road
Tiburon, CA 94920
(415) 435-4839

Technical Proposal

I. Title: Influence of Petroleum on Egg Formation and Embryonic Development in Seabirds.

Research Unit Number: 423

Contract Number: 03-7-022-35163

Proposed Dates of Contract: 1 October 1977 to 30 September 1978.

II. Principal Investigators: D. G. Ainley, C. R. Grau and S. H. Morrell

III. Cost of Proposal

C. Total: $32,993

D. Distribution of Effort by Lease Area: Totally Non-Lease Specific Area Laboratory and Field Work, but the species worked with are common in Alaskan lease areas from the vicinity of Kodiak Island southward.

IV. BACKGROUND

Abstract. We propose here the second year of study, as well as an outlook for continuation in future years, in a project designed to assess some possible physiological effects on seabirds by short-term low-level exposure to oil slicks at sea. Preliminary laboratory work on quail and waterfowl showed that ingestion or cutaneous contact with less than a gram of oil resulted in lowered reproductive output. In the first year of NOAA funded work, the project was extended to seabirds in the field. We worked with Bunker C oil in FY 1977. Results are encouraging but field work is still in progress. In FY 1978 we propose to compare crude oil with Bunker C in their effects on reproductive success of Cassin's Auklets at the Farallon Islands. In following years we plan to compare the physiological responses of seabirds of different sex and to investigate whether oil on a seabird's skin has the same effect as it does in domestic fowl. The work will provide information to help assess the impact of oil pollution on breeding seabird populations.

Introduction. Major oil slicks are relatively recent components of the marine environment, except in rare places such as Santa Barbara, California, where natural seeps occur. Seabirds, particularly the more susceptible diving and plunge-diving types (Ainley and Sanger MS), have not had contact with oil pollution long enough to have evolved or acquired defense mechanisms. Mortality of seabirds due to oiled plumage resulting from direct contact with oil slicks is thus becoming a frequent occurrence (see, for instance, Straughan 1970, 1971; Smail et al., 1972). Death in this situation has been attributed to hypothermic stress after the oil destroys the insulating properties of a bird's plumage. Ingestion of oil under these circumstances also affects intestinal absorption of water as at least one contributing cause of death (Crocker et al., 1975). In spite of information about bird survival following direct oiling, little is known about the possible effects of petroleum on physiological processes, especially reproduction, in birds. The present proposal is designed to evaluate the significance of oil ingestion in seabird reproduction.

Coating of laid eggs by oils can cause embryonic mortality, probably by limiting gaseous exchange through the shell (Rittinghaus 1956, Abbott et al., 1964, Hartung 1965), but also by a toxic effect of substances absorbed through the shell. Albers (1976) reported that as little as 1 μl of fuel oil reduced the hatchability of 8-day Mallard Duck embryos that were being incubated artificially. Ingested substances can be deposited in eggs, usually in the yolk (Shenstone 1968), but we are only beginning to understand the mechanism and effects of such incorporations. Both fat and water-soluble materials, including drugs, pesticides, toxins, and dyes have been identified in the yolk.

A recently published study of the effects of Bunker C oil on egg formation and hatchability in Japanese quail (Coturnix coturnix japonica), a pilot animal, showed that a single dose of 200 mg reduced egg production and drastically interfered with embryonic development, resulting in very poor hatchability for several days (Grau et al., 1977). It is not yet clear whether these effects represent incorporation of oil components in yolk or some indirect effect on intestinal or liver functions. Extension of this study to fractions of Bunker C has shown that the primary effects lie in an isopentane-soluble fraction, not in the heavy residue. When experiments similar to these were carried out with Prudhoe Bay crude oil, fed at 400 and 800 mg levels, egg production and shell thickness were reduced, and therefore total reproduction was markedly affected, but the hatchability of fertile eggs was not reduced (Engel, et al., 1977), in contrast to the results with Bunker C.

Ingestion of petroleum hydrocarbons by seabirds and waterfowl can occur in several ways. First, a bird ingests oil while attempting to preen it from its plumage. Hartung and Hunt (1966) reported that a duck with 7 g oil on its feathers ingested 1.5 g of the oil during the first day after oiling, or 2-3 g/kg body weight. Autopsies of heavily-oiled birds have disclosed oil in the alimentary tract, indicating that ingestion occurred during preening. At least twice during the past five years, up to 10% of Common Murres (Uria aalge), Pigeon Guillemots (Cepphus columba) and Western Gulls (Larus occidentalis) at their breeding grounds on the Farallon Islands have been counted with small amounts of oil on their feathers (PRBO Farallon Journal). In such instances significant amount of oil might be ingested through preening without the birds being sufficiently coated with oil to cause death. Second, a seabird might directly eat oil. Some species, for instance large gulls (Larus) and albatrosses (Diomedea) feed heavily at times on pelagic barnacles (Lepas) that attach themselves to objects floating on the sea (Miller 1940, Sanger 1973). The barnacles readily attach to oil globs with a hardened outer surface; such tar balls can in some areas be quite common (Heyerdahl 1971; Ainley, personal observation). If a bird finds barnacles on a small tar ball it might ingest the entire thing. Thirdly, seabirds maintain fluid and salt balance by drinking seawater. They could conceivably drink water contaminated by oil. Finally direct contact of skin with oil causes changes in tissue structure and permeability (Renden and Abbott 1973). We found recently that such contact will also affect yolk structure in the same way as does oral dosage. Similarly, we found that intraperitoneal injection of Bunker C oil resulted in abnormal yolk structure (unpublished observations).

Smearing of as little as 1 ml of Bunker C on the feathers and skin of the head and neck of quail resulted in formation of yolk with the same abnormal structure as was observed when 200 mg was given in a capsule by mouth. From this experiment it was not possible to determine whether the effect was a direct one on the skin, or whether the bird preened and thereby ingested the oil.

Recently developed approaches to the study of yolk structures and its relation to nutrition and other environmental factors have been made possible through new methods of fixation, staining and analysis of eggs (Grau 1976). After freezing whole eggs to alter lipoproteins, the yolk can be fixed in formalin and stained to reveal rings of yolk that can be related to the time the egg was laid. Frozen, unfixed yolks can be cut in half and material isolated from particular parts of the yolk can be analyzed chemically. Thus the composition of yolk deposited during a known period of 8-12 hours can be related to environmental pollution by oil or other materials without maintaining the female in captivity.

Study Area and Research Subjects. The Farallon Islands lie 45 km west of San Francisco, California. They are the site of the largest seabird breeding colony in the contiguous 48 states of the U. S. and a National Wildlife Refuge. Since 1968 the Point Reyes Bird Observatory (PRBO) has maintained a year round research station on Southeast Farallon, largest island of the chain. Based on our 1977 studies, we have concluded that Cassin's Auklet (*Ptychoramphus aleutica*) will be our major study subject. It is abundant at the Farallones, its ecology has been intensively studied there, it easily lends itself to the proposed studies, and lastly and very importantly, it is a member of that seabird family (the Alcidae) that world-round has been most heavily impacted by oil pollution. Furthermore, these auklets breed as far north as the Kodiak Island area of Alaska and thus occur in important lease areas. Study of the species at the Farallones will mean a minimum of logistics arrangements and problems.

Preliminary Findings. We have used several approaches in developing our studies and have attempted to integrate them through field and laboratory observations. New techniques were developed to reveal the internal structure of yolk and to study the effects of diet and environmental pollutants on yolk formation. Most of this work was done with Japanese Quail and with chickens, two convenient laboratory animals that serve as models for field investigations. By using pairs of quail kept in individual cages, the effects that single, small doses of oil had on embryo survival could be correlated with structural changes that occurred in the yolk in response to oil. Chickens and Canada geese (*Branta canadensis*) were also found to deposit yolk abnormally after oil dosage, but hatchability was not studied in these species. Investigations are now in progress on variation in yolk composition in relation to oil dosage.

Field work on yolk formation was begun in 1975 with a study of eggs from 20 species of birds, principally waterfowl and gulls, nesting in Alaska (Roudybush and Grau, 1977). This provided background experience and data on times required for the rapid phase of yolk formation. During the 1976 breeding season on the Farallon Islands we attempted to develop methods and obtain information on the effects of oil in a capsule hidden in a fish on the yolks produced by Western Gulls. Careful laboratory observation of two eggs laid were unsuccessful in revealing any differences in yolk structure or staining properties that could be attributed to oil ingestion. The chemical analytical procedures being developed at Davis are not yet adequate to reveal compositional effects of oil pollution on eggs; hence they have not yet been applied to these or other seabird eggs. Furthermore, the results of 1976 as well as those of 1977 reported below suggest that Western Gulls, although very numerous are more difficult to study than other birds such as auklets as they may be better able to cope with oil than other birds (Ericson 1963) and they are difficult to approach and dose. The diet of gulls is varied, and a significant portion sometimes comes from garbage. This decreases the uniformity of yolk deposited, and thus makes it difficult to detect yolk components affected by ingested oil. Also, gulls appear to regurgitate irritating substances, thus making successful dosage by capsule uncertain.

During the 1976 nesting season, on the Farallones, 13 female Western Gulls were each fed 1 g of Bunker C oil in a gelatin capsule concealed in a fish. Eggs were recovered from 4 nests belonging to gulls which had been fed the oil. The remainder of the nests were left undisturbed except for daily observations. Only 6 of the remaining 9 oil-fed gulls laid eggs in the nests under observation. Only 2 of the 14 eggs in these nests failed to hatch. These were the first and second eggs from a 3 egg clutch and were laid 7 and 9 days after the female gull was fed oil. The third egg, which hatched, was laid 11 days after the gull was fed oil. Since Western Gulls take about 12 days to form yolks and probably 1 day to form white, membranes, and shell, all 3 yolks from these eggs should have been forming when the oil was fed. Since eggs of other oil-fed gulls that were laid 7 and 9 days after oil feeding hatched successfully, we do not know whether the unhatched eggs failed to hatch because of oil ingestion by the adult. Some gulls were observed regurgitating oil after ingesting the fish containing oil Others were observed with oil on their feet and bills after ingesting oil. This regurgitation makes it impossible to know how much oil actually passed through the gulls' gastroin testinal tract.

Laboratory studies of eggs from 4 nests suggested that oil may have affected yolk structure, but the characteristic ring patterns after dichromate staining were not observed. This may have resulted in part because of the extreme variability of natural pigmentation of gull eggs. There was an intense blue ring resulting from staining for available iron by the Prussian blue test (acidified ferrocyanide). This unique response was similar to those seen in chickens, quail, and goose eggs of birds dosed with Bunker C. Yolk sphere size appeared to have been decreased by Bunker C dosing of gulls, but the results were not clear-cut.

Preliminary analysis of results from FY 1977 work. Based on these preliminary findings, the research plan for the 1977 breeding season, as submitted and funded by NOAA, utilized Cassin's Auklets and Western Gulls in a two-pronged study. The auklets, which lay their one egg early in the season, are abundant and relatively accessible. We have extensive data and experience with the reproduction of these birds on the Farallon Islands. The gulls lay later, produce several eggs that are easily monitored, but dosing the adults posed problems that have not ever yet been solved.

In the auklet study, relatively few changes were made from the original plans. Three groups of 100 burrows each were identified and prepared with auxiliary openings thus allowing access to the nesting chamber without disturbing the normal entrance. In order to avoid bias from variation in position or soil conditions of burrwos, the treatments were distributed randomly. In the first burrow of a group of three, 2 or 3 empty capsules were given to the female; in the second, 300 mg Bunker C oil in 2 capsules was given; in the third, 600 mg Bunker C in 3 capsules was given. If on the day dosing was to occur a burrow was found to have a egg, that egg was removed and the female was treated 3-7 days later. Burrows were examined daily until an egg was found, then were not disturbed until a check was made for hatching 38 days later. At the time of writing this proposal, most but not all of the auklets have completed incubation; hence only preliminary data, not analyzed statistically, can be presented.

There appears to be no difference in numbers of eggs produced by pairs in any of the groups, and there was no mortality that could be related to treatment. The hatching success appears to have been affected by the treatments, as indicated by the following table; only birds that laid 2-7 days after dosing are included:

Treatment Mg. Bunker C	Number of females	Hatching Success (%)
0	15	59
300	26	68
600	24	58

The hatching success in a group of untreated burrows that has been studied for several years was 82%, thus indicating an effect of the disturbance of the birds by the experiment.

Weight at hatching was not affected by the treatments; data on chick development and weight at fledging are not yet available.

The field results obtained thus far indicate that the treatments by the higher level of oil may have had an effect on reproduction, but the results were less striking than in the work on quail and geese. In our 1977 proposal we had anticipated dosage level as presenting a problem and now have a better understanding of this for work with auklets.

After preliminary laboratory examination of some of the eggs, as outlined below, in which no evidence of an oil effect was obtained, some separate trials were made on the fats of the oil contained in capsules given to auklets and held for a few hours after dosing, because it was suspected that the birds were regurgitating the oil after the capsule dissolved. However, it was found in every instance that the oil passed through the bird and was voided explosively in the feces within a period of 10 minutes to one hour; none of the oil was regurgitated. Sudan black dye in a capsule was similarly voided.

The field observations on the effects of the oil on gulls confirmed the 1976 results in which dosing became the principal problem. In the present year, capsules containing oil were coated with hydrogenated vegetable oil to lengthen time of capsule solution, and the capsules were sewn inside small squid. The gulls readily took the squid. As soon as the capsule dissolved and the oil was released, the squid, now covered with oil, was regurgitated, and was eaten by the mate or another bird. Within a few seconds it was regurgitated again.

Sometimes this was repeated several times. This study convinced us that doing gulls by capsule is fruitless. Other small trials with gulls included snaring and smearing with oil on the head and neck, and injecting the oil intraperitoneally into two birds. All these gulls abandoned their nests. Another potentially more useful technique that is still being evaluated was to coat the first egg laid with oil, and after the female incubated it overnight thus coating the brood patch with oil, the egg was removed. Eggs laid subsequently were collected for chemical analysis and observation of yolk structure. Results are not yet available

Laboratory studies of both auklet and quail eggs have been limited to date to observations of frozen, fixed, and stained halves of yolks. The remaining halves are being saved for chemical analyses. In contrast to the easily observed effects of oil on the yolks of quail, chicken, and goose eggs the eggs of auklets and gulls have not yet been found to exhibit any abnormalities in rings, staining appearances, or yolk sphere structure. Whether this can be explained by the behavioral responses of the auklets and gulls to oil dosing, or by differences in mechanisms of yolk formation can only be speculated. Chemical analyses of yolks may aid in clarifying these results.

With the entire collaboration of Dr. W. G. Jennings, Department of Food Sciences and Technology, University of California, Davis, capillary column gas chromatography of extracts of quail yolks is being used to try to identify distinctive components of oil in eggs. We are also attempting to identify such components by ultraviolet absorption analyses. As soon as these or other techniques such as liquid chromatography can be applied to yolk extracts, auklet and gull egg yolks will be studied.

V. Objectives for FY 1978

1. To examine the effects of ingested petroleum on egg formation, biochemistry of yolk formation and developmental embryology of incubating eggs in Cassin's Auklet.

2. To examine the effects of ingested petroleum on hatching success of eggs incubated under natural field conditions with subsequent chick survival in Cassin's Auklet.

3. To compare Bunker C fuel oil and Prudhoe Bay crude oil in the above two analyses.

The achievement of these objectives will help in the evaluation of oil spill impacts on breeding seabirds that nest in many parts of the Alaskan and other Pacific Coast coastlines and islands. The objectives are specifically aimed at the effects of the two most likely sources of spills in the area, Alaskan crude oil and heavy fuel oil such as that commonly used in tankers and other ships. If no effects are observed, oil can be handled directly in relation to bird cleanup and recovery. If oils cause significant although possibly hidden effects, bird resource managers will need to devise ways of minimizing oil spill effects on colonies.

VI. General Strategy and Approach

We propose to continue our study to appraise the effects that a brief exposure to an oil spill would have on the reproduction of Cassin's Auklets (Ptychoramphus aleutica) nesting on the Farallon Islands of California. This species is representative of many birds breeding along the Pacific Coast that are at risk from oil pollution during the reproductive period.

During the first year of the project breeding pairs were identified and dosed with capsules containing small amounts of Bunker C oil during the period of rapid yolk formation. Controls were treated identically except that an empty capsule was given. We are attempting to determine the effects on egg structure and composition, on egg production, on embryo development, and on hatching success and survival of auklets and gulls. Attempts are now being made to correlate any chemical and structural changes in the yolk with embryo survival to determine possible mechanisms of the action of oil on reproduction.

Status of the first year of the project. Because auklets breed early in the year, work on the project had to be started in advance of funding by NOAA. During January and February, 1977, 300 burrows were identified and prepared; daily monitoring of burrows was begun in March. Ocean temperatures remained high during early March, not reaching the critical temperatures of 10.4^{o}C, indicating upwelling, until mid month. The first eggs were laid as expected in late March. At the time of submitting this proposal, work on the auklets is still in progress; most eggs have just now hatched.

VII. Sampling methods

One of the problems encountered this year has been that of effective monitoring of auklet burrows and their occupants, primarily because of the continual changes that the birds make in burrow structure up to the time that the egg is laid. Much effort had to be expended to keep the end of the burrow within an arm's reach of the last intercepting hole cut from the surface into the burrow. Some burrows had 4 holes, each covered by a piece of masonite which the observer had to make in order to have access to the nesting chamber. Some burrows collapsed, some became connected with a neighboring burrow, and some were abandoned.

As part of a study of burrow attendance, eight semi-artificial burrows have been fitted for one year with entrance monitoring devices. These burrows, constructed of plywood, have been well occupied (7 eggs laid; 6 eggs hatched) and effectively utilized by breeding pairs through all periods of reproduction. Chick-growth has apparently been normal. For 6 seasons we have used similar artificial nests for other seabird species on the Farallones with no signs of affecting their behavior. We propose to prepare and utilize 200 such wooden nest boxes, but not to fit them with monitoring devices.

The 100 most structurally sound burrows remaining from 1977 will also be followed, providing a grand total of 300 burrows, for experimental use in 1978.

About 10 days after sea water temperatures drop to a consistent 10.4° or lower (indicating onset of upwelling) or about 10 March (the earliest auklet laying day), whichever occurs first, burrows will be checked every other day until the first egg is found. Since we can not know exactly when an individual pair will produce its egg we will dose some females every night throughout the period up to peak egg laying, a span usually of about 10 days. This will insure incorporation of oil into eggs at different intervals prior to ovulation. Each night when both members of each pair are in their burrow, we will capture 30 pairs and force feed the smaller member of each pair, the female, with a gelatin capsule, a different sample each night:

GROUP A. 10♀♀ will be given empty gelatin capsules
GROUP B. 10♀♀ will be given 600 mg of Bunker C oil.
GROUP C. 10♀♀ will be given1000 mg of Prudhoe Bay Crude oil.

Pairs will be banded and returned together to their burrows.

Dosed pairs will be checked for eggs every morning thereafter. Some eggs will be removed for laboratory analysis, the exact number to be determined based on results of the 1977 laboratory analyses. The pairs will re-lay within about 10 days following loss of their eggs. Eggs will be left in other burrows to determine hatching success. Controls in Group A will be checked in a similar manner. Another control group (D) of 70 burrows, studied each season from 1972 to 1977, will be studied without handling of occupants. Burrows in which eggs were not removed will be checked daily beginning 42 days after laying to determine hatching success. Burrows will next be checked when parents leave chicks alone during the day, eight days after eggs hatch. Some chicks from experimental and control burrows may be weighed daily to compare development. The number will be determined after weight data collected in 1977 are analyzed.

Materials. Two types of oil, Venezuelan Bunker C and Prudhoe Bay Crude, will be administered in gelatin capsules to the respective experimental birds. The Prudhoe Bay crude oil is an authentic sample obtained from NOAA - Seattel; analytical data will be available from that laboratory. This sample has also been used in studies with quail (Engel et al., 1977).

VIII. Analytical Methods

Eggs to be used will be collected before incubation and kept at room temperature until taken to Davis. There they will be degassed in vacuum to reduce entrapped air bubbles, frozen in air at -20°C for 25 hours, thawed briefly in water to remove the shells, fixed in 4% formalin at 65°C for 18 hours, cut in half and one half put into 6% aqueous potassium dichromate for 16 hours at 65°C, washed to destain, stored in 0.05% mercuric chloride, and sliced at 2 mm thickness for observation. Slices from the formalin-fixed half will be stained with acidified potassium ferrocyanide to reveal available iron. Some eggs will be kept frozen for gas chromatographic and other analyses of samples of yolk laid down before and after dosing. Details are given in Grau (1976);

supplementary methods are being developed and will be applied as they become useful. We are fortunate in having the collaboration of Dr. W. G. Jennings Department of Food Science, UC Davis, in the chromatographic studies. He is an authority in capillary gas chromatographic techniques.

Data analysis and results. We will compare breeding success between experimental and control birds and analyze egg structure between the two groups. We will also compare breeding success and egg structure of females dosed at different time intervals prior to ovulation and laying. We should be able to determine critical dosages, critical times for dosing to cause effects, and how petroleum oils alter seabird reproduction. We will also obtain information about egg formation in wild birds and be able to learn something about the timing of differenct events in egg formation and the times required to form yolk, white and shell.

IX. Anticipated Problems

A problem anticipated in the first year of study (FY 1977) was that of dosage levels of the oils. This we solved for Bunker C oil. In FY 1978, however, we will be comparing results between Bunker C and Prudhoe Bay crude. Our work with quail indicate that dosage levels causing effects are not the same. Our work in 1977 suggests that the minimum level for auklets may be 1000 mg.

Another potential problem for the whole study is that an inadvertent oil spill may occur in the Farallon Islands region at the time of the study. If this does occur, attempts will be made to salvage information from affected birds, but clearly the original basis for the study would be destroyed. Finally, we can not foretell marine conditions for 1978. Reproduction in auklets and other seabird species are very responsive to changes in marine climate and other oceanographic factors. Conditions in 1977 were in fact very interesting in this regard. Short of total breeding failure by the population which is a remote possibility, our experience with the breeding ecology of auklets should allow us to cope with most conditions.

Other tactical and logistic problems could also occur; if they do, the investigators will use their judgement in attempts to solve the problem.

X. Deliverable products

A. Digital data - none

B. Narrative reports - approximately three scientific publications

C. Visual data - none except in reports and publications

D. Other non-digital data - Photographs of terrain, techniques, birds, nests and eggs will be obtained. Journals of observations will be kept, together with data on bird and egg measurements. Laboratory data will be obtained and stored as usual.

E. Data submission schedule. Data will be submitted by cruise; see following Data Products Schedule.

XI. Information Required from Other Investigators

Describe data required from other investigators to carry out your proposed work.

None is anticipated.

XII. Calibration and Intercomparison ; Quality Assurance Plans

Briefly describe your procedures for the calibration and intercomparison of instruments and methods.

This study is unique in that no other investigations utilizing the proposed approaches have been made or are in progress, as far as we know. We will be using a reference Bunker C oil product that has been studied in other laboratories.

XIII. Special Sample and Specimen Archival Plans

If, as part of this study, samples are collected which should be kept for future reference (e.g., core samples) describe the number of samples, special storage conditions, location of the archive, annual cost of archive, etc.

Specimens to be collected will be stored at Point Reyes Bird Observatory or University of California, Davis. No special needs are anticipated.

XIV. Logistics Requirements: This form will be used by the project offices to plan and coordinate all field operations. Therefore, the information should be as complete as possible. Questions regarding the form should be directed to Capt. Phil Taetz, (303) 499-1000 (Ext. 6562) or Lt. John Murphy (Ext. 6531).

These will be arranged through PRBO; no NOAA components are anticipated (see <u>Other data</u> for information about the Farallon Islands and facilities available there).

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

Point Reyes Bird Observatory maintains a year round research station on Southeast Farallon Island. Electrical power and all the luxuries of modern living are provided. Regular weekly boat service to the island is also provided. Biologists will be working on the island, at the PRBO headquarters, and in the laboratories of the Department of Avian Sciences, University of California, Davis. Island quarters are available at no cost to biologists; food is available at cost.

It is expected that one or two biologists, in addition to the regular staff, will be on the island from 1 March to 31 July 1978. The total person-days is expected to be 210.

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

Except for food, PRBO will provide quarters and subsistence.

3. What is your estimated per man day cost for this support at each location?

Food costs are $4.00 per day per person, or 4 x 217 = $ 868

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

XV . Management Plan: Briefly describe how you will manage your project. Also provide an Activity/Milestone chart.

Because the station on the Farallones is permanently established and continuously operated by PRBO, field management consists primarily of scheduling personnel, travel from Davis to Marin County (70 miles), and care of samples. All of these problems were managed successfully during the preliminary work in 1977

Chemical and biological laboratories are available in the Department of Avian Sciences, UCD, to conduct the egg and embryo preparation and analysis. Most of these are carried out regularly in other studies. Special analyses of petroleum components in yolk fractions prepared at Davis would be required and would be sent to laboratories especially equipped for this work.

Salaries of the co-principal investigators will be provided by their respective institutions.

For administrative convenience it is suggested that PRBO be the prime grantee or contractor and submit a requisition for the work to be done in Davis. The University of California will submit a quarterly invoice for expenses, up to the amounts budgeted, to PRBO. This sub-account would be maintained in a manner that would conform to all UCD accounting procedures, and would be readily available for NOAA auditing. All reports would be made through PRBO.

XVI. Outlook

Because this proposal for FY 78 is being written for the middle of the first funded year, it is difficult to project into FY 79. It appears, however, that it will be possible to extend the study of auklets into several new areas, to answer such questions as the following:

A. What are the effects of two or more doses of oil at various intervals, in terms of survival, egg formation, and reproductive success?

B. Does oil place a larger chronic burden on an auklet, which lays only one egg, than it does on a quail which lays many eggs, and thus has a mechanism for removing fat-soluble substances from its body?

C. What are the responses of male auklets to oil dosage, separate from or in addition to that of females?

D. Does external application of oil that simulates the effects of a spill have a major adverse effect on reproduction, or is such a direct effect primarily one on survival?

Answers to these and similar questions should yield data that will help to evaluate the magnitude of oil spill effects. Because only two or three variables can be studied each year, two or three additional years may be required to answer the question. In this connection it should be pointed out that this approach is unique as far as we know, and no comparable studies are in progress in the U.S., Canada, or Great Britain.

The cost per fiscal year is expected to remain at approximately the present level, adjusted for inflation.

Major equipment is not anticipated.

We anticipate continued use of the Farallon Islands as an ideal field laboratory for these studies.

No changes in logistics are expected.

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds

will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgement is standard.

> " This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

OTHER INFORMATION

a. The Co-Principal Investigators are D. G. Ainley, Biologist and Director of Research, Point Reyes Bird Observatory, Stinson Beach, California; C. R. Grau, Professor and Nutritionist, Department of Avian Sciences, University of California, Davis; and S. H. Morrell, Farallon Biologist, Point Reyes Bird Observatory. Biobibliographic material is attached.

Ainley is an ornithologist whose professional activities have been primarily concerned with population dynamics, ecology, and conservation of seabirds. Grau has been concerned with nutrition in relation to avian reproduction for several years. Since 1972, he has studied yolk formation, yolk structure, and nutritional factors that influence yolk deposition. Both men will devote 10% of their time to the project. Morrell is a zoologist whose activities are mainly directed toward research on the Farallon Islands. He will devote 60% of his time during appropriate months of field work to this project.

b. The Co-Principal Investigators will be actively engaged in the project, and will directly lead and supervise the work. They will be responsible for the timely completion of the project.

c. Biobibliographic material for the participants is appended.

d. Other data from related Projects.

Studies with Canada Geese(*Branta canadensis moffitti*). Canada Geese which were kept in a large outdoor pen were dosed with 2, 3, or 5 g Bunker C oil and the eggs were collected, frozen, fixed, and stained. Eggs laid after dosing showed a characteristic light ring after dichromate staining; yolk deposited later stained darkly.

In addition to the results from specific investigations using doses of oil, we have data and experience on breeding and feeding behaviors of several birds found on the Farallon Islands. This information is essential for a successful field study. Many of the technical and logistic problems involved in carrying out an oil pollution study have already been solved.

Because of differences in structure or composition of yolk deposited during the day and night, light and dark rings are revealed when fixed yolks are stained with dichromate. Application of this technique to the eggs of several species indicates differences in the number of days required for yolk formation, as summarized in Table 1.

A report on the effects of oil on quail, chickens, and geese has been submitted for publication (Grau et al., 1976).

Results of experiments with quail. In order to indicate whether ingested oil might influence egg formation and embryonic development of birds such as seabirds and waterfowl, several experiments have been performed using the Japanese Quail as a pilot bird. Four petroleum oils were fed at various levels and egg production and yolk structure were observed. The major part of the subsequent work was done with the most toxic oil, a high viscosity Venezuelan residual fuel oil. Bunker C. Yolk that was abnormal in structure and staining properties was deposited during the 24-hour period following administration of a single capsule containing 200 mg of Bunker C oil. Fewer eggs were laid during the 4 days after dosing, as compared with controls, and hatchability was drastically reduced. The results of these experiments are presented in the attached manuscript by Grau, et al. (1977) and show that both egg production and hatchability returned to normal in a few days. High doses of oil halted production entirely, but there was no mortality.

A similar experiment with a Kuwait crude oil given as a single 800 mg dose resulted in slightly reduced egg production; hatchability dipped and recovered in a pattern similar to that caused by Bunker C, but did not fall below 62%. When Alaskan crude oils from Cook Inlet and from Prudhoe Bay were fed at the 800 mg. level, egg production was affected in essentially the same way as 200 mg Bunker C; the hatchability experiments have not yet been completed.

Results of experiments with other seabirds. When in 1977 it was found that gulls and auklets regurgitated or passed in their feces at least part of oil dosage, oil capsules (Bunker C) were fed to captive Common Murres (*Uria aalge*) and Black-footed Albatrosses (*Diomedea nigripes*) to examine their responses. These birds were housed at the International Bird Rescue Research Center in Berkeley, California. The murres immediately regurgitated some oil and passed the remainder in the feces within a short time. The albatrosses did not regurgitate oil but rather took 8 or more hours to pass it in their feces.

TABLE 1

Time Required for the Rapid Phase of Yolk Formation in some Pacific Birds

Species	Range in Days	Number of Eggs Examined
Arctic Loon (*Gavia arctica*)	8-10?	1
Red-throated Loon (*Gavia stellata*)	11-12?	2
Canada Goose (*Branta canadensis*)	12-13	7
Emperor Goose (*Philacte canagica*)	14	2
White-fronted Goose (*Anser albifrons*)	11-14	8
Pintail (*Anas acuta*)	8-9	7
Greater Scaup (*Aythya marila*)	7-8	4
Oldsquaw (*Clangula hyemalis*)	6-7	12
Willow Ptarmigan (*Lagopus l. alascensis*)	7-8	7
Ruddy Turnstone (*Arenaria interpres*)	5-6	4
Bar-tailed Godwit (*Limosa lapponica*)	8-12	8
Western Sandpiper (*Calidris mauri*)	5-8	9
Red Phalarope (*Phalaropus fulicarius*)	4-5	5
Northern Phalarope (*Lobipes lobatus*)	6-7	7
Glaucous Gull (*Larus hyperboreus*)	12	2
Western Gull (*Larus occidentalis*)	10-11	8
Mew Gull (*Larus canus*)	5-8	6
Sabine's Gull (*Xema sabini*)	7-8	4
Arctic Tern (*Sterna paradisaea*)	6	2
Pigeon Guillemot (*Cepphus columba*)	10	2
Cassin's Auklet (*Ptychoramphus aleutica*)	8	4
Lapland Longspur (*Calcarius lapponicus*)	2-3	7

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Field Data					March 1978 - July 1978	Nov 78
Laboratory Data					May 1978 - November 1978	Nov 78

MILESTONE CHART

RU #: 423 PI: Ainley, Grau and Morrell

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978														
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D			
Preliminary field work (prepare nest boxes)	x																	
Field work					x	x	x	x	x	x								
Laboratory analyses								x	x	x	x	x						
Final report															x			
Quarterly progress reports			x			x			x			x						
Annual report						x												
Data analysis												x	x	x				

BIBLIOGRAPHY

Abbott, U. K., R. M. Craig, and J. O. Keith, 1964. Effects of malathion spray on embryonated chicken eggs exposed under field conditions at Tuolumne Meadow, Yosemite National Park. Poultry Sci. 43:1297

Ainley, D. G., and T. J. Lewis. 1974. The history of Farallon Island marine bird populations, 1854-1972. Condor 76: 432-446.

____________ and G. A. Sanger (in press). Seabird trophic relationships in the northeastern Pacific Ocean and Bering Sea. In (J. C. Bartonek D. N. Nettleship, and W. B. King, eds.) Conservation of seabirds in Western North America. U. S. Fish Wildlife Service, Wildl. Res. Rept.

Albers, P. H. 1976. Effects of external applications of oil on hatchability of mallard eggs. Presented at meeting on "Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms," Seattle, Washington, Nov. 10-12.

Coulter, M. 1973. Breeding biology of the Western Gull, Larus occidentalis. MSc Thesis, Trinity College, Oxford University.

Crocker, A. D., J. Cranshaw, and W. N. Holmes, 1974. The effect of a crude oil on intestinal absorption in ducklings (Anas platyrhynchos). Environ. Pollution 7:165

Engel, S. W., T. E. Roudybush, J. C. Dobbs, and C. R. Grau. Depressed food intake and reduced reproduction in Japanese quail following a single dose of Prudhoe Bay crude oil. (Submitted for presentation to the 17th Hanford Biology Symposium, Richland, Washington, Oct. 17-19, 1977.

Erickson, R. C., 1963. Oil pollution and migratory birds. Atlantic Naturalist 18:(1);5.

Grau, C. R., 1976. Ring structure of avian egg yolk. poultry Sci. 55:1418

____________, T. Roudybush, J. Dobbs, and J. Wathem. 1977. Altered yolk structure and reduced hatchability of eggs from birds fed single doses of petroleum oils. Science (in press).

Hartung, R., 1965. Some effects of oiling on reproduction in ducks. J. Wil life Management 29:872-874.

Heyerdahl, T. 1971. The Ra Expeditions., New York, Doubleday & Company, Inc.

Manual, D. A. 1974a. The natural history of Cassin's Auklet (Ptychoramphus aleuticus). Condor 76:421-431.

Manuwal, D. A. 1974b. Effects of territoriality on breeding in a population of Cassin's Auklet. Ecology 55:1399-1406.

Miller, L. 1940. Observations on the Black-footed Albatross. Condor 42:229-238.

Renden, J., and U. K. Abbott. 1973. The response of avian skin to an oil-based pesticide and its carrier. Poultry Sci. 52:2077.

Rittinghaus, H., 1956. Etwas über die "indirekte" Verbreitung der Ölpest in einem Seevogelschutzgebeite. Ornithol. Mitt., Lubeck 3: 43-46. (Quoted by Nelson-Smith, A., 1972. Oil Pollution and Marine Ecology, Paul Elek, London).

Sanger, G. A. 1973. Pelagic records of Glaucous-winged and Herring Gulls in the North Pacific Ocean. Auk 90:384-393.

Shenstone, F. A., 1968. The gross composition, chemistry and physio-chemical basis of organization of the yolk and white. Chapter 2 in Egg Quality - A Study of the Hen's Egg. T. C. Carter, ed. Oliver and Boyd, Edinburgh (1968).

Smail, J., D. G. Ainley and H. Strong. 1972. Notes of birds killed in the 1971 San Francisco oil spill. Calif. Birds 3:25-32.

Speich, S. and D. A. Manuwal. 1974. Gular pouch development and population structure of Cassin's Auklet. Auk 91: 291-306.

Straughan, D. 1970. Ecological effects of the Santa Barbara oil spill. Sympos. ed. by R. W. Holmes and F. A. DeWitt, Santa Barbara, CA., pp. 173-182.

__________, 1971. Oil pollution and sea birds. In (D. Straughan, comp.) Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970. Vol. 1., Allan Hancock Foundation, U. of S. California. pp.307-312.

Publications:

Ainley, D. G. 1972. Flocking in Adélie Penguins. Ibis 114: 388-390.

———. 1972. Brown Pelicans in north-central coastal California. Calif. Birds 3:59-64.

———. 1974. Development of reproductive maturity in Adélie Penguins. In (B. Stonehouse, ed.) The biology of penguins. pp. 139-157. Macmillan Press Ltd., London.

———. 1974. Displays of Adélie Penguins: a reinterpretation. In (B. Stonehouse, ed.) The biology of penguins. pp. 503-534. Macmillan Press Ltd., London.

———. 1974. The comfort behaviour of Adélie and other penguins. Behav. 50:16-51.

———. (in press). Feeding methods of seabirds: a comparison of tropical and polar communities in the eastern Pacific Ocean. In (G. A. Llano, ed.) Adaptations in antarctic ecosystems. Proc. Third Sympos. Antarc. Ecol., Washington D. C.

———. (in press). The occurrence of seabirds in the coastal region of California. West. Birds.

———. (in prep.). Breeding biology of non-breeding Adélie Penguins. Auk.

———. (in prep.). Dark-rumped Leach's Storm-Petrels on the Farallon Islands, California. Auk.

——— and W. B. Emison. 1972. Sexual size dimorphism in Adélie Penguins. Ibis 114:267-271.

———, H. R. Huber, R. P. Henderson, and T. J. Lewis. 1975. Studies of marine mammals at the Farallon Islands, California. PRBO Report to the Marine Mammal Commission.

——— and R. E. LeResche. 1973. The effects of weather and ice conditions on breeding in Adélie Penguins. Condor 75:235-239.

——— and T. J. Lewis. 1974. The history of Farallon Island marine bird populations, 1854-1972. Condor 76:432-446.

———, T. J. Lewis, and S. Morrell. 1976. Molt in Leach's and Ashy Storm-Petrels. Wilson Bull. 88:76-95.

———, S. Morrell, and T. J. Lewis. 1974. Patterns in the life histories of storm petrels on the Farallon Islands. Living Bird 13:295-312.

Ainley, D. G. and T. Osborne. 1972. A Marin County, California, breeding site for Ashy Petrels. Calif. Birds 3:71.

Ainley, D. G. and G. A. Sanger. (in press). Seabird trophic relationships in the northeastern Pacific Ocean and Bering Sea. In (J. C. Bartonek, D. N. Nettleship, and W. B. King, eds.) Conservation of seabirds in western North America. U. S. Fish and Wildl. Serv., Wildl. Res. Rept.

Ainley, D. G. and R. P. Schlatter. 1972. Chick raising ability in Adélie Penguins. Auk 89:559-566.

Ainley, D. G., R. W. Stallcup, and D. F. DeSante. (in prep.). The avifauna of the Farallon Islands, California. Pac. Coast Avifauna.

Ainley, D. G. and M. C. Whitt. 1973. Numbers of marine birds breeding in northern California. West. Birds 4:65-70.

Brownell, R. L., Jr. and D. G. Ainley. (in prep.). Southern Elephant Seals in the Ross Sea. Antarc. J. U. S.

Follet, W. I. and D. G. Ainley. 1976. Fishes collected by Pigeon Guillemots, Cepphus columba (Pallas), nesting on Southeast Farallon Island, California. Calif. Fish and Game 62:28-31.

LeBoeuf, B. J., D. G. Ainley, and T. J. Lewis. 1974. Elephant seals on the Farallones: population structure of an incipient breeding colony. J. Mammalogy 55:370-385.

Lewis, T. J., D. G. Ainley, D. Greenberg, and R. Greenberg. 1974. A Golden-cheeked Warbler on the Farallon Islands. Auk 91: 411-412.

Scott, J. M., W. Hoffman, D. Ainley, and C. F. Zeillemaker. 1974. Range expansion and activity patterns in Rhinoceros Auklets. West. Birds 5:13-20.

Smail, J., D. G. Ainley and H. Strong. 1972. Notes on birds killed in the 1971 San Francisco oil spill. Calif. Birds 3:25-32.

Wood, R. C., D. G. Ainley, and W. J. L. Sladen. 1971. Antarctic avian population studies, 1969-70. Antarc. J. U. S. 6:45-46.

Wood, R. C. and D. G. Ainley. (in prep.). Birds observed at Cape Crozier, Antarctica. Auk.

Selected Publications:

Grau, C. R., and M. Kamei. Delayed oviposition observed in hens fed purified diets. Poultry Sci. 29: 469 (1949).

Kritchevsky, D., C. R. Grau, B. M. Tolbert and B. J. Kruechkel. Distribution of radioactivity in the egg after feeding sodium acetate-1-C14. Proc. Soc. Exp. Biol. and Med. 76: 741-743 (1951).

Grau, C. R., E. Allen, M. Nagumo, C. L. Woromick and P. A. Zweigard. Cottonseed meal in poultry feed. A distinctive yolk component in the fresh eggs of hens fed gossypol. Ag. and Food Chem., Vol. 2, No. 19, p. 982 (1954).

Woronick, C. L., and C. R. Grau. Gossypol-cephalin compound from fresh eggs of hens fed cottonseed meal. Ag. and Food Chem. 3: 706 (1955).

Grau, C. R., N. W. Klein and T. L. Lau. Total replacement of the yolk of chick embryos. J. Embryol. Exp. Morph. 5: 210-214 (1957).

__________, H. I. Fritz, N. E. Walker and N. W. Klein. Nutrition studies with chick embryos deprived of yolk. J. Exp. Zoology 150: 185-195 (1962).

__________, N. E. Walker, H. I. Fritz and S. M. Peters. Successful development of chick embryos nourished by yolk-sac perfusion with calcium-low media. Nature 197: 257-259 (1963).

Grau, C. R., and B. W. Wilson. Avian oogenesis and yolk deposition. Experimentia 20: 26 (1965).

__________, R. E. Austic and G. C. Matteson. Degeneration of the eyes of tyrosine-deficient chick embryos. Science 148: 1743-1745 (1965).

__________. Avian embryo nutrition. Federation Proceedings 27: 185-192 (1968).

__________. Ring structure of avian egg yolk. Poultry Sci. 55: 1418 (1976).

Dobbs, J. C., C. R. Grau, T. Roudybush, and J. Wathen. Yolk ring structure of quail subjected to food deprivation and refeeding. Poultry Sci. 55: (in press) (1976) (abstract).

Grau, C. R., T. Roudybush, J. Dobbs, and J. Wathen. Altered yolk structure and reduced hatchability of eggs from birds fed single doses of petroleum oils. Science: (in press) (1977).

Roudybush, T., and C. R. Grau. Yolk formation in some Pacific seabirds and shorebirds. (Pacific Sea Group Meeting, Asilomar, California, Abstract.

Engel, S. W., T. E. Roudybush, J. C. Dobbs, and C. R. Grau. Depressed food intake and reduced reproduction in Japanese quail following a single dose of Prudhoe Bay crude oil. (Submitted for presentation to the 17th Hanford Biology Symposium, Richland, Washington, Oct. 17-19, 1977.

Publications:

Vohra, P., and T. Roudybush. The effect of various levels of dietary protein on the growth and egg production of Coturnix coturnix japonica. Poultry Sci. 50: 1081-1084 (1971).

Roudybush, T., D. L. Anthony and P. Vohra. The use of polyethylene as an indicator in determination of metabolizable energy of diets for Japanese quail. Poultry Sci. 53: 1894-1896 (1974).

Dobbs, J. C., C. R. Grau, T. Roudybush, and J. Wathen. Yolk ring structure of quail subjected to food deprivation and refeeding. Poultry Sci. 55: (in press) (1976) (abstract).

Grau, C. R., T. Roudybush, J. Dobbs, and J. Wathen. Altered yolk structure and reduced hatchability of eggs from birds fed single doses of petroleum oils. Science: (in press) (1977).

Roudybush, T., and C. R. Grau. Yolk formation in some Pacific seabirds and shorebirds. (To be presented to meeting of Pacific Seabird Group, January 8, 1977).

Engel, S.E., T. E. Roudybush, J. C. Dobbs, and C. R. Grau. Depressed food intake and reduced reproduction in Japanese quail following a single dose of Prudhoe Bay crude oil. (Submitted for presentation to the 17th Hanford Biology Symposium, Richland, Washington, Oct. 17-19, 1977.

Publications:

Morrell, S. 1972. Life history of the San Joaquin Kit Fox. Calif. Fish and Game 58:162-174.

Ainley, D. G., T. J. Lewis, and S. Morrell. 1976. Molt in Leach's and Ashy Storm-Petrels. Wilson Bull. 88:76-95.

Ainley, D. G., S. Morrell, and T. J. Lewis. 1974. Patterns in the life histories of storm petrels on the Farallon Islands. Living Bird 13:295-312.

Ainley, D. G., H. R. Huber, R. P. Henderson, and T. J. Lewis. 1975. Studies of marine mammals at the Farallon Islands, California. PRBO Report to the Marine Mammal Commission.

Huber, H. R. and T. J. Lewis. (in prep.). First records of the Red-footed Booby in western North America. West. Birds.

McGinnis, S. M., C. G. Whittow, C. A. Ohata and H. R. Huber. 1972. Body heat dissipation and conservation in two species of dolphins. Comp. Biochem. Physiol.

Stenzel, L. E., H. R. Huber, and G. W. Page. 1976. Feeding behavior and diet of the Long-billed Curlew and Willet. Wilson Bull. 88:314-332.

RFx41-423-730

2 SEP 1977

David G. Ainley
Point Reyes Bird Observatory
4990 State Route 1
Stinson Beach, CA 94970

Reference: R.U. 423 and Guidance letters RFx41-423-543
RFx41-423-659

Dear Dr. Ainley:

Your FY 78 renewal proposal, entitled "Influence of Petroleum on Egg Formation and Embryonic Development in Seabirds," and responses to guidance have been reviewed in the Juneau Project Office. The original proposal together with the addenda contained in the guidance letters and your letters of August 3, 1977, and August 19, 1977 are now judged acceptable at the requested funding level of $32,993. We will instruct our Contracting Office to initiate contracting procedures based on the above items. Please note that the final funding commitment and level are contingent on approval of the FY 78 OCSEAP budget by BLM.

We look forward to your continued involvement in our program.

Sincerely,

Herbert E. Bruce
Bering SeaGulf of Alaska Project Manager

cc: Program Office

POINT REYES BIRD OBSERVATORY
Mesa Road, Bolinas, California 94924
mailing address: 4990 State Route 1, Stinson Beach, CA 94970

August 19, 1977

Reference: RU #423
Guidance letters: #RFx41-423-543
#RFx41-423-659

Dr. Herbert E. Bruce, Ph.D.
Bering Sea - Gulf of Alaska Project Manager
P.O. Box 1808
Juneau, Alaska 99802

Dear Dr. Bruce:

We agree to the changes in our work statement as outlined in your 17 August letter (RFx41-423-659).

Sincerely yours,

David G. Ainley

David G. Ainley, Ph.D.
Principal Investigator, RU 423

RFx41-423-659

AUG 1 7 1977

Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P.O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

Dr. D. G. Ainley
Point Reyes Bird Observatory
4990 State Route 1
Stinson Beach, California 94970

Reference: Research Unit #423
Guidance Letter #RFx41-423-543

Dear Dr. Ainley:

Your FY 78 renewal proposal entitled "Influence of Petroleum on Egg Formation and Embryonic Development in Seabirds" and your letter responding to guidance have been reviewed in the Juneau Project Office. The following revisions are required before your work statement can be sent to our contracting office for funding:

1. The effects of ingested petroleum on the developmental embryology of incubated eggs will be studied by a) staging of the dead embryos to establish time of death and b) examination of the gross morphology to determine cause of death.

2. No budget amendments to cover travel and per diem costs for trips to visit the Juneau Project Office at the request of that office are necessary.

The final funding level and commitment are contingent on approval of the FY 78 OCSEAP budget by the Bureau of Land Management.

If you have any questions concerning any of the above guidance, please phone the Juneau Project Office, (907) 586-7436.

Your letter agreeing to these changes, or a revised work statement, must be sent to and received in the Juneau Project Office, with a copy to Boulder no later than August 25, 1977. If there are extenuating circumstances which prevent you from meeting this schedule, please phone the Project Office. The short deadline is required to ensure continuous funding of your project in FY 78.

Upon receipt of your work statement, revised in accordance with the above guidelines, we will initiate contracting procedures for FY 78. I look forward to your continued involvement in our program.

Sincerely,

Herbert E. Bruce, Ph.D.
Bering Sea - Gulf of Alaska Project Manager

cc: Program Office

POINT REYES BIRD OBSERVATORY
Mesa Road, Bolinas, California 94924
Mailing address: 4990 Shoreline Highway, Stinson Beach, CA 94970

RFx41-423-543 (July 27, 1977) August 3, 1977

Dr. Herbert E. Bruce, Project Manager
Bering Sea-Gulf of Alaska Project
P. O. Box 1808
Juneau, AK 99802

Dear Dr. Bruce:

We received your letter on the first and immediately got in touch with Dr. Grau at Davis for the necessary answers to numbers 1, 2, and 6. We shall be glad to comply with numbers 3 and 4. With reference to number 5, could we amend our budget to include travel and per diem for Dr. Grau and me to come to Juneau? If by any chance the appropriate person from your office would be in the San Francisco area between now and the end of December, we would be glad to meet with him there.

The following should be added to our proposal: (the numbers refer to your requests):

(1) Page 15, add after line 6. The analytical methods that will be applied to eggs laid by dosed and controlled auklets will probably be of two types: (1) those designed to identify and quantify components or metabolites of Bunker C or PBCO that may be deposited in eggs; and (2) those that may show the effects of oils on the composition of lipids and other normal components of eggs.

Auklet eggs laid by Bunker C-dosed birds are being held in frozen storage until we are able to adapt methods from studies with quail to analyses of wild bird eggs. Eggs laid by quail dosed with 200 mg Bunker C were vacuum dried and extracted with isopentane. The extract was saponified with alcoholic potassium hydroxide and the non-saponifiable components taken up in isopentane. This solution was subjected directly to gas chromatographic analysis, or the extract was cleaned up with activated Florisil before GC analysis, using Hewlett-Packard instruments, gas capillary column coated with OV-3 and run at 60° to 250°. Extracts were also compared in a Cary recording spectrophotometer at ultraviolet wave lengths down to 210 nanometers.

This work is still in progress, but to date distinctive hydrocarbons have not yet been identified in these eggs. Possible protein-bound metabolites were sought by treating residual egg protein with HCl, extracting with isopentane, and observing UV absorption. No differences were found. Lipid composition of normal eggs and those from Bunker C-dosed quail have been studied by comparison of the following: phopholipid fractionation by thin-layer chromatography; visible and UV absorption of acetone extracts and subsequent extracts from hexane:acetone, chloroform, and methanol; chloresterol determinations; fatty acid distributions of total lipids. Although we have not yet found differences between treated and control quail eggs, reproducible differences in isopentane solubilities and in responses to acetone denaturation have been observed. These leads are being pursued. It is possible that the levels of Bunker C used for quail and auklets are too low to permit identification of components by presently available techniques. Biological responses may still be evaluated, however, by hatching success and other measures.

(2) (Sampling Methods p. 14). The dose level for Bunker C (600 mg) is the same as the higher dose used in 1977 and thus provides a comparison between 1978 and 1977. This level did not result in any reduction in hatching success in auklets, possibly because of rapid passage through the gut. In the artificial burrows to be constructed it will be possible to observe behavioral effects from the dose. The PBCO dose is the maximum that can be given, in four capsules at one time. Results from our quail study show that approximately four times as much Prudhoe Bay crude oil is required to give the same egg production reduction effect as Bunker C. However, because it is not yet possible to translate directly results from quail to auklets we propose to use the highest possible single dose, 1000 mg. We are afraid that multiple doses may be unduly harmful.

(6) (Add this to Section 12, p. 20).

Techniques for Preparing Doses Based on 1977 Experiences

Variation in individual dose weights distributed into the required three or four capsules will be less than one percent.

The balance used will be Mettler Type H15 which is calibrated every six months. Individual doses will be transported and stored on perforated cardboard sheets. Burrows will be identified by painted stakes and burrow covers. The oils will be the A.P.I. reference Bunker C oil and a PBCO obtained from NOAA/NMFS, Seattle. This is an Alaskan North Slope "Saderochit", from ARCO. Analytical quality assurance will be based upon standard laboratory procedure and instrument checks using standard compound mixtures and comparisons of oils used with published data. The UV calibration will be based on known standards for hydrocarbons or other substances identified in the eggs produced, if such compounds are found. The toxic faction of Bunker C oil appears to contain non-volatile hydrocarbon components. Efforts to make volatile derivatives of these components for GC analysis are continuing. Most investigators currently use GC analysis for determining hydrocarbon components of oils and biological samples.

Should the toxic faction of Bunker C oil prove to be volatile after some chemical treatment, intercalibration with other investigators will be pursued. If new analytical techniques are required to identify and quantify this faction, standards for other investigators to use and follow may be established. Work is planned in collaboration with Dr. Jennings to measure this faction using liquid chromatography.

Please let us know if you require further information.

Sincerely yours,

David G. Ainley

David G. Ainley, Ph.D.
Program Director

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

TO:	Outer Continental Shelf Energy Assessment Program Juneau Project Office P.O. Box 1808 Juneau, Alaska 99802
TYPE OF SUPPORT REQUESTED:	Contract
TITLE OF PROJECT:	"Lower Cook Inlet Meroplankton (RU 424)"
PRINCIPAL INVESTIGATOR:	T. Saunders English, Associate Professor Department of Oceanography, WB-10 College of Arts and Sciences University of Washington Seattle, Washington 98195 Telephone: area code 206, 543-5077
AMOUNT REQUESTED:	$150,000
DESIRED PERIOD:	1 October 1977 - 30 September 1978
UNIVERSITY OFFICE TO BE CONTACTED REGARDING GRANT OR CONTRACT NEGOTIATION:	Grant and Contract Services 1 Administration Building, AD-24 University of Washington Seattle, Washington 98195 Telephone: area code 206, 543-4043

DATE: ________________

____
Principal Investigator

____
Francis A. Richards
Associate Chairman for Research
Department of Oceanography

____
Joe S. Creager, Associate Dean
College of Arts & Sciences

OFFICIAL AUTHORIZED TO GIVE UNIVERSITY APPROVAL:

____
Donald R. Baldwin, Director
Grant and Contract Services
1 Administration Building, AD-24

REF: P77-38

TECHNICAL PROPOSAL

I. Title: Lower Cook Inlet Meroplankton

Research Unit Number: RU(424)

Contract Number: 03-5-022-67-TA8 #4

Proposed Dates of Contract: 1 October 1977 to 30 September 1978

II. Principal Investigator: T. Saunders English
Department of Oceanography
University of Washington

III. Cost of Proposal - Federal Fiscal Year 1978

Total $150,000

Distribution of Effort by Lease Area: 100% Lower Cook Inlet

IV. Background

This proposed research on early life history stages of fishes, shrimps, and crabs will contribute to knowledge of the quantitative temporal and spatial changes in composition and feeding habits for principal life stages of marine organisms in the Kamishak Bay area of Lower Cook Inlet. These data are needed for determining critical species or stages and will provide important information for use in evaluating the sensitivity of areas that may be impacted by petroleum development. This work will be based on earlier biological surveys which have provided species lists and general information on the relative abundance and distribution of important marine organisms. The field effort and analysis of past data will be coordinated with RU 512, fishes and stomach analyses, birds, and coordinated with other relevant programs.

V. Objectives

The objectives of this study are to contribute to an understanding of the quantitative seasonal changes in composition and feeding habits of dominant marine organisms. Specific objectives are:

1. Describe the temporal dynamics of the early life history stages of important fishes, shrimps, and crabs at specific sites.
2. Evaluate the timing and use of specific areas by critical life stages of fishes, shrimps, and crabs.
3. Contribute to an initial description of the food web.

These objectives are relevant to decision making during leasing and development because time periods and geographic areas will be identified as having greater abundance of early life history stages of fishes, crabs, and shrimps of substantial importance in sport and commercial harvests. This information will be useful in prediction and after-the-fact evaluation of environmental effects and hazards of oil and gas development in Lower Cook Inlet.

VI. General Strategy and Approach

Field studies in Lower Cook Inlet during FY 78 will be more concentrated in area and will be directed toward determining the quantitative seasonal composition and density distribution of early life history stages of fishes, shrimps, and crabs. The general strategy will be to conduct coordinated field sampling on a routine basis throughout the year with intensive sampling during the spring and summer to coincide with the expected increase in biological activity. The analysis and interpretation of the data collected during FY 76 and 77 will be coordinated with other biological research units underway to approach a comprehensive understanding of seasonal composition, distribution, and abundance of early life history stages of fishes, shrimps, and crabs in Lower Cook Inlet.

The approach will include coordination with Research Units 3, 5, 138, 341, and 417 to facilitate a synthesis of biological and environmental information.

VII. Sampling Methods

The temporal sampling scheme is to sample on a routine basis throughout the year, with more intense sampling during the spring and summer to coincide with the expected intensification of biological activity. The spatial sampling scheme will include stations in Kamishak Bay, Kachemak and the high energy area of Lower Cook Inlet. It is understood that the exact temporal scheme and spatial locations will be finalized during coordination meetings to be held during the period October to May by the Juneau Project Office. These meetings will involve coordination of research units 29, 138, 162, 190, 229, 243, 275, 424, 425, 430, 481, and 512. The supporting rationale is to facilitate coordination between the several Research Units active in the study area.

The coordinated efforts will entail the use of standardized sampling devices, probably the Bongo sampler and the Miller net (1961). The nets will be deployed and its actions recorded in accord with standard MARMAP methods (Smith, 1974). Nets for the Bongo sampler will have mesh sizes of 0.333 and 0.505 mm. These methods result in a double-oblique haul with an open net. The time is measured incrementally in conjunction with wire length and wire angle so that a haul track can be computed. A current meter allows an estimate of the cubic meters of water filtered by the net, or duration of haul; ship speed, and distance travelled can be used to estimate the volume of a Miller net sample.

A major advantage of the Miller net is that sample volumes are such that subsampling is not often required. We know the sampling statistics of our several subsampling devices, which are well below the variance of replicate samples from the field.

Reference: Smith, Paul Edward. 1974. Manual of Methods for Fisheries Resource Survey and Appraisal, Part 4. Standard Techniques for Pelagic Fish Egg and Larva Surveys. Edited by Paul Edward Smith. Draft Copy, August 1974.

Reference: Miller, D. 1961. A modification of the small Hardy plankton samples for simultaneous high-speed plankton hauls. Bulletin of Marine Ecology. 5(4): 165-172.

VIII. Analytical Methods

The methods of analysis to obtain densities of organisms per square meter and per cubic meter will be standard MARMAP methods. The theoretical model for estimating the abundance of organisms was described by English (1964). A partially hierarchical analysis of variance model with fixed and random factors will allow estimation of abundance in three dimensions with time, with confidence interval estimates about mean annual abundance and any other means of interest.

Reference: English, T. Saunders. 1964. A theoretical model for estimating the abundance of planktonic fish eggs. Rapports et Procès-Verbaux. Conseil Permanent International pour l'Exploration de la Mer. 155: 174-182.

IX. Anticipated Problems

None beyond the usual difficulties of a new program in a new area.

X. Deliverable Products (see also Other Information, Section 5)

A. Digital Data

1. Parameters

Parameters	Limits of Values: Min	Limits of Values: Max
File Type	024	024
File Identifier	alphanumeric	
Record Type	1	6
Station Number	alphanumeric	
Vessel Name	alphanumeric	
Cruise Number	1	999999
Cruise Dates	750101	991231
Area/Project	alphanumeric	
Investigator/Institution	alphanumeric	
Geographic Position	580000	626060
Date/Time	750101	991231
	0001	2400
Water Depth	0	1500
Sample Interval	0	1500
Gear Characteristics (codes)	1	99
Duration/Length of Haul	0.1	6
Volume of Water (Filtered)	1	10000

	Limits of Values Min	Max
Sample Number	1	9999
NODC Taxonomic Code	6179	8857041902
Life History (code)	alphanumeric	
Size/Number of Subsample	0.001	100
Concentration of Subsample	0	99999
Text	alphanumeric	
Sequence Number	1	99
Concentration Per Cubic Meter	0	999999
Ship Speed (0.1 m/sec)	0	100
Haul Type	alphanumeric	

All of these data fields will be used frequently, rather than occasionally or seldom. The new NODC taxonomic code, released in March 1977, will be used for all FY 78 data submissions.

2. Digital Products

Processing and formatting of digital data into OCSEAP format will be done by the investigator.

B. Narrative Reports

We will provide special reports for synthesis meetings and other project purposes.

C. Visual Data

Our data will be submitted in reports.

D. Other Non-Digital Data

None

E. Data Submission Schedule

We expect to collect field data from March through September 1978. Data will be submitted by 3-month data collection periods.

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)		Submission (Month/Year)
Early Life History Stages of Fishes, Shrimps and Crabs	Cards	400 cards	024	Yes	Jan 78	Mar 78	Sep 78
	Cards	600 cards	024	Yes	Apr 78	Jun 78	Dec 78
	Cards	600 cards	024	Yes	Jul 78	Sep 78	Mar 79

XI. Information Required from Other Investigators

We need a quantitative description of water movements of Lower Cook Inlet. Informal conversations with investigators in PMEL suggest that their efforts (such as buoy location) could be usefully directed to that purpose by the Juneau Project Office. Our needs most probably fit into the overall needs of Lower Cook Inlet, so the sources and fate of water in the area should also be available to us.

XII. Quality Assurance Plans

This short synopsis of procedures will be followed by a full documentation during the first quarter of this contract year.

The standard MARMAP methods will continue to be the backbone of our program, as documented in Smith (1974). The quality assurance plans include both the field and laboratory aspects of our program.

The quality assurance plans in the field center about the use of the standard Bongo array and our efforts to get a standardized, quantitative haul within acceptable limits of variation. The standard towing procedure has been described by Kramer, et al. (1972). The technician has standard record sheets to note time, depth, wire angle, speed, and other observations. The critical factors needed in later computations are the length of the tow path and the maximum depth of the tow. The best procedure does not allow a MARMAP tow to exceed acceptable limits of speed, clogging, wire angle, and filtration per unit depth. When the cruise plan allows, an unacceptable haul will be repeated. Spaces for initials by the responsible person help to maintain quality control at sea.

The net washing, preservation, labelling, and storage are also conducted within limits recommended by MARMAP procedures. The catches of small and large meshes can be compared to detect extrusion and other undesirable effects.

The laboratory analysis also proceeds under recommended MARMAP procedures. The volume is measured as a basis for considering splitting samples. The sorting by lesser skilled persons is checked in later sorting for other categories of organisms. Lower skilled persons can make preliminary identifications, but final identifications, sizing, enumeration, and staging are reserved for more skilled persons. Bottling, storing, curating, and voucher specimen selection are accomplished using MARMAP and OCSEAP procedures.

The computations, keypunching, and other manual aspects of data handling and analysis are all subject to independent proofreading.

XIII. Special Sample and Voucher Specimen Archival Plans

Voucher specimens will be retained by the Principal Investigator throughout the period of this contract unless OCSEAP requests an early transfer to a permanent archive.

XIV. Logistics Requirements

The strategy and approach offered to attain the stated objectives of RU 424 dictates logistic support of a field station and small boats continuously available. The field station will allow time series sampling adequately dense to describe temporal dynamics and the timing and use of specific areas of critical early life history stages. The field station should accommodate 2 scientists from RU 424 continuously and 3 occasionally. Iniskin Bay appears to be an appropriate location for 9 to 11 months each year; Homer or Seldovia might be a useful base for sampling during other months.

A commercial type vessel 40 to 60 feet long will be adequate to allow sampling to continue on enough days to maintain an adequate time series. Such a sampling platform can handle the required nets and weights, as well as obtain the required

Discipline ______
Area of Operation ______

LOGISTICS REQUIREMENTS

Please fill in all spaces or indicate not applicable (N/A). Use additional sheets as necessary. Budget line items concerning logistics should be keyed to the relevant item described on these forms.

INSTITUTION University of Washington PRINCIPAL INVESTIGATOR T. Saunders English

A. SHIP SUPPORT

1. Delineate proposed tracks and/or sampling grids, by leg, on a chart of the area. Include a list of proposed station geographic positions.
   See Figure 1 for general area of operations from Iniskin Bay field station.

2. Describe types of observations to be made on tracks and/or at each grid station. Include a description of shipboard sampling operations. Be as specific and comprehensive as possible.

   Standard MARMAP type net hauls.

3. What is the optimum time chronology of observations on a leg and seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification.)

   Available continuously from March 78 onwards.

4. How many sea days are required for each leg? (Assume vessel cruising speed of 14 knots for NOAA vessels. Do not include running time from port to beginning point and from end point to port and do not include a weather factor.)
   - N/A

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback?
   We are the principal investigation.
   Approximately how many vessel hours per day will be required for your observations and must these hours be during daylight? Include an estimate of sampling-time on station and sample processing time between stations. We can work 24 hours/day.
   We need no special time between stations.

6. What equipment and personnel would you expect the ship to provide?

   See Attachment A.

7. What is the approximate weight and volume of equipment you will bring?
   300 pounds, 48 cubic feet.

8. Will your data or equipment require special handling? No If yes, please describe:

9. Will you require any gasses and/or chemicals? Yes if yes, they should be on board the ship prior to departure from Seattle or time allowed for shipment by barge. Preservatives

10. Do you have a ship preference, either NOAA or non-NOAA? If "yes" please name the vessel and give the reason for so specifying.

    40-60 foot boat.

11. If you recommend the use of a non-NOAA vessel, what is the per sea day charter cost and have you verified its availability We do not know whether NOAA will purchase or charter the vessel we require.

12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals.

    2. No foreigners.

Attachment A

The boat must have an operator and should be equipped with commercial gear including a winch, Loran C, and recording fathometer. The rigging of the boat must be adequate to handle Bongo nets for a standard MARMAP haul.

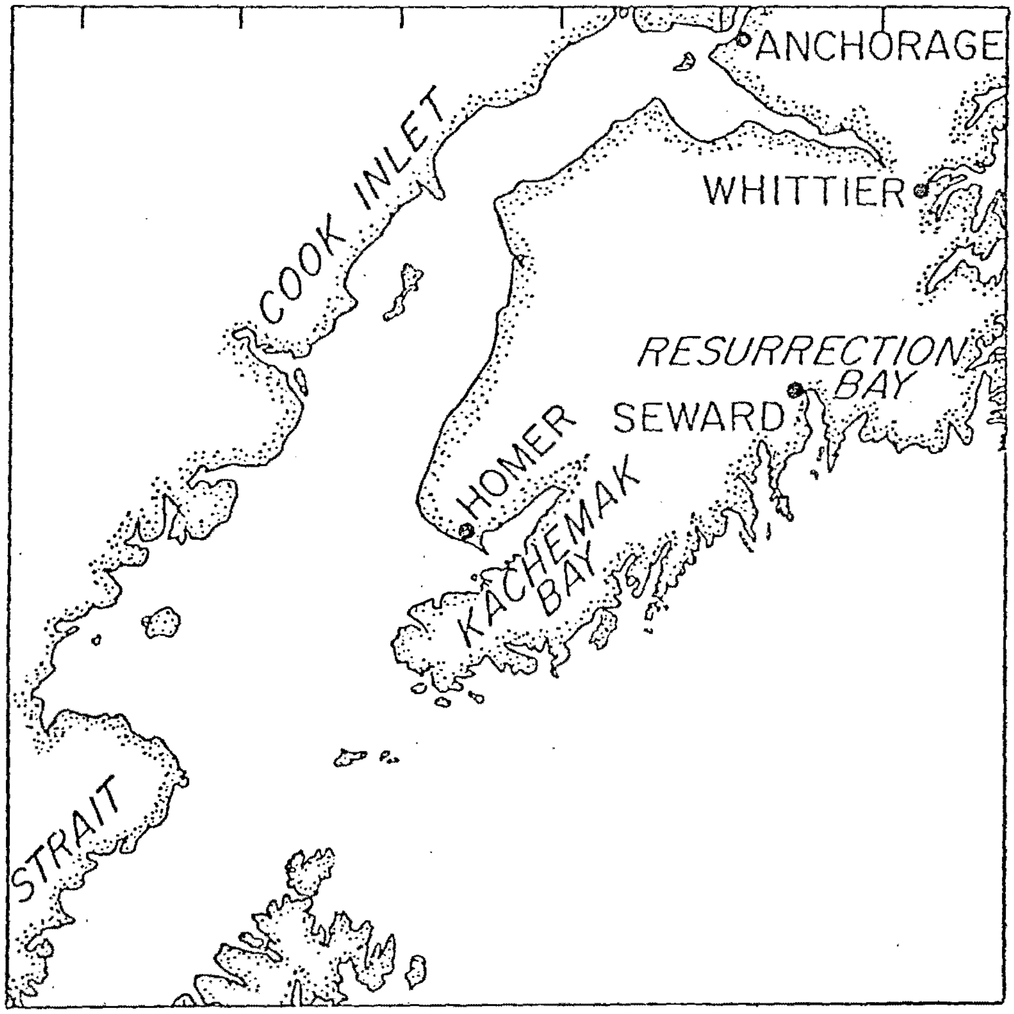


Figure 1. Sampling area for meroplankton work in Lower Cook Inlet, 1978.

8. AIRCRAFT SUPPORT - FIXED WING

1. Delineate proposed flight lines on a chart of the area. Indicate desired flight altitude on each line. (Note: If flights are for transportation only, chart submission is not necessary but origin and destination points should be listed)

   For transportation only: Homer to Iniskin Bay field station.
   See Attachment B for justification.

2. Describe types of observations to be made.

   N/A

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification)

   Weekly - 7-day variation.

4. How many days of flight operations are required and how many flight hours per day?

   Total flight hours? N/A

5. Do you consider your investigation to the principal one for the flight thus precluding other activities or requiring other activities to piggyback or could you piggyback?

   N/A

6. What types of special equipment are required for the aircraft (non carry-on)?

   What are the weights, dimensions, power requirements, and installation problems unique to the specific equipment.

   N/A

7. What are the weights, dimensions and power requirements of carry-on equipment?

   N/A

8. What type of aircraft is best suited for the purpose?

   Float plane.

9. Do you recommend a source for the aircraft?
   If "yes" please name the source and the reason for your recommendation.

   N/A

10. What is the per hour charter cost of the aircraft?

    ??

11. How many people are required on board for each flight (exclusive of flight crew)?

    None to two.

12. Where do you recommend that flights be staged from?

    Homer

Attachment B

The justification for the suggested use of a float plane is to transport personnel, mail, food, and supplies, as well as replacement parts and equipment, into the camp. The plane would remove personnel, samples, and data for shipment to home laboratories. The suggested frequency is an informed guess about how often a remote party of one vessel and three or more research units needs such contact. The guess makes assumptions about camp facilities that cannot be checked at this time; better storage and communications facilities could reduce the desirable frequency of flights.

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

We would like to have two scientists quartered in the Iniskin Bay field station continuously and a third on occasion from March through December 1978. We would like to man the field station or alternate winter location (Homer, Seldovia?) for several years. Eatimated man days:

Mar-Sep 78 = 450

Sep-Dec 78 = 250

Jan-Sep 79 = 600

The scientists will provide their own food.

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

N/A

3. What is your estimated per man day cost for this support at each location?

N/A

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

N/A

E. SPECIAL LOGISTICS PROBLEMS

1. What special logistics problems do you anticipate under your proposal and how do you propose that the problems be solved? (Provide cost estimates and indicate whether you propose handling the problems yourself or whether you must depend on NOAA to solve them for you?

We anticipate that NOAA will establish and maintain the Iniskin Bay field station. We expect the scientists to be able to devote essentially all waking hours to collection of samples and rough processing. We would like to continue sampling throughout 12 months of several years, so an alternative location (Homer, Seldovia ?) should be selected for the few winter months that the Iniskin Bay field station will not be manned. We have not budgeted for quarters and will depend on NOAA. The scientists will supply their own food.

observations of speed, position, bottom depth, and net depth. A suite of three or four sizes of Boston whalers will allow a variety of other field observations to be made while the seiner is otherwise engaged.

XV. Management Plan

This project will be managed by the Principal Investigator with the assistance of the Manager of Administrative Services, Department of Oceanography, the University Office of Grant and Contract Services, and the Vice President for Research, University of Washington.

XVI. Outlook

1. The final result at the first major plateau of accomplishment will be the initial stage of a theoretical model of abundance of specified early life history stages for important species populations of fishes, shrimps, and crabs.

   The complex distribution in space and time encountered in estimating populations of planktonic eggs and larvae can be treated with a partially hierarchical analysis of variance. Periods, areas, and depths of sampling can be considered to be fixed factors; cruises within periods, locations within areas and replications can be considered to be random factors. The confidence limits set for any mean can be used to establish meaningful contour intervals for depicting distributions. Procedures for allocating resources, choosing times and places of sampling, and setting confidence limits about estimated annual production can be established. The approximate cost of detecting specified fluctuations in egg abundance with a known probability of error can be determined.

2. Significant milestones will be reached annually as successive population estimates are computed and the sampling resources allocated for the most effective program in the succeeding

field season. Annually, the approximate cost of detecting specified fluctuations in egg and larval abundance with a known probability of error can be determined.

At that time a basis will be laid so that the direction can be changed to emphasize the population dynamics of several of the most important and tractable species.

3. Costs by fiscal year could increase in proportion to the sampling effort, possibly: 1979, $200,000; 1980, $250,000; 1981 and beyond, $300,000.

4. No additional major equipment would be required.

5. The location of future field efforts might be most effectively narrowed to one of the three to five representative sampling stations identified in FY 78.

6. The logistics requirements of FY 78 would continue, scaled slightly upward in proportion to sampling intensity.

XVII. Additional Contract Provisions

1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 210 days of the completion of a cruise or 3-month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or 3-month data collecting effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgement is standard:

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration,

under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

11. The new NODC taxonomic code, released in March 1977, will be used for all FY 78 data submissions.

MILESTONE CHART

RU #: 424 PI: T. Saunders English

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D			
Plan - Coordinate for Field Program	—	—	—	—	—	—	—	—										
Analysis - Interpretation of 76-77 Data	—	—	—	—	—	—												
Quarterly Report			△															
Winter Data Collection Period				—	—	—												
Data Processing							—	—	—	—	—	—	—	—	—	—	—	—
Annual Report						△												
Spring Data Collection Period							—	—	—									
Quarterly Report									△									
Summer Data Collection Period										—	—							
Submit Winter 78 Data (160 net hauls)												△						
Final Quarterly Report												△						
Final Report															△			

OTHER INFORMATION

1. The general background of the proposer is in fisheries and biological oceanography. His work experience includes freshwater hatcheries, farm ponds, lakes and streams; he has done biological oceanographic research in the tropics, temperate waters, and in the North Polar Sea. The investigator has done similar work in OCSEAP in FY 1976 and has done related work in Puget Sound since 1951.

2. There is only one contract.

3. The principal investigator shall actively lead and supervise the proposed work and shall take full responsibility for timely completion of all objectives, independent of the percentage of his salary requested in the budget. The principal investigator's time commitment is 34%, 25% from OCSEAP funding and 9% from the University of Washington.

4. The personnel assigned for direct work on the project and their major supervisory assignments, exclusive of hourly sorting helpers, are:

   T. English - principal investigator
   K. Daly - crab identification
   L. Legacie - fish identification
   D. Roetcisoender - shrimp identification
   M. Macaulay - data management, programming
   C. Pautzke - graphics, statistics, models

   This group worked together in the OCSEAP program since 1975. Resumes are attached.

5. Expected products from this research activity include:

   a. Narrative reports describing methods, spatial and temporal intensity of sampling, results, discussion, and conclusions.

   b. Digital data documenting quantitative results of this study submitted in OCSEAP format, File Type 024 - Zooplankton 02.

c. Maps identifying sampling sites.

Charts (Examples 1 and 2) illustrating:

(1) Seasonal density distributions and abundance of principal life stages for each major species or species group.

(2) The primary areas for retention of early life history stages.

Figures and tables illustrating:

(1) Seasonal changes in species composition at each sampling site (Example 3).

(2) Seasonal changes in density distribution of principal life stages by major species or species group at each sampling site (Example 4).

(3) Changes in density distribution by species, by location, over time (Example 5).

(4) Changes in density distribution, by depth, by species, over seasons (Example 6).

(5) Changes in density distribution, by life history stage, along sampling transect lines (Example 7).

(6) Changes in density distribution, by length, by area, by depth (Example 8).

(7) Changes in density distribution by life history stage, by depth, by time (Example 9).

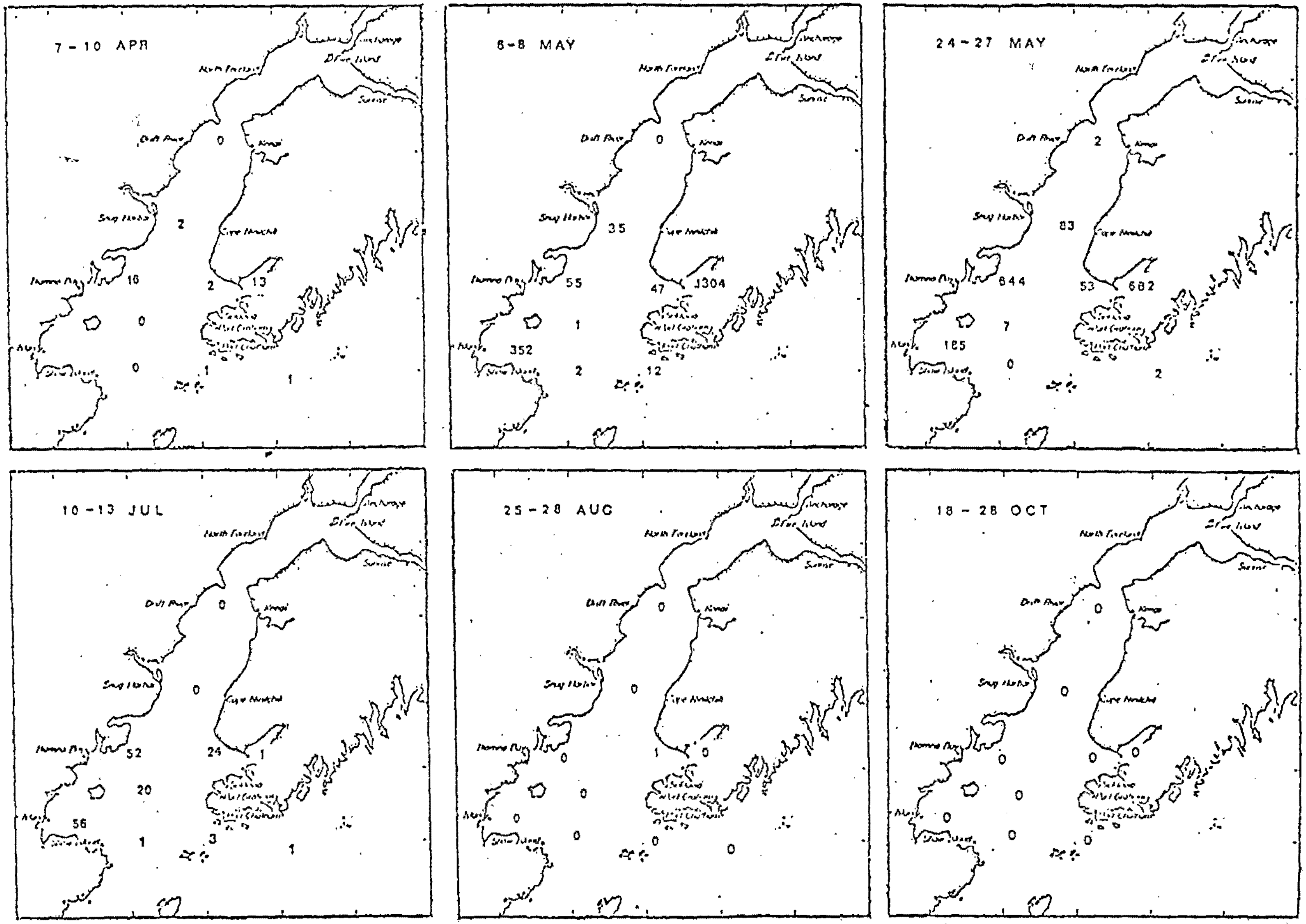
(8) Changes in density distribution, by life history stage, by length, over time (Example 10).

(9) Relative density distribution, by transect, by depth (Example 11).

(10) Relationship between confidence interval estimates, probability levels, and numbers of observations (Example 12).

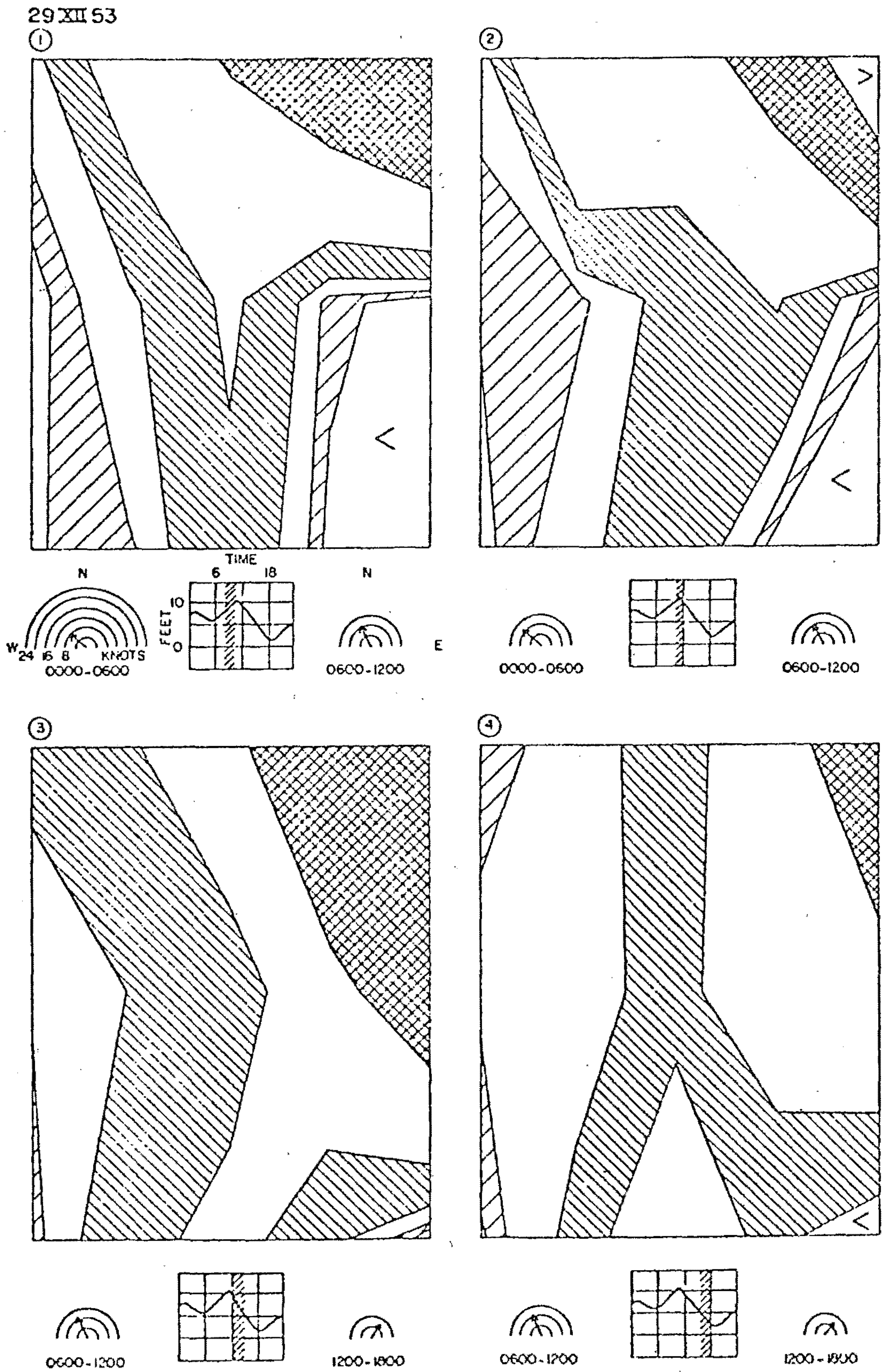
(11) Contours of water properties over time and depth (Example 13).

EXAMPLE 1



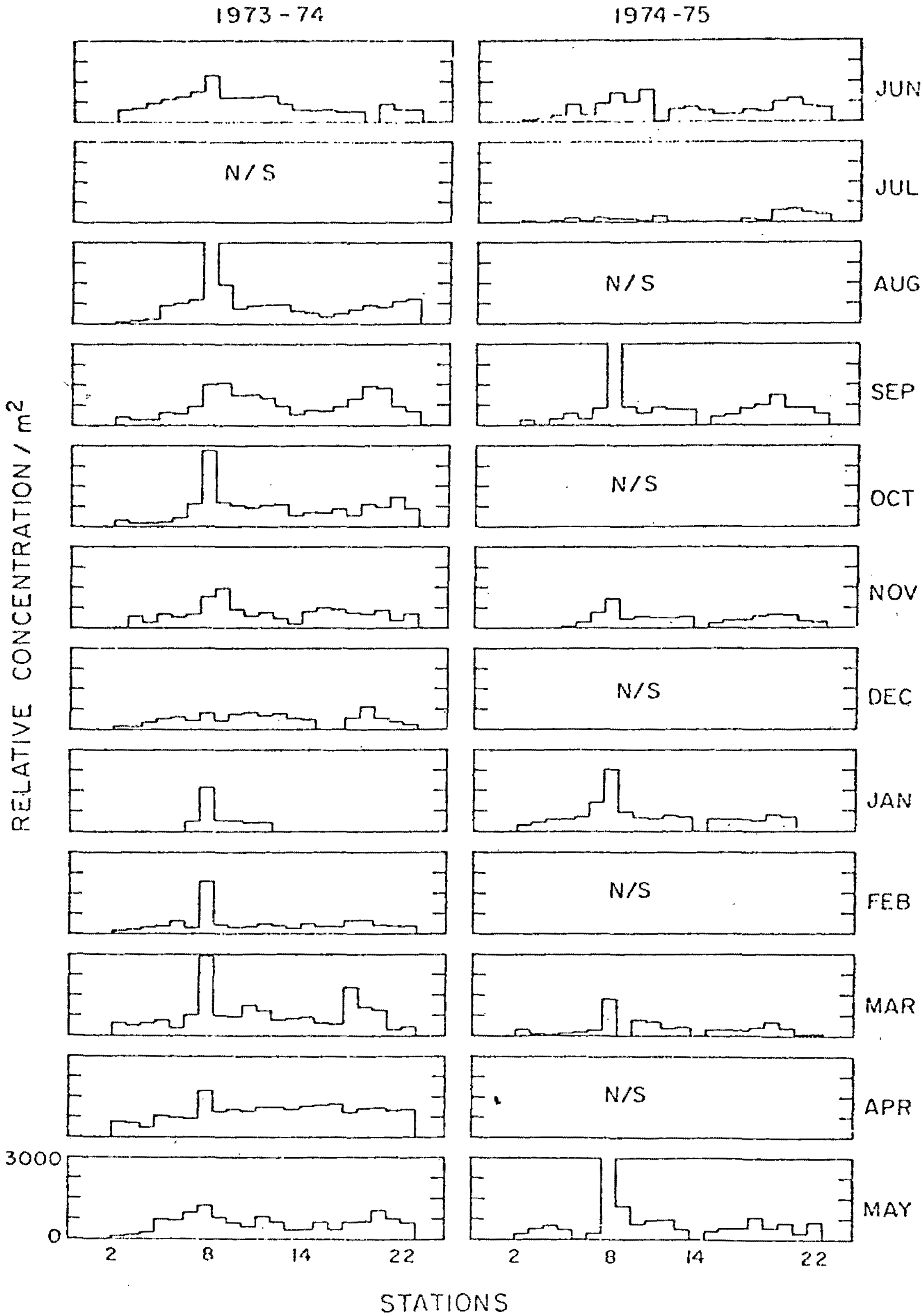
7 - 10 APR
0
2
16
2
13
0
0
1
1
6-8 MAY
0
35
55
47
1304
1
352
2
12
24 - 27 MAY
2
83
644
53
682
7
185
0
2
10 - 13 JUL
0
0
52
24
1
20
56
1
3
1
25 - 28 AUG
0
0
0
1
0
0
0
0
0
0
18 - 28 OCT
0
0
0
0
0
0
0
0
0
0

EXAMPLE 2

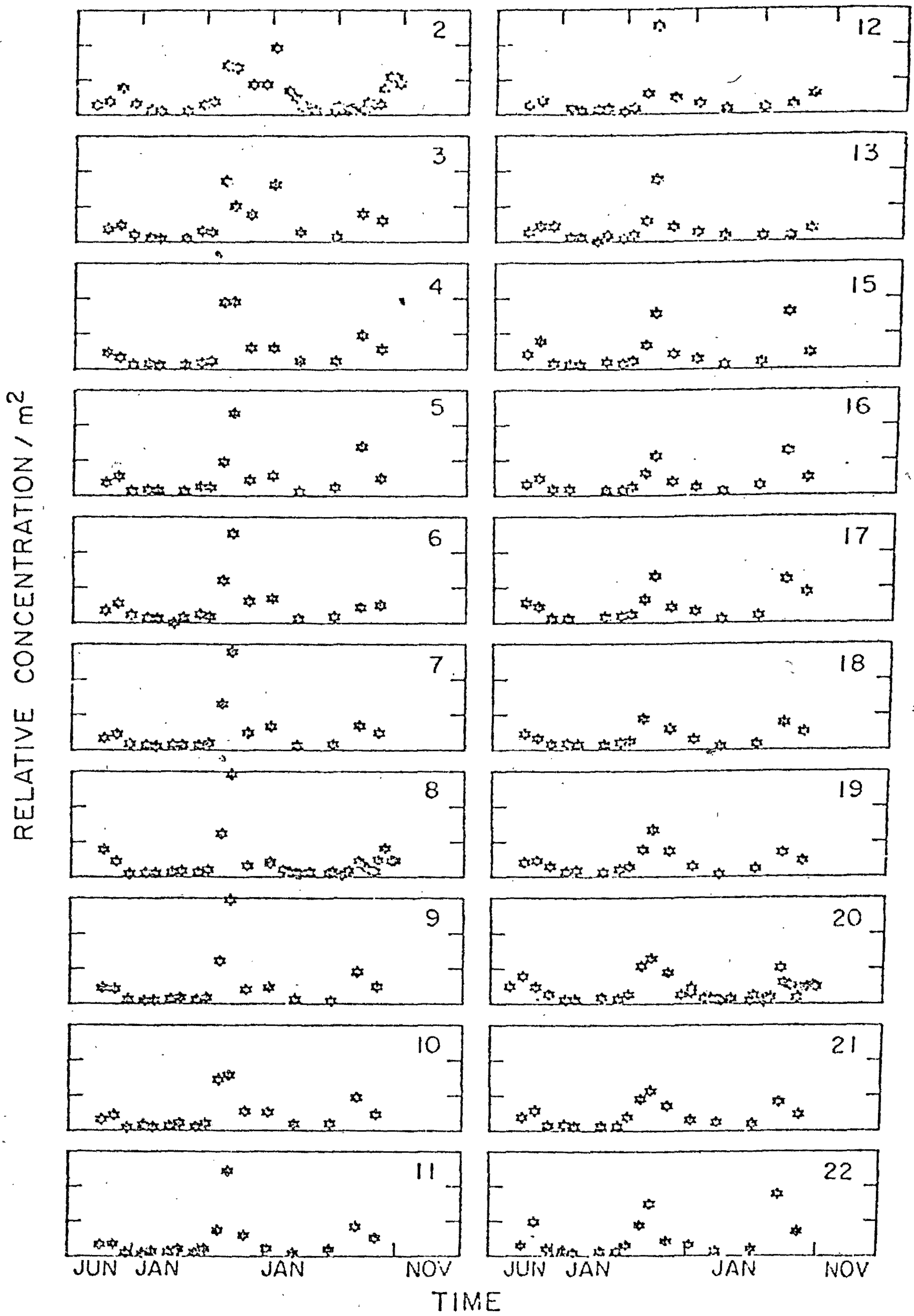


29 XII 53
1
2
3
4
TIME
6
18
N
W
E
24 16 8 KNOTS
10
FEET
0
0000-0600
0600-1200
0000-0600
0600-1200
0600-1200
1200-1800
0600-1200
1200-1800

EXAMPLE 3

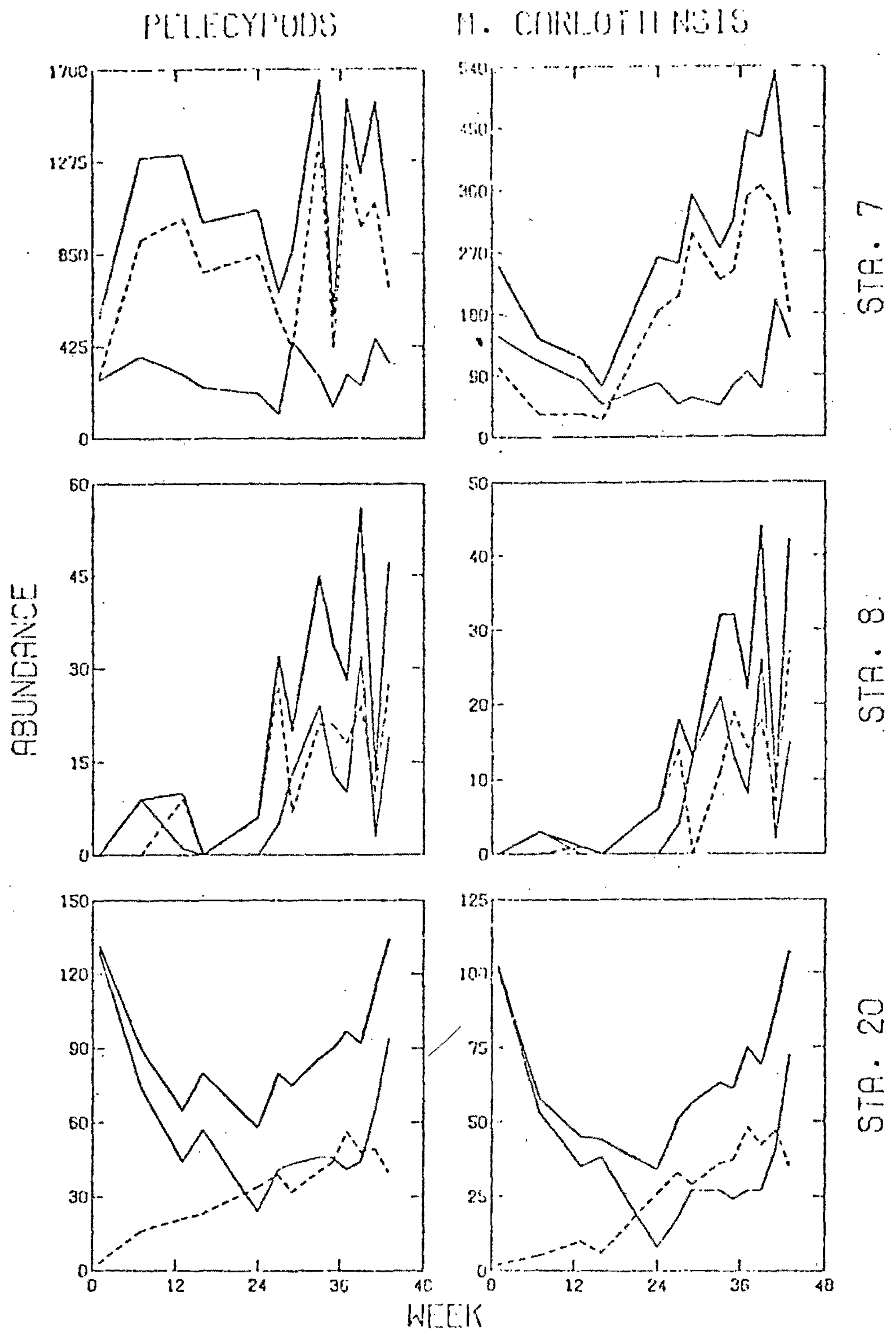

1973 - 74
1974 - 75
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
N / S
RELATIVE CONCENTRATION / m2
3000
0
2
8
14
22
STATIONS

EXAMPLE 4

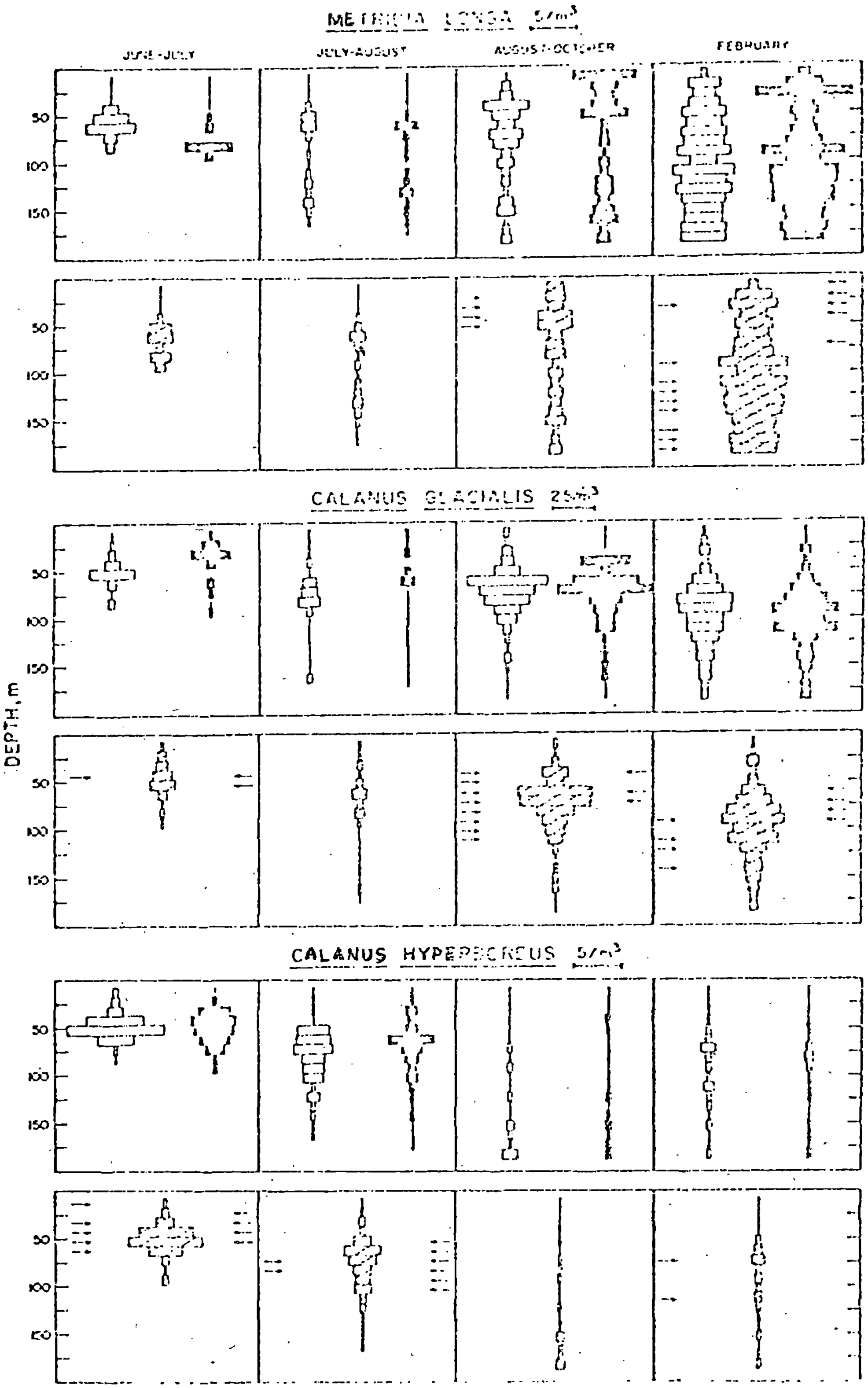


2
3
4
5
6
7
8
9
10
11
12
13
15
16
17
18
19
20
21
22
RELATIVE CONCENTRATION / m²
JUN JAN JAN NOV
JUN JAN JAN NOV
TIME

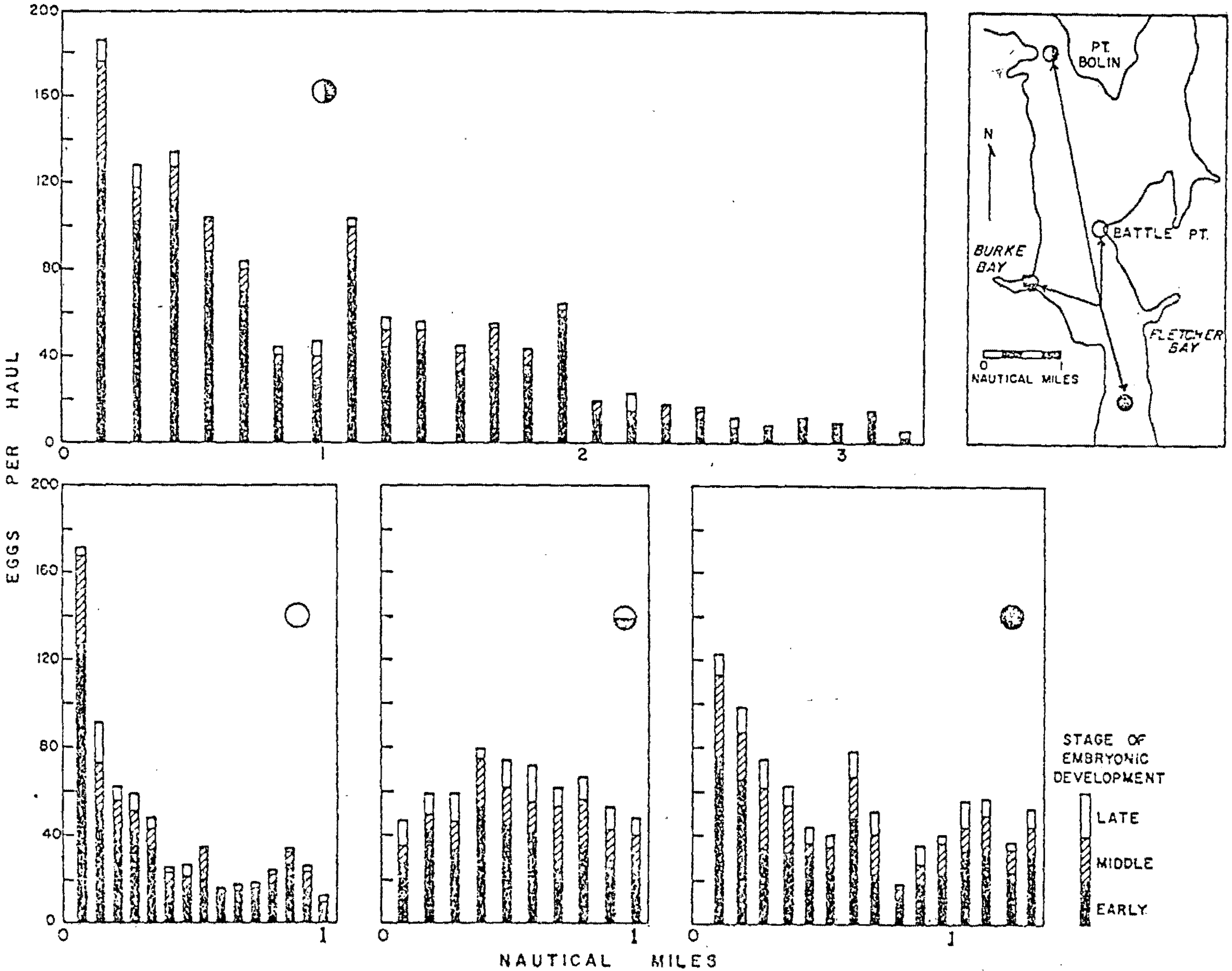
EXAMPLE 5



EXAMPLE 6.



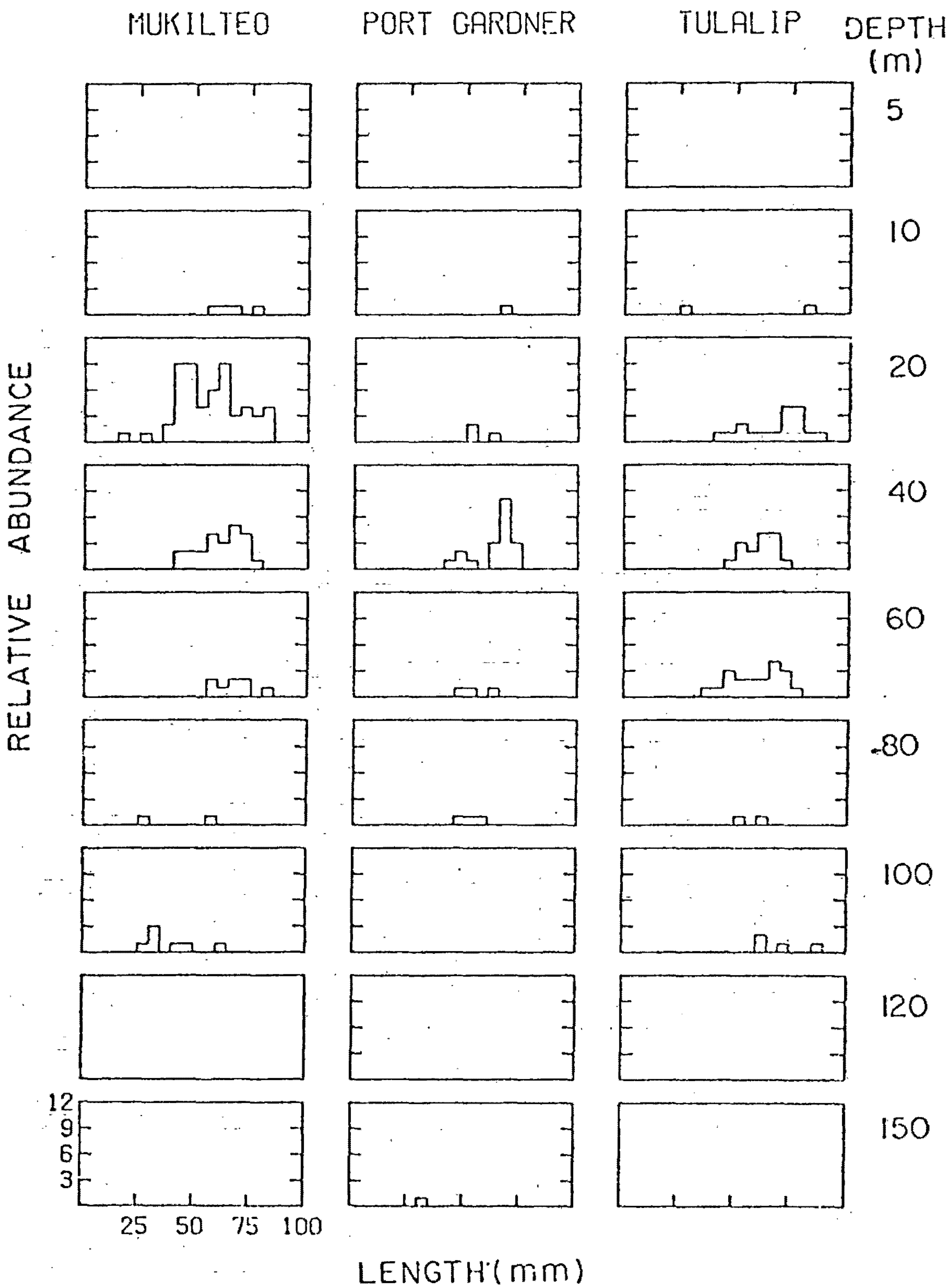
METRIDIA LONGA 5/m³
JUNE-JULY
JULY-AUGUST
AUGUST-OCTOBER
FEBRUARY
CALANUS GLACIALIS 25/m³
CALANUS HYPERBOREUS 5/m³
DEPTH, m
50
100
150



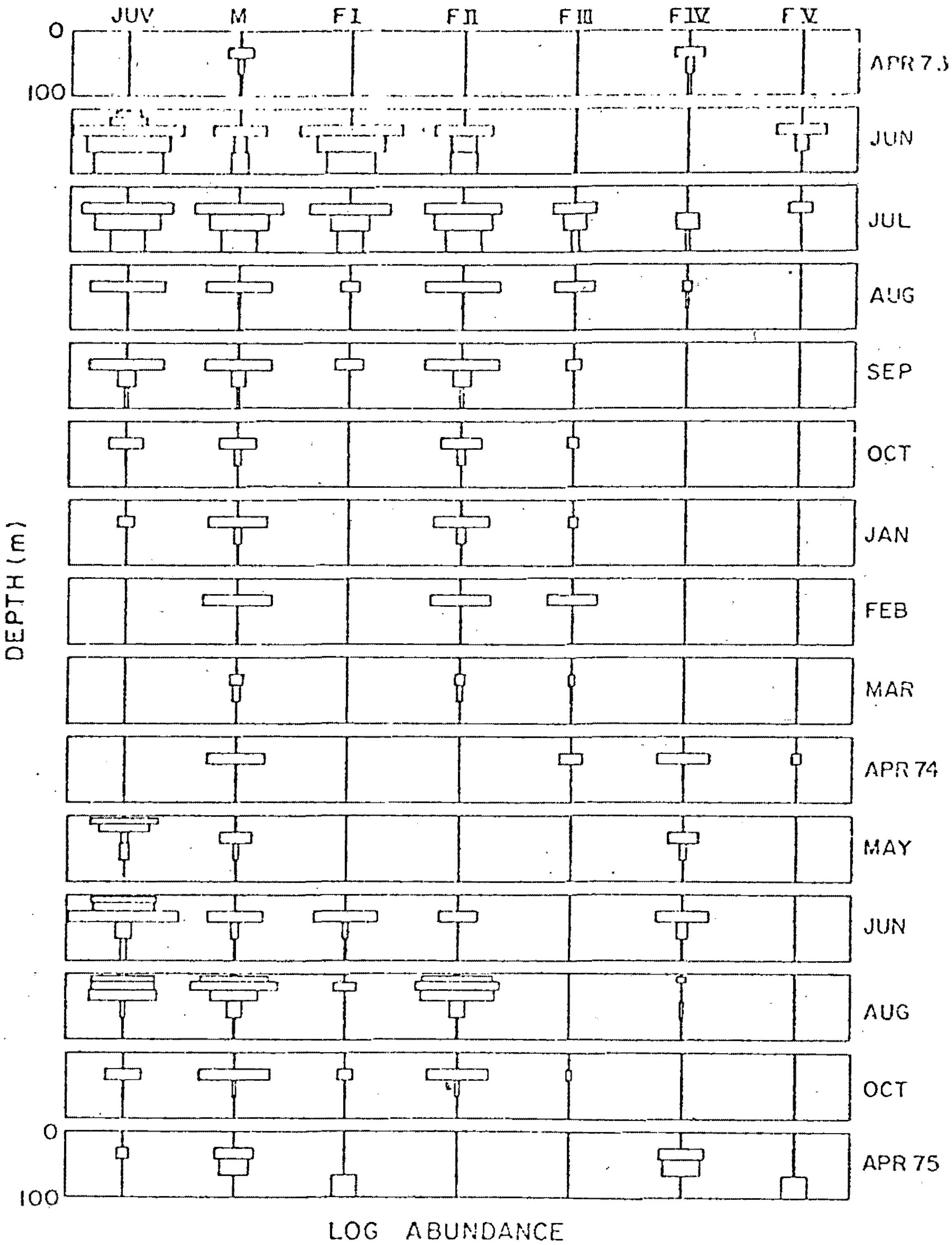
EGGS PER HAUL
200
160
120
80
40
0
0
1
2
3
PT. BOLIN
N
BATTLE PT.
BURKE BAY
FLETCHER BAY
0
1
NAUTICAL MILES
NAUTICAL MILES
STAGE OF EMBRYONIC DEVELOPMENT
LATE
MIDDLE
EARLY

EXAMPLE 7

EXAMPLE 8

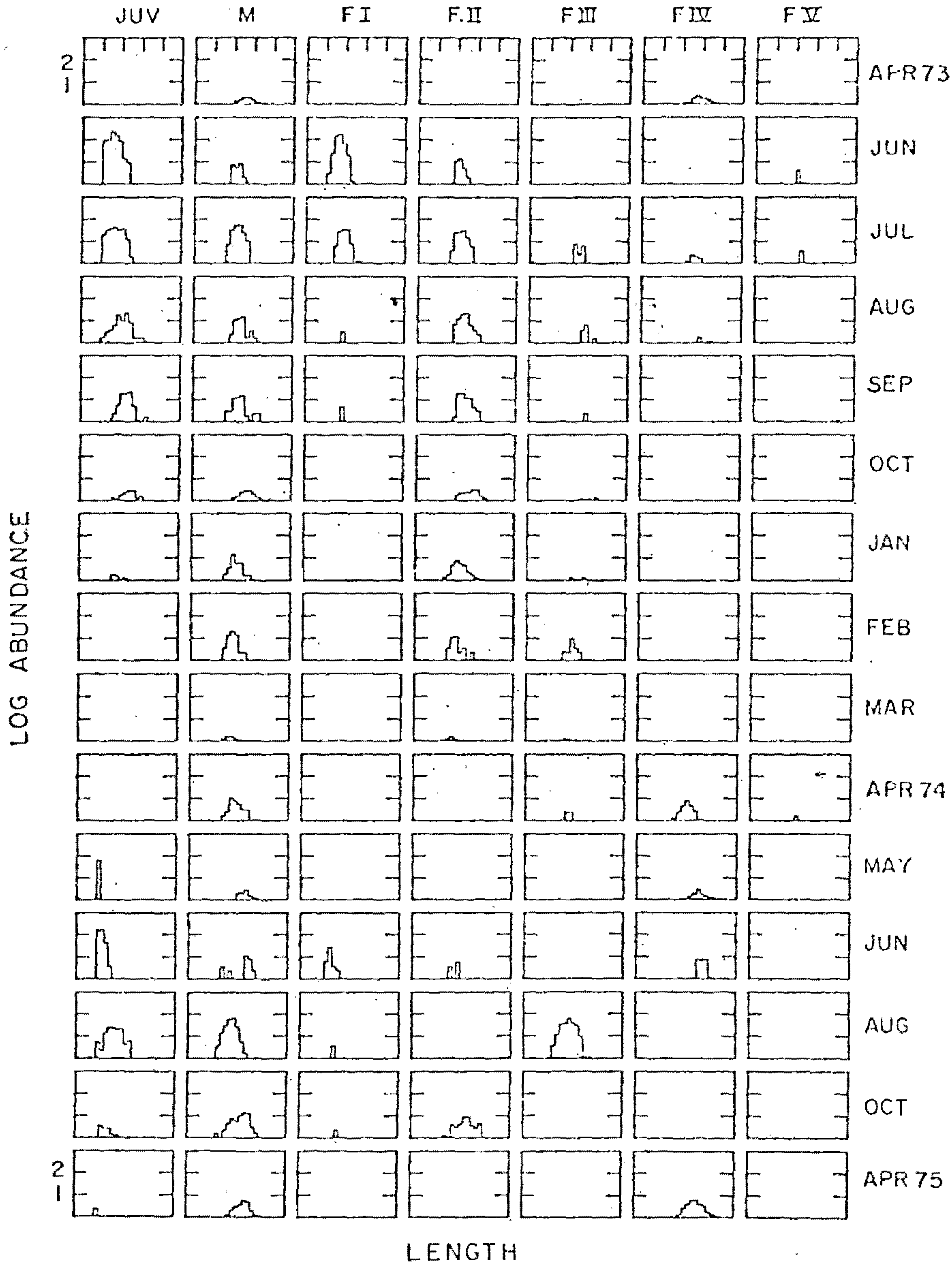

MUKILTEO
PORT GARDNER
TULALIP
DEPTH (m)
5
10
20
40
60
80
100
120
150
RELATIVE ABUNDANCE
12
9
6
3
25
50
75
100
LENGTH (mm)

EXAMPLE 9



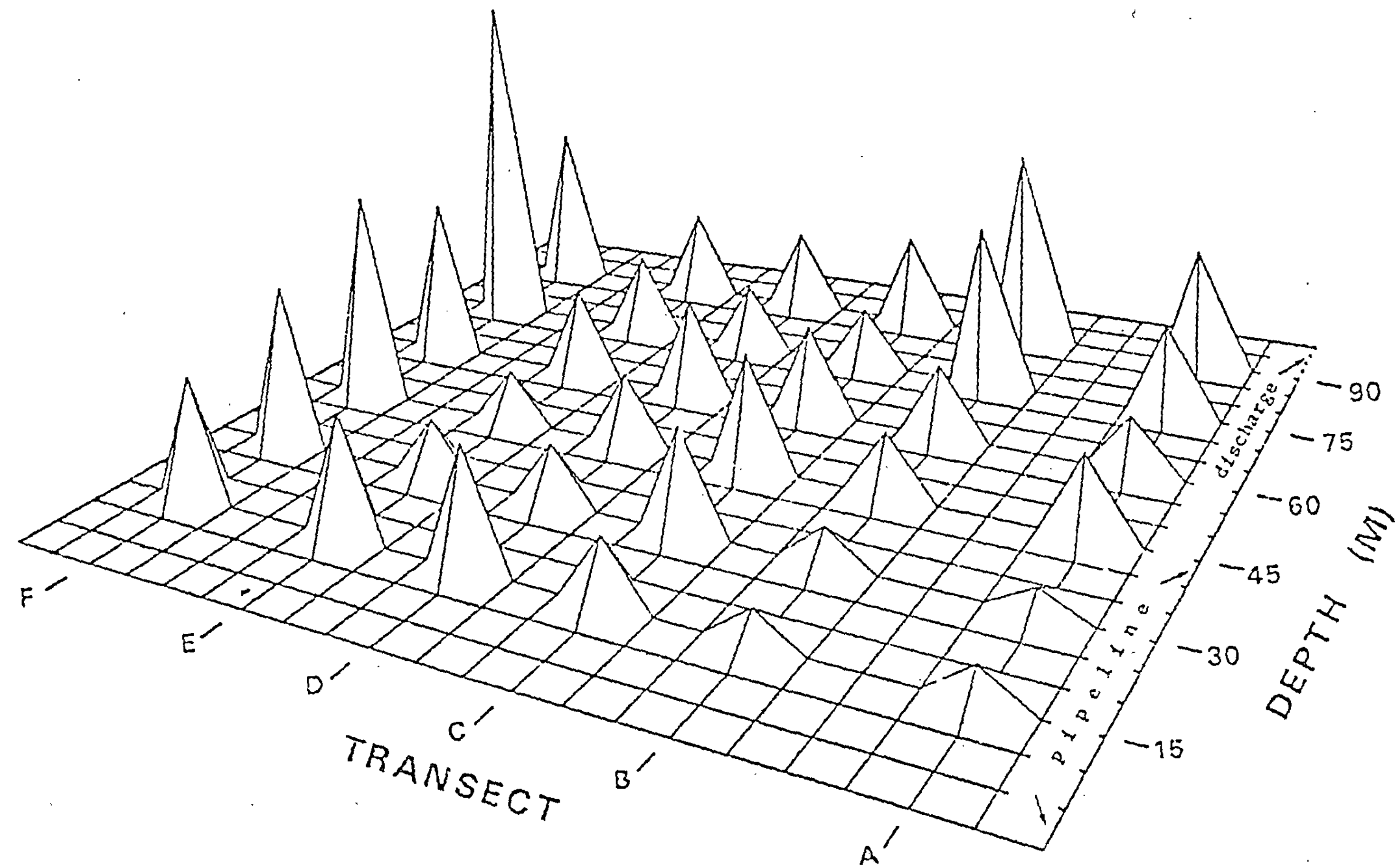
JUV
M
F I
F II
F III
F IV
F V
0
100
APR 73
JUN
JUL
AUG
SEP
OCT
JAN
FEB
MAR
APR 74
MAY
JUN
AUG
OCT
0
100
APR 75
DEPTH (m)
LOG ABUNDANCE

EXAMPLE 10

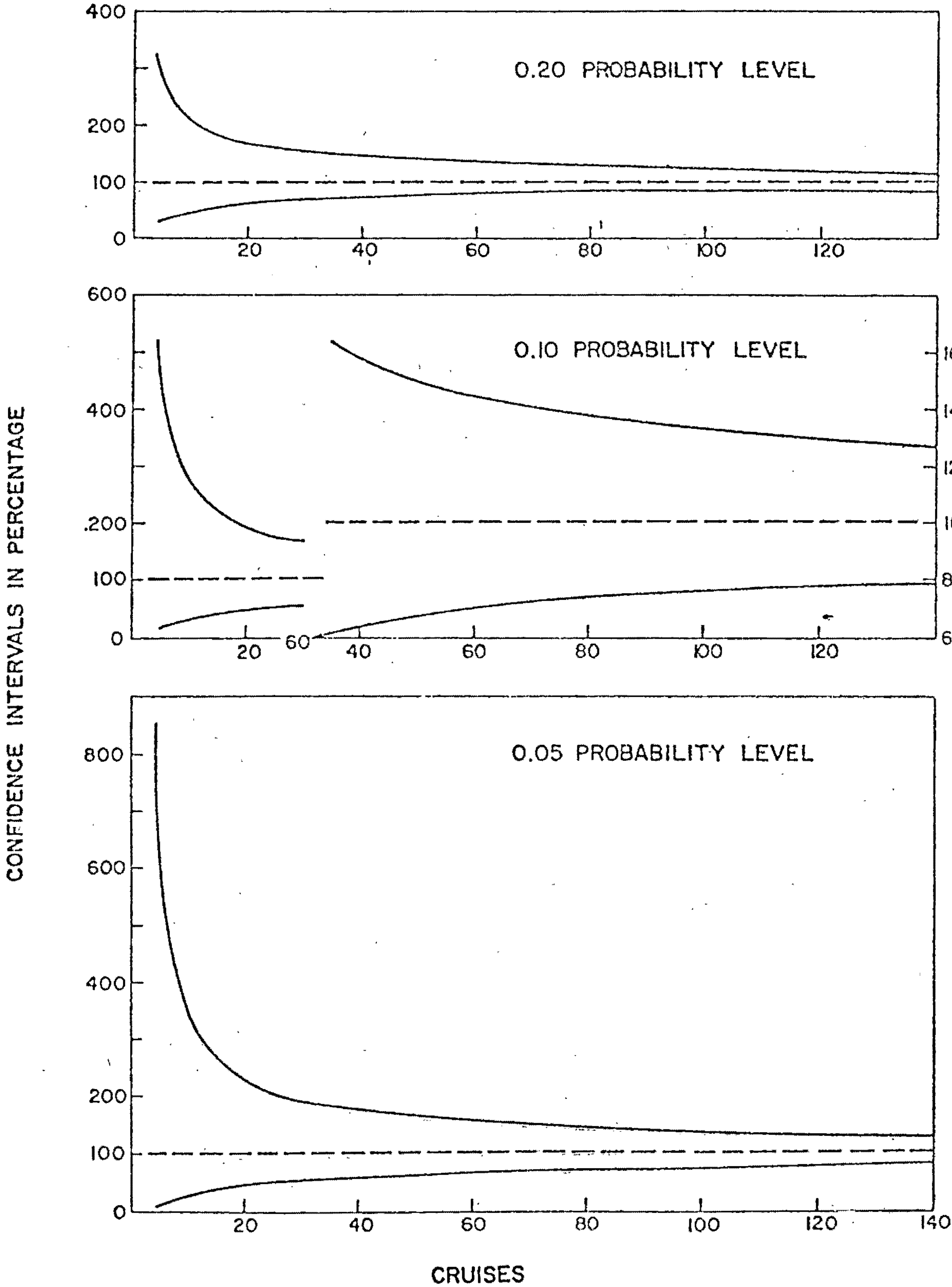


JUV
M
F I
F.II
F III
F IV
F V
2
1
APR 73
JUN
JUL
AUG
SEP
OCT
JAN
FEB
MAR
APR 74
MAY
JUN
AUG
OCT
APR 75
LOG ABUNDANCE
LENGTH

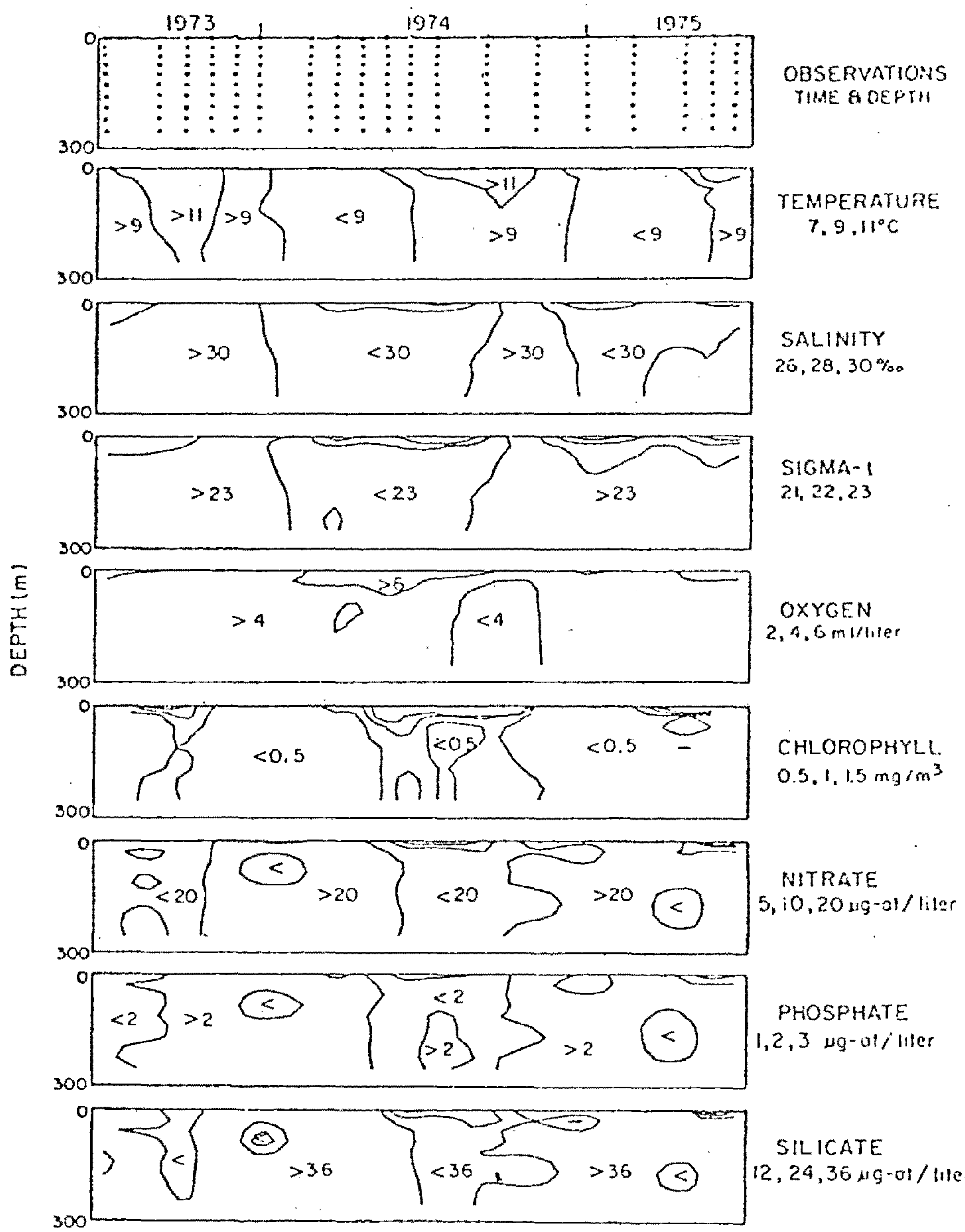
EXAMPLE 11



EXAMPLE 12


0.20 PROBABILITY LEVEL
0.10 PROBABILITY LEVEL
0.05 PROBABILITY LEVEL
CONFIDENCE INTERVALS IN PERCENTAGE
400
200
100
0
600
800
160
140
120
80
60
20
40
80
100
120
140
CRUISES

EXAMPLE 13



1973
1974
1975
0
300
OBSERVATIONS
TIME & DEPTH
TEMPERATURE
7, 9, 11°C
>9
>11
<9
SALINITY
26, 28, 30 ‰
>30
<30
SIGMA-t
21, 22, 23
>23
<23
OXYGEN
2, 4, 6 ml/liter
>6
>4
<4
CHLOROPHYLL
0.5, 1, 1.5 mg/m3
<0.5
NITRATE
5, 10, 20 µg-at/liter
<20
>20
<
PHOSPHATE
1, 2, 3 µg-at/liter
<2
>2
<
SILICATE
12, 24, 36 µg-at/liter
>36
<36
<
DEPTH (m)

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

Department of Oceanography
Cable Address: UNIWADO

22 September 1977

Dr. Herbert Bruce
OCSEAP
Juneau Project Office
P.O. Box 1808
Juneau, Alaska 99802

Dear Dr. Bruce:

In response to your letter of 15 September 1977, we understand the revisions you have requested concerning our FY 78 renewal proposal and we agree to these changes.

Sincerely,

David Rostenaender for

T. Saunders English
Associate Professor

TSE:cw

cc: Dr. Rudolph J. Engelmann,
Boulder Office

Environmental
Program
Alaska Project Office
[illegible]

RFx41-424-754

15 SEP 1977

Dr. T. Saunder English
Dept. of Oceanography
University of Washington
Seattle, WA 98195

Ref: R. U. 424 and
1) P. I. -OCSEAP Meeting 16 June 1977.
2) FY 78 Revised Proposal for R.U. 424, 20 June 1977
3) OCSEAP FY 78 Guidance Letter dated 12 July 1977
4) FY 78 Revised Proposal for R.U. 424 received 22 August 1977

Dear Dr. English:

Your FY 78 renewal proposal entitled "Lower Cook Inlet Meroplankton has been reviewed by the Juneau Project Office. The following additional revisions are required before your work statement can be sent to our Contracting Office for funding.

1. The zooplankton remaining after sorting for ichthyoplankton, crab and shrimp larvae constitutes archivable material and, as such, shall be saved pending advisement of deposition by OCSEAP.

2. No winter sampling will take place in FY 78. All sampling schemes will be designed during coordination meetings.

3. All data submissions shall precede or be simultaneous with the final report.

4. A new milestone chart will be constructed reflecting the preceding items and showing data processing separately for each collection period. This milestone chart will be submitted with the first quarterly report for FY 78.

5. A detailed description for quality control of data processing will also be submitted with the first quarterly report.

6. You must define the ranges of values actually expected for your digital data paramaters. Please note: Length of haul is measured in terms of distance (m) not time (hrs.), Gear codes have a present range of 1-10, size/number of subsample should be .1-1000. 'Concentration of subsample' should read 'Number in Subsample'. A new listing of parameters and ranges of values should be submitted with the first quarterly report.

The final funding commitment and level are contingent on approval of the FY 78 OCSEAP budget by the Bureau of Land Management.

If you have questions concerning any of the above guidance, please phone the Juneau Project Office, (907) 586-7436.

Your letter agreeing to thses changes, or a revised work statement, must be sent to and received in the Juneau Project Office, with a copy to Boulder no later than September 28, 1977. If there are extenuating circumstances which prevent you from meeting this schedule, please phone the Project Office. The short deadline is required to ensure continuous funding of your project in FY 78.

Upon receipt of your work statement or letter, revised in accordance with the above guidelines, we will initiate contracting procedures for FY 78. I look forward to your continued involvement in our program.

Sincerely,

Herbert E. Bruce, Ph. D.
Bering Sea-Gulf of Alaska Project Manager

cc: Program Office

Title: Composition and Source Identification of Organic Detritus in Lower Cook Inlet

Research Unit: #425

Principal Investigator: Jerry D. Larrance

Cost: $102,827

Work Period: October 1, 1977 through September 30, 1978

Institution: Pacific Marine Environmental Laboratory
3711-15th Avenue N.E.
Seattle, Washington 98105

Date of Proposal: August 15, 1977

Endorsements:

Principal Investigator	Jerry D. Larrance Jerry D. Larrance
Director, PMEL	for Marcia [illegible] John R. Apel
Financial Officer, PMEL	Louise Johnson for Ralph F. Cunningham Ralph Cunningham

C. TECHNICAL PROPOSAL

I. Title: Composition and Source Identification of Organic Detritus in Lower Cook Inlet

Research Unit: #425

Proposed Dates of Contract: October 1, 1977 through September 30, 1978

II. Principal Investigator: Jerry D. Larrance

III. Cost of Proposal

Total	$102,827
Lower Cook Inlet	$102,827

IV. BACKGROUND

Offshore petroleum development in lower Cook Inlet will provide a potential source of contamination of the environment by accidental large spills and chronic low-level oil pollution. Such pollution would undoubtedly have a harmful effect on important commercial fisheries in lower Cook Inlet.

Benthic species harvested include snow, king, and Dungeness crab, shrimp, razor clams, and scallops. These are commercially harvested primarily within the rectangle bordered by Anchor Point, Kachemak Bay, the Barren Islands, and Kamishak Bay (Bureau of Land Management, Final Environmental Statement, 1976). Some primary king crab recruitment grounds are within this area in the Bluff Point-Kachemak Bay region. The adverse effects to these species from oil pollution are discussed in BLM (1976).

The larval stages of these and other benthic species are planktonic and rely on phytoplankton as food. Adults in the benthic community ultimately depend on organic production from phytoplankton and other plants. Phytoplankton grazed by zooplankton enters the detrital food web via fecal pellet deposition. Other cells enter the benthos by sinking directly. As small sinking particles, the cells and pellets may act to transport oil from the surface to the bottom. Studies have indicated rapid removal and dispersal of surface oil by suspended particles. When oil enters seawater, emulsions of very tiny droplets can form. Some of the droplets become bound to particles by absorbtion and adsorbtion; they subsequently sink directly or are sedimented in fecal pellets after being ingested by zooplankton. Thus, ingestion and sorbtion act as precipitation mechanisms to transfer otherwise buoyant oil particles to the detrital food web (NOAA Special Report, 1977; Forrester 1971 in NOAA; Conover, 1971).

Since lower Cook Inlet has a seasonally sustained high yield of phytoplankton, it can be assumed that their input of organic matter (fecal pellets and cells) to the benthos is considerable. The respective fraction of each is not known, but combined they can probably provide the means for transporting considerable amounts of oil to the bottom where it can undoubtedly impact the benthos.

In addition to the role of phytoplankton in transporting oil to the benthos, primary production can be affected by oil contamination and thus impact higher trophic levels. The impact on phytoplankton depends on oil and other contaminant concentrations, proximity of the cells to the contaminant, localized geography, species composition, and other variables. The species composition of a natural population can be significantly altered by oil contamination (Dunstan et al., 1975 and Lee et al., 1977). Other effects can include death, increased and decreased photosynthetic rates, decreased cell division rates, cell membrane damage, and other physiological abnormalities (Shiels et al., 1973; Gordon and Prouse, 1973; BLM, 1976; Hufford, 1971 in BLM, 1976). Surface oil can lower light levels to decrease photosynthesis and can interrupt gas exchange across the surface. Hufford (1971) in BLM (1976) states that photosynthesis can be decreased by 50 to 90 percent from lowered light levels and lowered cell division rates from phytoplankton under an oil spill. Drilling muds may contaminate phytoplankton and other biota due to the presence of toxic chromium and pipeline burial may resuspend contaminated sediments (BLM, 1976).

Phytoplankton standing stock and primary productivity are high in lower Cook Inlet. During our 1976 investigations, cell concentrations were greater than 10^6 cells/ℓ and primary production was as much as 7.7 gC/m^2/day in May in Kachemak Bay. Mean primary productivity in lower Cook Inlet reached a peak of about 4.9 gC/m^2/day in late May and decreased to about 0.7 gC/m^2/day by late August (Larrance et al., 1977). BLM (1976) reports that photosynthetic rates in lower Cook Inlet range between 0.25 and 0.50 gC/m^2/day. The latter figures are averages for an extensive region including the Aleutian Islands and may be annual estimates. They appear to be somewhat low for lower Cook Inlet in any case.

The extremely high productivity in Kachemak Bay can be explained in part by the water circulation, or lack of it, and by a strong pycnocline development in that region. A gyre tends to keep local water entrained in outer Kachemak Bay and a constriction (Homer Spit) prevents rapid turnover of inner Kachemak Bay waters (Larrance et al., 1977; Evans et al., 1972; Knull and Williamson, 1969). The local permanence and stability of the water column (i.e., water is not advected either laterally or vertically) enhances conditions for a bloom. Elsewhere in lower Cook Inlet, strong tidal currents prevent pronounced local entrainment and stabilization of the water.

Phytoplankton populations in such embayments and locally entrained waters are particularly vulnerable to toxic contamination since clean water dilution by mixing will not occur. The Kachemak Bay area is of particular importance, also, because king crab zoea in that recruitment area undoubtedly rely on the local phytoplankton community.

There is an east to west transition across lower Cook Inlet with respect to magnitude and timing of maximum phytoplankton standing stock and productivity. Organic production by phytoplankton in 1976 was 0.1 to 0.5 as great in Kamishak as in Kachemak Bay, and maximum productivity and standing stocks occurred about two months later in Kamishak Bay. Midchannel values were as high as in Kachemak Bay, but occurred about one month later when the water column became slightly stable. Thus, the organic input to the detrital food web from phytoplankton has distinctly variable components with respect to season, magnitude, and locale in lower Cook Inlet.

Phytoplankton is abundant in lower Cook Inlet and its importance to the larval stages of commercial and other species is evident both in the transport of oil to the benthos and as sustenance for the benthos. It is of utmost importance to determine: the rate that primary produced organic matter is contributed to the food web sustaining the benthic community; the respective contributions from the phytoplankton and macrophyte communities; the possible role to be played by phytoplankton in the removal of surface spilled oil and its subsequent sedimentation. It, therefore, becomes necessary to determine the vertical flux of organic detritus and to define its origin, composition, and seasonal variation. Accordingly, we propose to conduct an investigation which will elucidate the role of organic detritus in the lower Cook Inlet ecosystem. The specific objectives of the study and the general strategy to be used in meeting these objectives are discussed in detail below.

V-VI. OBJECTIVES, STRATEGY, AND APPROACH

We will conduct a study of the vertical fluxes, distribution, and composition of the suspended organic particles contributed to the benthic food web of lower Cook Inlet. Specifically, our objectives are to:

1. Define the seasonal composition and origin of the organic detrital material.

2. Determine the short- and long-term vertical fluxes of organic particles to the bottom of special importance to the benthic community.

3. Determine phytoplankton composition, standing stock, and productivity during the biologically active period of the year.

4. Develop or adapt an experimental method for measuring the primary production of macrophytes.

A field program consisting of sediment trap deployment, intensive water column sampling, and primary productivity measurements has been developed to address the stated objectives. Four cruises are tentatively planned through the spring and summer of 1978 to correspond to the period of highest biological production. The selection of sampling sites was influenced by studies conducted in 1976 (Larrance et al., 1977). The timing and degree of biological activity differed from east to west across lower Cook Inlet as a partial function of variable water column stability and light attenuation by suspended particulates. Therefore, a 3-station transect running east-west has been chosen to study the variable input of pelagic material to the benthic communities of Cook Inlet. Stations will be occupied in Kachemak Bay, mid-channel, and Kamishak Bay.

Sediment traps, moored near the bottom at all sampling sites, will be recovered after several days to provide minimum estimates of the input rate and composition of suspended particles reaching the sea floor. Aliquots will be withdrawn from the sediment traps for the following analyses:

a. total particulate matter and total particulate carbon;

b. microscopic enumeration of major sedimented components including phytoplankton cells, zooplankton fecal pellets, macrophyte debris, etc.;

c. plant pigments - chlorophyll a and pheopigments.

A chlorophyll budget will be derived to examine the contribution of the algal biomass to benthic communities. Pigment concentrations in sediment traps can provide useful measures of total plant matter lost from the water column while sediment traps were in place.

Phytoplankton material can reach the sea floor in two important ways:

a. cells may sink directly

b. cells may be ingested by zooplankton, metabolically processed, repackaged, and eliminated as fecal material.

Smayda (1970) reviewed the literature and reported highly variable sinking rates for phytoplankton cells (0-30 m dy^{-1}) depending on cell buoyancy, cell shape, ability to swim in response to stimuli, and nutrient concentration. Fecal pellets sink at significantly faster rates ($\simeq$100-200 m dy^{-1}) and are, therefore, less apt to be advected from their area of production.

Recent work (Shuman and Lorenzen, 1975) demonstrated that planktonic herbivores degrade chlorophyll to pheopigments with a 100% molar efficiency. Therefore, the total chlorophyll lost to the water column due to zooplankton grazing and fecal pellet production can be calculated from the pheopigment content of a sediment trap. The chlorophyll concentration measured in the sediment traps is a clue to the chlorophyll deposited by direct sinking of phytoplankton cells. This estimate is complicated by fecal pellets bearing nondegraded chlorophyll molecules. The bound chlorophyll can, however, be measured in the fecal material and accounted for. The direct chlorophyll measurement can then be added to the equivalent chlorophyll grazed (computed from pheopigments) to yield the total chlorophyll lost from the water column. In addition, the relative contribution of fecal pellet production (i.e., grazing) versus direct algal sinking can be quantified.

The average chlorophyll content of the ambient water column will be determined concurrently. The absolute loss of chlorophyll from the water column (computed from sediment trap data) may then be expressed as the average daily percentage of the total phytoplankton standing stock that settles to the bottom. Chlorophyll production in the euphotic zone represents a gain to total biomass. Chlorophyll synthesis may be calculated from carbon uptake experiments by applying a carbon/chlorophyll ratio interpreted from field data. It may be possible, then, to compare the amount of chlorophyll produced with that lost to the benthos to determine net loss or gain of chlorophyll to the system.

Coupled with the sediment trap technique, a field sampling program will be conducted to gather information from the ambient water columns. We propose to alternately occupy each sediment trap location at least once per day to sample for phytoplankton species, plant pigments, nutrients, solar insolation, primary productivity, total particulate matter, total particulate carbon, salinity, and temperature. These data will provide the necessary information for the chlorophyll budget and will enable us to determine phytoplankton composition, biomass, and productivity during the biologically active portion of the year.

The chlorophyll budget approach will be most useful in areas where residence time of the ambient water is long relative to the length of sediment trap emplacement. Work in 1976 (Larrance et al., 1977) suggested that Kachemak Bay may be a particularly fruitful area for such a technique because observed biological changes were mainly local rather than advective. Identical analyses will, of course, be conducted at midchannel and in Kamishak Bay. Comparisons of results from the three areas may provide insights about the validity of this approach in these distinct circulation regimes.

The experimental approach outlined above will identify the major components and sources of the organic detritus and quantify the short-term vertical inputs of organic material to the sea bottom. We are also concerned with total sedimentation over longer periods and plan to cooperate closely with Dr. Richard Feely of this research laboratory (OCSEAP Research Unit #152). He will deploy sediment traps for periods of 4-5 months each in lower Cook Inlet. We anticipate comparing these long-term results to data obtained from our short-term experiments to more completely document total detrital input. We will also employ results of the circulation studies obtained by Dr. Muench et al. of PMEL.

Extensive stands of macrophytes in lower Cook Inlet have been described by Lees and Rosenthal in the Bureau of Land Management, Final Environmental Statement (1976). To the best of our knowledge no estimates have been made of standing stock or primary productivity. From the descriptions of the extent of the stands the productivity and the organic input to the detrital food web must be of considerable magnitude. Standard methods can be employed to estimate macrophyte standing stock and primary productivity and are described by Westlake and Wetzel in Vollenweider (1971) and in UNESCO (1973). Existing techniques will be reviewed and evaluated as to their suitability in the lower Cook Inlet environment, and recommendations will be made for possible future studies.

VII-VIII. SAMPLING AND ANALYTICAL METHODS

Station sampling will begin following deployment of sediment trap moorings. Routine CTD-rosette casts will be made to obtain temperature and salinity profiles. Water samples will be collected from several depths with 5-liter PVC Niskin bottles. Aliquots withdrawn from these samplers will be used to measure various biological and chemical parameters. Subsamples for phytoplankton species determination will be preserved in acetate buffered formalin and returned to the laboratory for analysis by inverted microscope techniques (Lund, Kipling and LeCren, 1958). Plant pigments will be analyzed aboard ship using fluorometric methods (Lorenzen, 1966). Seawater samples for determination of dissolved inorganic nutrients will be frozen and returned to the University of Washington Department of Oceanography for analysis by Auto Analyzer methods (Strickland and Parsons, 1972). Half-day primary productivity experiments will be conducted using standard carbon-14 methodology (Strickland and Parsons, 1972). Total particulate matter will be measured by filtering subsamples through preweighed 47 mm 0.4 μm Nuclepore filters. The filters will be washed with de-ionized water, dried in a dessicator, and reweighed in the laboratory. Total particulate carbon will be determined by filtering through precombusted silver filters. Filters will be rinsed in de-ionized water, dessicated, frozen, and analyzed by the micro-Dumas combustion method, employing a Hewlett Packard C-H-N analyzer (Sharp, 1974). During each cruise, sunlight will be continuously monitored with a Lamda Instruments quantum sensor sensitive to light in the photosynthetically active region (approx. 400-680 nm).

Material recovered from sediment traps will be collected for analysis of plant pigment content, total particulates, total particulate carbon, and microscopic inspection using methods adapted from those described previously.

IX. ANTICIPATED PROBLEMS

No major obstacles are anticipated for the program as outlined above. However, the emplacement, recovery, and overall performance of sediment traps is more easily relied upon in areas of decreased current velocity. To the extent possible we will sample during neap tide periods to ameliorate any potential problems. We request the Project Office to schedule vessels for purposes of this study as close to neap tide periods as possible during April, May, June, and July of 1978. Preferred dates are stated in the "logistic" section of this proposal.

X. DELIVERABLE PRODUCTS

Results of field sampling will be presented in digital form on IBM punch cards and submitted to EDS in accordance with currently existing OCSEAP data formats (028, 029).

Quarterly and annual narrative reports will be submitted according to pre-arranged schedules. Reports will include tables and graphs depicting relationships and distributions of various parameters. Concise reporting necessitates that only findings most relevant to the stated objectives will be displayed graphically.

Data from field studies will be submitted according to the following schedule:

Sampling Period	Data Submission
4/78	10/78
5/78	10/78
6/78	11/78
7/78	12/78

XI. INFORMATION REQUIRED OF OTHER INVESTIGATORS

The organic detritus program will operate in close cooperation with Drs. Richard Feely and Joel Cline (OCSEAP Research Unit #152) to obtain long-term estimates of vertical fluxes in lower Cook Inlet. We also need detailed descriptions of circulation patterns and current velocities from physical oceanographic observations of the study area. In addition, the results of Dennis Lees' (OCSEAP Research Unit #417) macrophyte surveys are necessary to assess their potential importance to total detrital input.

XII. QUALITY ASSURANCE PLANS

Fluorometers will be calibrated in the laboratory using acetone extracts of plant pigments prepared from log-phase phytoplankton cultures and natural surface populations. Extracts will be standardized with a Beckman DU spectrophotometer.

Carbon-14 samples will be counted with a Packard liquid scintillation counter calibrated with radioactive standards supplied by Packard Instruments, Inc.

Nutrient analyses will be conducted at the University of Washington using proper blanks and standards to assure quality results.

We will be working closely with Research Unit #152 within our laboratory to analyze total particulate matter and total particulate carbon. Intercalibrations will be made for those analyses jointly performed.

XIII. ARCHIVAL PLANS

We presently do not have plans to archive any samples.

XIV. LOGISTICS REQUIREMENTS

A. SHIP SUPPORT

1. Exact station locations cannot be delineated at this time. One station each will be sampled in outer Kachemak Bay, midchannel lower Cook Inlet, and the Kamishak Bay region.

2. We will deploy sediment traps to the bottom at each station at the beginning of each cruise and recover them at the end of each cruise. Between times we will sample the water column at each station with the CTD-Rosette approximately once a day.

3. Cruises will be made once a month commencing in April and terminating after July. They will coincide with neap tides as closely as possible.

Cruise No.	Dates 1978
1	April 14-April 19
2	May 13-May 18
3	June 12-June 17
4	July 11-July 16

Deviation from this schedule may complicate the interpretation of results.

4. Six days of sea time will be required per cruise.

5. Our investigation will be principal to the operation. Our schedule includes 24-hr. a day sampling; on station time will be about 1 hr./station. Deployment and recovery of sediment traps may take longer, and should be done during daylight.

6. Equipment required: CTD-Rosette with ten 5 ℓ Niskin bottles. We will require ship personnel for deploying the CTD-Rosette, CTD calibration, and sediment trap deployment and retrieving. A deep chest freezer will be required for storing nutrient samples.

7. We will bring 2000 lbs. and 200 cubic feet of gear plus 3 moorings for sediment traps.

8. Ordinary precautions.

9. No.

10. We require the DISCOVERER for two reasons: (1) adequate laboratory space and (2) stability while deploying sediment traps. We anticipate using railroad wheels for anchors.

11. N/A.

12. We anticipate 6 people per trip. Jerry Larrance, Alex Chester, and David Tennant will participate in field work.

13. We will require overnight quarters for one or two nights once a month for 6 people/visit.

    (a) Presumbably Kodiak Coast Guard Station BOQ
    (b) once/mo., April-July 1978
    (c) 6 people/day.

14. Above quarters and subsistence will be paid by principal investigator with funds requested by this proposal.

15. Estimated costs per man per day:

Quarters	$ 8.00
Meals	22.00
Total	$30.00

16. We anticipate the need of warehouse space at Gibson Cove in Kodiak for storage and staging between, prior to and after cruises. We will need about 300 cubic feet of space.

    We suggest that the OD as well as the liaison officer retain a key to the warehouse. Accessibility to our gear has been a problem in the past.

XV. MANAGEMENT PLAN

The organic detritus program for lower Cook Inlet will be directly supervised by Jerry D. Larrance. He is responsible for development of the field program, proper analysis of samples, submission and content of all scientific reports, and coordination between other research groups.

XVI. OUTLOOK

The first year's activities will stress identification of major components and sources or organic detritus in critical areas of lower Cook Inlet. Quantifying the input processes and relating these processes to production and biomass conditions is also a goal.

It is anticipated that additional field studies will be needed to further examine the nature of organic sedimentation and its role as a transport vehicle for sorbed hydrocarbons. Specifically, total organic particulate concentrations change from spring bloom to summer conditions. As this occurs, the relative contribution of fecal pellet versus direct algal sinking may also change. The rate of pollutant input as well as the final concentrations in bottom sediments will be affected by the resulting interplay since the fecal input operates more quickly and is less diluted by advective processes. Our preliminary work will also surely suggest other areas needing consideration. For example, our results may necessitate more intensive studies of macrophyte productivity and biomass in the region.

Another approach which should be explored which may help to identify sources of particulate matter, is to analyze isotopic ratios of carbon and nitrogen. Relative concentrations of ^{12}C and ^{13}C and of ^{14}N and ^{15}N have been found to differ significantly in particulate matter of terrestrial and marine origin. It is likely that such ratios in lower Cook Inlet will differ seasonally and regionally within the Inlet according to circulation and biological production. In addition to identifying the sources of suspended particles (terrestrial or marine), the isotopic ratios in zooplankton and filter- or deposit-feeding benthos may provide clues about the origin of their respective food supplies.

Whether or not additional projects are supported, we can estimate that, because of tentative field program schedules, an additional $50 K funding in FY 79 will be required to complete analysis and reporting of data collected in FY 78.

XVII. CONTRACT TERMS

1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least 60 days prior to release for information and for forwarding to BLM. The release of such material within a period of less than 60 days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship.

MILESTONE CHART

RU #: 425 PI: Jerry Larrance

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
April Cruise							—								
May Cruise								—							
June Cruise									—						
Submit Quarterly Report									—						
July Cruise										—					
Submit Quarterly Report												—			
Submit IBM cards on April, May cruises												—	—		
Submit IBM cards on June, July cruises														—	—
Submit Quarterly Report															—

Publications -

McAlister, W. B., W. J. Ingraham, Jr., D. Day, and J. Larrance. 1969. Oceanography. In Int. N. Pac. Fish. Comm. Annual Rep. 1967. 97-107.

McAlister, W. B., W. J. Ingraham, Jr., D. Day, and J. Larrance. 1970. Oceanography. In Int. N. Pac. Fish. Comm. Annual Rep. 1968.

Larrance, Jerry D. 1971. Primary productivity and related oceanographic data, Subarctic Pacific Region, 1966-68. NOAA/NMFS Data Rep. 50, 113 p.

Larrance, Jerry D. 1971. Primary productivity, Subarctic Pacific Region, 1966-68. Fishery Bulletin 69(3): 595-613.

Tennent, David A. and William O. Forster, 1970. Seasonal variation and distribution of ^{65}Zn, ^{54}Mn and ^{51}Cr in tissues of the crab, *Cancer magister* Dana. *Health Physics*, 18(6): 649-657.

Other Reports-

Allen, George H., Jerry Larrance, and Carl W. Sims. 1958. An oceanographic study between the points of Trinidad Head and the Eel River. For the State of California Water Pollution Control Board. 31 p.

Allen, George H., Jerry D. Larrance, Carl W. Sims, Robert Gordon, and Gerald A. Sanger. 1959. An oceanographic study between the points of Trinidad Head and the Eel River. Annual Report, 1959. For the State of California Water Pollution Control Board. 131 p.

Kovala, Paavo E. and Jerry D. Larrance. 1966. Computation of phytoplankton cell numbers, cell volume, cell surface, and plasma volume per liter from microscopical counts. Univ. of Washington Spec. Rep. No. 38. 21 p.

McAlister, W. B., C. Mahnken, R. C. Clark, Jr., W. J. Ingraham, J. Larrance, and D. Day. 1968. Oceanography and Marine Ecology in the Vicinity of Amchitka Island. Final Report to AEC - Understanding No. AT(26 1)-353. 146 p.

REFERENCES

Bureau of Land Management (1976): Final environmental impact statement. Alaska Outer Continental Shelf Office, O.C.S. Oil and Gas Lease Sale No. CI, Vol. 1 of 3.

Conover, R. S. (1971): Some relations between zooplankton and Bunker C oil in Chadabueta Bay following the wreck of the tanker ARROW. J. Fish Res. Bl. Can., 28: 1327-1330.

Dunstan, W., L. P. Atkinson, and J. Natoli (1975): Stimulation and inhibition of phytoplankton growth by low molecular weight hydrocarbons. Mar. Biol., 31: 305-310.

Gordon, D. C., Jr., and N. J. Prouse (1973): The effects of three oils on marine phytoplankton photosynthesis. Mar. Biol., 22: 329-333.

Knull, J. R., and R. Williamson (1969): Oceanographic survey of Kachemak Bay, Alaska, April 1969. U.S. Dept. Int., Bureau Commercial Fisheries Manuscript Report, File MR-F No. 60, 54 p.

Larrance, J. D., David A. Tennant, Alexander J. Chester, and Patricia A. Ruffio (1977): Phytoplankton and primary productivity in the northeast Gulf of Alaska and lower Cook Inlet. Final Report. Pacific Marine Environmental Laboratory, Seattle, Wash.

Lee, R. F., M. Takahashi, J. R. Beers, W. H. Thomas, D.L.R. Seibert, P. Koeller, and D. R. Green (1977): Controlled ecosystems: their use in the study of the effects of petroleum hydrocarbons on plankton. In: Physiological responses of marine biota to pollutants, F. J. Vernberg et al. (eds.). Academic Press. New York.

Lorenzen, C. J. (1966): A method for the continuous measurement of in vivo chlorophyll concentration. Deep Sea Res., 13: 223-227.

Lund, J.W.G., C. Kipling, and E. D. LeCren (1958): The inverted microscope method of estimating algol numbers and the statistical basis of estimations by counting. Hydrobiologia, 16: 143-170.

NOAA. The ARGO MERCHANT Oil Spill--A Preliminary Scientific Report. Natl. Oceanographic Atmos. Admin., Boulder, Colo., 1977.

Sharp, J. H. (1974): Improved analysis for "particulate" organic carbon and nitrogen from seawater. Limnol. and Oceanogr., 19(6): 984-989.

Shiels, W. E., J. J. Goering, and D. W. Hood (1973): Crude oil phytotoxicity studies. In: Environmental studies of Port Valdez. D. W. Hood et al. (eds.). Inst. of Mar. Sci., Univ. Fairbanks, AK.

Strickland, J.D.H., and T. R. Parsons (1972): A practical handbook of seawater analysis. Fish. Res. Bd. Can., Bull. 167. 310 p.

UNESCO (1973): A guide to the measurement of marine primary production under some special conditions. Monographs on oceanographic methodology. Paris. 73 p.

Vollenweider, R. A, Editor (1971): A manual on methods for measuring primary production in aquatic environments. IBP Handbook, No. 12. Blackwell, Oxford, second printing, 213 p.

OCS 78-9

RESEARCH PROPOSAL

to

National Oceanic and Atmospheric Administration
Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado 80302

ICE-EDGE ECOSYSTEM STUDY: PRIMARY PRODUCTIVITY, NUTRIENT CYCLING AND ORGANIC MATTER TRANSFER (Revised)

R.U. #427

TOTAL COST: $175,537

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Vera Alexander
Co-Principal Investigator
Institute of Marine Science
University of Alaska
(907) 479-7210

R. Ted Cooney
Co-Principal Investigator
Institute of Marine Science
University of Alaska
(907) 479-7895

J. Robert Moore, Director
Institute of Marine Science
University of Alaska
(907) 479-7531

A. B. Frol, Director
Administrative Services
University of Alaska
(907) 479-7340

K. B. Mather, Vice Chancellor
Research and ADvanced Study
University of Alaska
(907) 479-7282

October 17, 1977

TECHNICAL PROPOSAL

I. Title:

Ice-Edge Ecosystem Study: Primary Productivity, Nutrient Cycling, and Organic Matter Transfer
Research Unit #R.U. 427
Contract #03-5-022-56

II. Co-Principal Investigators:

Dr. Vera Alexander; IMS
Dr. R. Ted Cooney; IMS

III. Cost of Proposal (by federal fiscal year)
FY 78

Total 175,537
Distribution of effort by lease area:
100% Saint George's Basin

IV. Background:

The phytoplankton and zooplankton ice-edge studies have now completed three field seasons in the southeastern Bering Sea, with emphasis on describing biological phenomena associated with the dissipating and receeding ice-edge zone. Detailed surveys of the distributions of plants, animals, and major nutrients have been made along with standard hydrographic measurements to determine the relationship between the physical structure of the water column, the nature of the ice, and observed biological activity. This work has special significance since the edge zone of the seasonal pack annually attracts large numbers of sea birds and mammals. This unique oceanographic region is intensely productive at lower trophic levels during the spring which in turn influences the continuing survival of higher order consumers occurring on or in the ice, and in the water column or on the seabed below the ice. The degree to which the system might be perturbed by offshore hydrocarbon development is being evaluated by describing the major biological components, their interactions, their dependencies on the chemical-physical environment, and aspects of their life histories which determine their participation and/or duration in the phytoplankton and zooplankton communities. This work is being guided by a computer simulation model which is presently being developed and tested. We know that the process of organic matter (carbon) transfer is an exceedingly complex one, and dependent not only upon the kinds and amounts of plant cells present at any time, but also on the kinds and numbers of "pelagic grazers" available to utilize these cells. This trophic interaction is further modified annually by differing weather patterns and periodic shifts in hydrography which alter the timing and sequencing of important seasonal events. Our experimental modelling efforts are directed at sorting out the dominant lower trophic level signals from the background noise of natural annual variability.

We now have on hand data which support an hypothesis concerning the factors controlling phytoplankton production during the spring and early summer. The effectiveness of organic matter transfer, or how closely coupled the system is, depends on grazing pressure and nutrient availability modified by the light regime. Loss of phytoplankton cells to the benthos as detritus (uncoupled system) appears to be very significant at some times during the growth season.

We believe that an understanding of the nature (both temporal and spatial) of critical consumer dependencies and factors controlling organic matter synthesis will provide a means for predicting the most likely effects of man-induced environmental perturbations.

V. Objectives:

1. Assess the significance of the ice-edge region in the productivity of the lease areas by studying the dynamics and mechanisms regulating the phytoplankton populations.

2. Determine temporal and spatial density distributions and environmental requirements of the principal species of zooplankton, micronekton and ichthyoplankton associated with the ice-edge region. (Much of this work has been completed in the field, and most of the effort will relate to data analysis.)

3. Identify sensitive ecological parameters and information gaps by using a simulation model that represents the lower trophic components and dynamics of the ice-edge region (continuing emphasis).

We see our information as contributing some part to the overall understanding of the dynamics of the ice-edge ecosystem. Coupled with descriptions detailing trophic dependencies at higher levels (fishes, birds, and mammals) the significance of the edge-zone as "critical habitat" can be ascertained and appropriate decisions made concerning leasing schedules and development stratagems.

The work proposed here will be carried out on data principally available from St. George's Basin (continuing analysis effort).

VI. General Strategy and Approach:

The field work planned for this coming spring and early summer was to have stressed the measurement of organic matter transfer between phytoplankton producers and zooplankton grazers. This work was needed to complete the planned field work for the modelling and final synthesis effort. Because this important aspect of the study must now be eliminated, we have revised the overall aims of the project. Phytoplankton and zooplankton populations will be handled individually but since the details of transfer will not be available the work will emphasize completing all sample processing from the FY 77 work, carrying the synthesis and modelling to its maximum potential within the constraints of currently available information.

VIII. Analytical Methods:

Fundamental statistical analyses will be executed by means of numerous programs previously developed by, or supplied to, the University of Alaska Computer Network (UACN) for the Honeywell Series 60 (level 66)/ 6000 computer. Numerical data sets will be analyzed using a mixed hierarchical model of the analysis of variance (Kirk, 1968; Winer, 1971) to test hypotheses and to provide measures of precision. The Ullrich-Pitz Analysis of Variance Program (Ullrich and Pitz, 1976) has been sufficiently modified and updated (Geist, 1977) to run on the Honeywell 66/40 and will provide maximal power for the analysis of variance of the relatively large data sets which are currently anticipated. Chi-square values, determinants, F-max values, F ratios, means, mean squares, sums of squares, transformations, variances, variances-covariance matrices, and exact probability levels represent standard output parameters. Coefficients of correlation will be determined for many of the variables of the numerical data sets in order to more closely establish and estimate the degree of association or interdependence between selected parameters (Sokal and Rohlf, 1969). *Post hoc* statistical analyses will consist of chi-square values, confidence intervals for differences between means, confidence limits, Scheffe's test for multiple comparisons, *t*-tests for differences between means, and, importantly, trend analyses of the cubic, linear, and quadratic components using orthogonal polynomials where applicable. Statistical computer programs, the University of California Los Angeles Biomedical Computer Programs and the Statistical Package for the Social Sciences, exist to facilitate most *a priori* and *post hoc* analyses (Dixon, 1974; Nie *et al.*, 1975). The techniques of cluster analysis will be employed to examine the anticipated large sets of multivariate observations and parameters by partitioning into disjoint clusters of observations that are in some sense dissimilar from one another. Two Fortran IV cluster analysis programs have recently been modified and updated to run on the Honeywell 66/40 (Geist, 1977), MIKCA: Multivariate Iterative K-Means Cluster Analysis (McRae, 1970) and TAXMAP: The TAXMAP Classification Program (Carmichael, 1974). Factor analytical techniques may be employed in a similar fashion to that of cluster analysis (Dixon, 1974; Honeywell, 1974).

The dynamics describing the interactions between the various "important" plant food species and specific grazers will be modelled temporally for typical ice-edge regimes. This simulation will involve the major driving functions (light, stability, nutrients, plant cell composition and grazer constituency) which seemingly govern the rate at which organic matter is passed from the synthesizers to the first order consumers. We expect the rate to vary seasonally and with the composition of the plankton community (both plant and animal) present at any particular time. Since the ice-edge traverses a wide variety of environments from the shelf break in the southern Bering Sea to the shallow Chukchi Sea in the north, the degree to which the grazing is coupled to production may differ greatly. Also, because the open water over the shelf may bloom independently of the ice-edge regime it will be necessary to monitor this phenomena along standard transects coming and going from each experimental location so that the interaction of these events may be discerned.

References for Section VIII

Carmichael, J. W. The TAXMAP Classification Program. Edmonton, Canada: Department of Medical Bacteriology, University of Alberta, 1974.

Dixon, W. J. BMD Biomedical Computer Programs. Berkeley, California: University of California Press, 1974.

Geist, C. R. MIKCA: Multivariate iterative K-Means Cluster Analysis--A Revision. Fairbanks, Alaska: Institute of Marine Science, University of Alaska, 1977.

Geist, C. R. The TAXMAP Classification Program--A Revision. Fairbanks, Alaska: Institute of Marine Science, University of Alaska, 1977.

Honeywell Series 6000. Biomedical (BMD) Statistical Programs Reference Manual. 1974.

Kirk, R. E. Experimental Design: Procedures for the Behavioral Sciences. Belmont, California: Brooks/Cole, 1968.

McRae, D. J. MIKCA: A Fortran IV Iterative K-Means Cluster Analysis Program. Monterey, California: CTB McGraw Hill, 1974.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., and Bent, D. H. Statistical Package for the Social Sciences. New York, New York: McGraw-Hill, 1975.

Sokal, R. R. and Rohlf, F. J. Biometry. San Francisco, California: W. H. Freeman, 1969.

Ullrich, J. R., and Pitz, G. F. Fortran IV ANOVA For the DEC System 10. Missoula, Montana: Department of Psychology, University of Montana, 1976.

Winer, B. J. Statistical Principles in Experimental Design. New York, Now York: McGraw-Hill, 1971.

IX. Anticipated Problems:

None (as revised).

X. Deliverable Products (Requested Inventories)

A. The Plankton Simulation Model:

A phytoplankton submodel, currently under development with the assistance of Dr. K. Green will be fundamentally completed by December, 1977. This formulation will describe seasonally dependent rates of synthesis as a function of nutrient availability, light, and other environmental factors.

Since coupling with the grazing community was dependent upon field studies planned for FY 78, a strictly integrated plankton model will not be possible. However, we expect to use some acceptable generalities to compute first-order estimates of grazing pressure associated with our measures of animal plankton and micronekton standing stocks. These efforts will utilize literature values of "minimal ration" per unit of grazing biomass needed to meet basic metabolic requirements at the temperatures encounted by the microconsumer groups in the study area.

Dr. Geist will be responsible for further developing our computer simulation.

B. Sample Inventories:

1. Phytoplankton

There are still 258 phytoplankton samples from the 1977 cruises as follows:

Surveyor II	87
Surveyor III	97
Discoverer VI	74

These will be counted during the fall, 1977 and will be available for synthesis and modelling by mid-winter. All other samples from 1977 cruises have been analysed. The nutrients have been completed and are currently being calculated and tabulated as follows:

Surveyor II	132
Surveyor III	117
Discoverer VI	168
UH1H Helo	16

All other basic measurements are on hand but as yet not completely analysed or synthesized.

VII. Primary production simulation model -

Analysis of phytoplankton population structure relating seasonal and spatial distributions to environmental factors; preliminary evaluation of grazing pressure

VIII. The role of physical oceanographic parameters

IX. An evaluation of the vulnerability of planktonic populations of St. George's Basin with special reference to seasonal and spatial considerations

X. Conclusions

XI. Recommendations

XII. Citations

XIII. Acknowledgments

XIV. Appendices

A. Bibliography of North Pacific studies of lower trophic levels

B. Other tabulations as appropriate.

2. Zooplankton

All samples from previous cruises have been processed with the exception of the last Norton Sound/Chukchi survey (Surveyor) June 27-July 7, 1977. These include the following:

1-m net vertical	55
1/2-m net horizontal	8
Bongo-net double oblique	3

All other samples have been processed and will be used in the descriptions of the dynamics of the animal plankton and micronekton communities at the ice-edge. Those samples obtained in or near the ice in 1976 will also be used in the analysis even though a preliminary synthesis of this information is available as last year's annual report.

I estimate that $5,000, in addition to Sorting Center Service monies being requested in this proposal to cover sample recounts, will be necessary to process and report the 1977 Norton Sound/Chukchi data presently in inventory. This added expense will cover approximately 1,000 man-hours of part-time sample sorting, identification, recording and preparation for keypunching of this material. The work will be supervised by salaried personnel presently in budget (i.e., Ms. Wagner, Mr. Coyle).

C. <u>Tentative Final Report - Table of Contents</u>:

I. Introduction

Background

Objectives of study

II. Phytoplankton populations

Composition, distribution, seasonal cycles, relationship to ice-edge

III. Primary production

Rates, seasonal distribution, relationship to ice-edge, chlorophyll biomass

IV. Nutrient availability relationship to phytoplankton populations and primary production

V. Zooplankton populations

Composition, distribution, seasonal cycles, relationship to ice-edge

VI. Organic matter transfer

Data Products Schedule*

Data Type i.e. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of Processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/year to Month/ Year	Submission (Month/ Year
Zooplankton and micronekton species and abundance[1]	tape	82	024	Yes		See Section XVII, 1 and 6

1 Provided funds are made available to process these samples (See Section X b)

* All other data, collected in 1977 field season, including zooplankton, primary productivity, phytoplankton and CTD, will be submitted according to the D.M.P. and schedule recently negotiated by the University of Alaska and the Contract Data Manager.

XII. Quality Assurance Plans:

Data processing proceedures will be monitored with appropriate experiments to describe the nature and magnitude of error introduced by the methodology employed. Precision and accuracy of measures will be evaluated by replicated observations of a frequency to be determined by the investigators.

XIII. Special Sample and Voucher Specimen Archival Plans:

This office has agreed and continues to agree to negotiate a reasonable plan for collecting and maintaining Voucher Specimens for all appropriate tasks under our jurisdiction. As of this time, no such plan exists to our knowledge. We agree to review any plan proposed by NOAA/OCS, making comments and to reach an agreeable solution.

XIV. Logistic Requirements:

None (as revised)

XIV. Information Required from Other Investigators:

Additional information will be solicited from OCS investigators studying physical, chemical, and other biological sectors of the Bering Sea environment as needed in the preparation of the final report.

XV. Management Plan:

Technical management for the task orders supported by this office is provided by the principal investigators of those task orders. This task order provides logistics, data, and contractual and fiscal management as outlined below. The University of Alaska agrees that the principal investigator can travel to the Juneau Project Office at least twice during the contract year, provided that such travel is in accordance with University of Alaska travel policy and consistent with other university duties of the principal investigator. Funds for travel are labeled "Administrative Travel" in the R.U. 350 proposal.

XVI. Future outlook:

We are disappointed that funding difficulties have curtailed our field operations at a juncture in the study that was to have tied the synthesizer and consumer groups together. It is our opinion that such work should be implemented as soon as possible in the Bering Sea when funding is resumed.

XVII. Contractual Statements:

1. A schedule for data submission for each task order has been, and will continue to be, submitted and updated each quarter.

2. This statement is in accordance with out base contract, and we will continue to comply.

3. See Section XIII of this proposal. The University of Alaska will continue to negotiate a Voucher Specimen Policy with NOAA/OCS. We will comply with the then agreed to policy.

4. See Section XV of this proposal. The University of Alaska agrees that the principal investigators can travel to the Project Office at least twice during the contract year, provided that such travel is in accordance with University of Alaska travel policy and consistent with other university duties of the principal investigator.

5. Data will be provided in the form and format agreed to by the university and NOAA/OCS in the negotiating of the Data Management Plans for each of the tasks falling under the jurisdiction of this office.

6. As per Article 9 of the base contract, the University of Alaska agrees to the following: "...all archivable data is to be submitted by the contractor to the Contract Data Manager within 120 days after acquisition. Certain data sets such as plankton counts or volumes are not available until sorting of samples is complete. The data so obtained are archivable 120 days following the actual sorting or other laboratory procedure."

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager by the Chief Scientist.

8. This is in accordance with the base contract with which we shall comply.

9. Three copies of all publications or presentation abstracts or manuscripts pertaining to technical or scientific material developed under OCSEAP funding will be submitted to the COTR 60 days prior to publication or presentation. Copies of all news releases mentioning OCS or using information gathered by OCS funding will be sent to the COTR.

10. The following acknowledgement of sponsorship will be used:

> "This study was supported under contract 03-5-022-56 between the University of Alaska and NOAA, Department of Commerce through the Other Continental Shelf Environmental Assessment Program to which funds were provided by the Bureau of Land Management, Department of Interior."

MILESTONE CHART

RU #: 427 PI: Alexander/Cooney

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Quarterly Reports	Δ			Δ						Δ			Δ		
Annual Report							Δ								
Final Report															
All Sample Analyses				Δ											
Modelling 1. Phytoplankton							Δ								
2. Grazing pressure						Δ									
3. Final simulation										Δ					
Draft										Δ					
Final Copy Report												Δ			

Publications

Dugdale, V. A., and R. C. Dugdale. 1962. Nitrogen metabolism in lakes. II. Role of nitrogen fixation in Sanctuary Lake, Pennsylvania. Limnol. Oceanog. 7(2):170-177.

Neess, J. C., R. C. Dugdale, J. J. Goering, and V. A. Dugdale. 1963. Use of ^{15}N for measurement of rates in the nitrogen cycle. *In* R. V. Schultz and A. F. Kelement, Jr., eds. Radioecology. Reinhold Publ. Corp., New York, pp. 481-484.

Dugdale, V. A., and R. C. Dugdale. 1965. Nitrogen metabolism in lakes. III. Tracer studies of the assimilation of inorganic nitrogen sources. Limnol. Oceanog. 10(1):53-57.

Dugdale, V. A. 1965. Inorganic nitrogen metabolism and phytoplankton primary productivity in a subarctic lake. Ph.D. thesis. Univ. Alaska. Univ. Microfilms, Ann Arbor, Michigan.

Goering, J. J., and V. A. Dugdale. 1966. Estimates of the rates of denitrification in a subarctic lake. Limnol. Oceanog. 11(1):113-117.

Dugdale, V. A. 1967. Aspects of the nitrogen nutrition of some naturally-occurring populations of blue-green algae. *In* Environmental Requirements of Blue-green Algae. Fed. Water Pollut. Contr. Admin.

Billaud, V. A. 1968. Nitrogen fixation and the utilization of other inorganic nitrogen sources in a subarctic lake. J. Fish. Res. Bd. Canada 25(10):2101-2110.

Alexander, V. 1970. Relationships between turnover rates in the biological nitrogen cycle and algal productivity. Proc. 25th Ind. Waste Conf. Purdue Univ. Eng. Ext. Ser. 137:1-7.

Barsdate, R. J., and V. Alexander. 1970. Photosynthetic organisms in subarctic lake ice. Arctic 23(3):201.

Schell, D. M., and V. Alexander. 1970. Improved incubation and gas sampling techniques for nitrogen fixation studies. Limnol. Oceanog. 15:961-962.

Barsdate, R. J., and V. Alexander. 1971. Geochemistry and primary productivity of the Tangle Lake system, an Alaskan alpine watershed. Arctic Alpine Res. 3:27-42.

Alexander, V., and R. J. Barsdate. 1971. Physical limnology, chemistry and plant productivity of a Taiga lake. Int. Rev. Gesamten Hydrobiol. 56:559-606.

Kinney, P. J., D. M. Schell, V. Alexander, A. S. Naidu, C. P. McRoy, and D. C. Burrell. 1971. Nearshore and estuarine environments of this Alaska Arctic coast: Parameter for engineering solutions. Proc. 1st Int. Conf. Port and Ocean Engineering Under Arctic Conditions, Trondheim. Tech. Univ. of Norway, pp. 48-72.

Horner, R., and V. Alexander. 1972. Algal populations in Arctic sea ice; an investigation of heterotrophy. Limnol. Oceanog. 17:454-457.

Publications (cont'd)

Coulon, C., and V. Alexander. 1972. A sliding-chamber settling technique for making permanent quantitative slides with applications in fluorescent microscopy and autoradiography. Limnol. Oceanog. 17:149-152.

Clasby, R. C., W. S. Reeburgh, and V. Alexander. 1972. A close-interval syringe sampler. Limnol. Oceanog. 17:632-633.

Alexander, V. 1972. Phytoplankton primary productivity as an indication of biologic status in Alaskan freshwater environments. *In* Alaska Fisheries Policy, A. R. Tussing, T. A. Morehouse, and J. D. Babb, eds., pp. 131-136.

Hobbie, J. E., R. J. Barsdate, V. Alexander, D. W. Stanley, C. P. McRoy, R. G. Stross, D. A. Bierle, R. D. Dillon, and M. C. Miller. 1972. Carbon flux through a tundra pond ecosystem at Barrow, Alaska. Tundra Biome Rept. 72-1. Tundra Biome Center, Univ. Alaska, Fairbanks. 26 pp.

Alexander, V., and D. M. Schell. 1973. Seasonal and spatial variation of nitrogen fixation in the Barrow, Alaska, tundra. Arctic Alpine Res. 5:77-88.

Schell, D. M., and V. Alexander. 1973. Nitrogen fixation in Arctic coastal tundra in relation to vegetation and micro-relief. Arctic 26:131-137.

Alexander, V. , R. J. Barsdate, and R. C. Clasby. 1973. Denitrification in arctic soils and aquatic sediments. Tundra Biome Rept. 73-20. Tundra Biome Center, Univ. Alaska, Fairbanks. 14 pp.

Clasby, R. C., R. Horner and V. Alexander. 1973. An *in situ* method for measuring primary productivity of arctic sea ice algae. J. Fish. Res. Bd. Can. 30:835-838.

Barsdate, R. J., V. Alexander, and R. E. Benoit. 1973. Natural oil seeps at Cape Simpson, Alaska: Aquatic effects. *In* Oil Resource Development. Proc. Symp. on the Northern Plant communities. Occas. Publ. 1. Inst. Arctic Biol., Univ. Alaska, Fairbanks, pp. 91-95.

Alexander, V. 1974. A synthesis of the IBP Tundra Biome Circumpolar Study of Nitrogen Fixation. 1974. Soil Organisms and Decomposition in Tundra. Proc. of the Microbiology, Decomposition and Invertebrate Working Groups Meeting, Fairbanks, Alaska. Stockholm: IBP Tundra Biome Steering Committee, pp. 109-121, Fairbanks.

Alexander, V. , M. Billington, and D. M. Schell. 1974. The influence of abiotic factors on nitrogen fixation rates in Barrow, Alaska, arctic tundra. Rept. from the Kevo Subarctic Res. Sta. 11:3-11.

Alexander, V., and R. J. Barsdate. 1974. Limnological Studies of a subarctic lake system. Int. Rev. Gesamten Hydrobiol. 59:737-753.

Alexander, V. , C. Coulon, and J. Chang. 1974. Studies of primary productivity and phytoplankton organisms in the Colville River system, pp. 283-403. *In* Environmental Studies of an Arctic Estuarine System. Report R74-1, Institute of Marine Science, University of Alaska, Fairbanks, (report).

Publications (cont'd)

Alexander, V. 1975. Nitrogen fixation by blue-green algae in polar and subpolar regions. *In* Nitrogen Fixation by Free-Living Micro-Organisms. W. D. P. Stewart, ed., Cambridge University Press.

Alexander, V. 1975. Primary productivity regimes of the near-shore Beaufort Sea, with reference to the potential role of ice biota. *In* The Coast and Shelf of the Beaufort Sea, J. C. Reed and J. E. Sater, eds. A.I.N.A.:609-632.

Barsdate, R. J., and V. Alexander. 1975. The Nitrogen Balance of Arctic Tundra: Pathways, Rates and Environmental Implications. J. of Environmental Quality 4:111-117.

McRoy, C. P., and V. Alexander. 1975. Nitrogen kinetics in aquatic plants in Arctic Alaska. Aquatic Botany 1:3-10.

Alexander, V. and R. J. Barsdate. 1975. Studies of nitrogen cycles processes in Arctic tundra. *In* Proc. Circumpolar Conference on Northern Ecology, Nat'l Res. Counc. Can., Ottawa. III. pp. 53-64.

Clasby, R. C., V. Alexander and R. Horner. 1976. Primary productivity of sea-ice algae. *In* Assessment of the Arctic Marine Environment: Selected Topics. Univ. of Alaska. pp. 289-304.

Hoskins, L. C. and V. Alexander. 1977. Determination of Carotenoid Concentration in Marine Phytoplankton by Resonance Raman Spectrometry. Analytical Chemistry 49: 695-697.

Alexander, V. and S. Kallio. 1976. Nitrogenase activity in Peltigera aphthosa and Stereocaulon paschale in early spring. Rep. Kevo Subarctic Res. Stat. 13:12-15.

Publications: (cont'd)

Holm-Hanson, O., F. R. V. Taylor and R. J. Barsdate. 1970. A ciliate red tide at Barrow, Alaska. Marine Biology 7:37-46.

McRoy, C. P. and R. J. Barsdate. 1970. Phosphate absorption in eelgrass. Limnol. Oceanogr. 15:6-13.

Barsdate, R. J. 1970. Transition metal binding by large molecules in high latitude waters. *In* Proc. Symp. Organic Matter in Natural Waters, D. W. Hood, ed., Inst. Mar. Sci., Univ. of Alaska Occas. Pub. No. 1, pp. 485-493.

Barsdate, R. J. and V. Alexander. 1970. Photosynthetic organisms in subarctic lake ice. Arctic 23:201.

Barsdate, R. J. and V. Alexander. 1971. Geochemistry and primary productivity of the Tangle Lakes system, an Alaska alpine watershed. Arctic and Alpine Res. 3:27-42.

Alexander, V. and R. J. Barsdate. 1971. Physical limnology chemistry and plant productivity of a taiga lake. Int. Revue Hydrobiol. 56:825-872.

Sharma, G. D. and R. J. Barsdate. 1971. Liquid scintillation counting of ^{45}Ca in geochemical studies. Chem. Geol. 8:33-36.

Barsdate, R. J. and R. C. Dugdale. 1972. Effects of volcanic ashfalls on Alaskan lakes. J. Fish. Res. Bed. Canada 29:229-236.

McRoy, C. P., R. J. Barsdate and M. Nebert. 1972. Phosphorus cycling in an eelgrass *Zostera marina* L. ecosystem. Limnol. Oceanogr. 17:58-67.

Barsdate, R. J. and T. Prentki. 1972. Nutrient dynamics in tundra ponds. Proceedings of the 1972 U.S. Tundra Biome Symposium, pp. 192-199.

Hobbie, J. E., R. J. Barsdate, V. Alexander, D. W. Stanley, C. P. McRoy, R. G. Stross, D. A. Bierle, R. D. Dillon and M. C. Miller. 1972. Carbon flux through a tundra pond ecosystem at Barrow, Alaska. Tundra Biome Report 72-1, Tundra Biome Center, University of Alaska, Fairbanks, Alaska, 26 pp.

Barsdate, R. J. 1973. Ecologic changes in an arctic tundra pond following exposure to crude oil, (abstract only), p. 52. *In* Proc. Symp. on the Impact of Oil Resource Development on Northern Plant Communities, B. H. McCown and D. R. Simpson, eds. Occas. Publ. on Northern Life No. 1, Inst. Arctic Biol., Univ. of Alaska, Fairbanks, Alaska.

McCown, B. H., J. Brown and R. J. Barsdate. 1973. Natural oil seeps at Cape Simpson, Alaska: Localized influences on terrestrial habitat, pp. 86-90. *In* Proc. Symp. on the Impact of Oil Resource Development on Northern Plant Communities, B. H. McCown and D. R. Simpson, eds. Occas. Publ. on Northern Life No. 1, Inst. Arctic Biol., Univ. of Alaska, Fairbanks, Alaska.

Publications: (cont'd)

Barsdate, R. J., V. Alexander and R. E. Benoit. 1973. Natural oil seeps at Cape Simpson, Alaska: Aquatic effects, pp. 91-95. *In* Proc. Symp. on the Impact of Oil Resource Development on Northern Plant Communities, B. H. McCown and D. R. Simpson, eds. Occas. Publ. on Northern Life No. 1, Inst. Arctic Biol., Univ. of Alaska, Fairbanks, Alaska.

Barsdate, R. J., M. Nebert and C. P. McRoy. 1974. Lagoon contributions to sediments and water of the Bering Sea, pp. 553-576. *In* Proc. Internat. Symp. on Oceanography of the Bering Sea, D. W. Hood and E. J. Kelley, eds. Inst. Mar. Sci. Occas. Publ. No. 2, Univ. of Alaska, Fairbanks, Alaska.

Alexander, V. and R. J. Barsdate. 1974. Limnological studies of a subarctic lake system. Int. Rev. ges. Hydrobiol. 59:737-753.

Nebert, M. and R. J. Barsdate. 1974. Atmospheric lead in a subarctic watershed. *In* Proc. 24th Alaskan Sci. Conf. S. Bowling, eds. (in press).

Barsdate, R. J., T. Fenchel and R. T. Prentki. 1974. The phosphorus cycle of model microcosms: significance for decomposer food chains and the effect of bacterial grazers. Oikos. 25:239-251.

Barsdate, R. J. and V. Alexander. 1975. The nitrogen balance of arctic tundra: pathways, rates, and environmental implications. J. Envir. Qual. 4:111-117.

Alexander, V. and R. J. Barsdate. 1975. Studies of nitrogen cycles processes in arctic tundra systems. *In* Circumpolar Conference on Northern Ecology, NRC Canada, Ottawa. pp. 55-64.

Barèl, D. and R. J. Barsdate. 1976. Phosphorus dynamics of wet coastal tundra soils near Barrow, Alaska. *In* Environmental Chemistry and cycling processes, D. C. Adriano and I. L. Brisbin, eds. In press.

June/77

Publications: Geist, C. R. 1971. The impact of H. R. 5821. Sea of Cortez Institute of Biological Research Newsletter 5:4.

Geist, C. R., R. R. Zimmermann, and D. A. Strobel. 1972. Effects of protein-calorie malnutrition on food consumption, weight gain, serum proteins, and activity in the developing rhesus monkey (*Macaca mulatta*). Laboratory Animal Science 22:369-377.

Wells, A. M., C. R. Geist, and R. R. Zimmermann. 1972. The influence of environmental and nutritional factors on problem solving in the rat. Perceptual and Motor Skills 35:235-244.

Zimmermann, R. R. and C. R. Geist. 1972. A highly palatable and easy to make diet for producing protein-calorie malnutrition in the rhesus monkey. Laboratory Primate Newsletter 11:1-3.

Aakre, B., D. A. Strobel, R. R. Zimmermann, and C. R. Geist. 1973. Reactions to intrinsic and extrinsic rewards in protein malnourished monkeys. Perceptual and Motor Skills 36:787-790.

Gilson, J. E., T. Green, III, and H. J. Niebauer. 1973. Short-Term Variations in the Baroclinic Flow of a Coastal Current. The 16th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., (Abstract) April 16-18, 1973, Huron, OH.

Ragotzkie, R. A. and H. J. Niebauer. 1975. Temperature Regime of Lake Superior at Silver Bay, MN. Verh. Int. Verein. Limnol, Stuttgart, Germany. 144-148 pp.

Niebauer, H. J. 1975. Coastal Upwelling in Lake Superior. The 18th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., (Abstract), May 20-23, 1975, Albany, NY.

Niebauer, H. J. 1976. Wind Driven Coastal Upwelling in Lake Superior. Ph.D. Thesis, University of Wisconsin, Madison. 264 pp.

<u>In Preparation</u>

Niebauer, H. J., T. Green and R. A. Ragotzkie. Coastal Upwelling/Downwelling Cycles in Lake Superior. submitted to J. Phys. Oceanogr.

Niebauer, H. J. A Model of an Upwelling/Downwelling Cycle in Lake Superior. To be submitted to J. Phys. Oceanogr.

Publications: (cont'd)

Pettus, J. P., C. R. Geist, G. E. Schulta, and R. R. Zimmermann. 1974. Recovery from malnutrition: food preference and neophobia. Perceptual and Motor Skills 38:767-773.

Strobel, D. A., C. R. Geist, R. R. Zimmermann, and E. K. Lindvig. 1974. Cue locus - a factor in the behavioral deficiency of the developing protein malnourished monkey (*Macaca mulatta*). Behavioral Biology 10:473-484.

Wells, A., A. Jones, M. Williams, and C. R. Geist. 1974. Noise, vitamin A deficiency, and emotional behavior in rats. Perceptual and Motor Skills 38:392-394.

Zimmermann, R. R. and C. R. Geist. 1974. A primer of animal behavior for the lay-person. Contemporary Psychology 19: 115-116.

Zimmermann, R. R., C. R. Geist, and L. A. Wise. 1974. Behavioral development, environmental deprivation, and malnutrition. *In* Advances in Psychobiology, vol. 2, ch. 3, G. Newton and A. H. Riesen, eds. John Wiley & Sons, Inc., New York.

Zimmermann, R. R., R. Guest, and C. R. Geist. 1974. Improvements in self-concept during psychotherapy in a maximum security prison. Perceptual and Motor Skills 39:311-314.

Zimmermann, R. R., C. R. Geist and P. K. Ackels. 1975. Changes in the social behavior of rhesus monkeys during rehabilitation from prolonged protein-calorie malnutrition. Behavioral Biology 14:325-333.

Zimmermann, R. R., C. R. Geist, D. A. Strobel and T. J. Cleveland. 1975. Attention deficiencies in malnourished monkeys. *In* Early Malnutrition and Mental Development. (Symposium of the Swedish Nutrition Foundation, vol. XII.) J. Craviota, L. Hambraeus, and B. Vahlquist, eds. Uppsala, Sweden, Almquist and Wiks Wiksells.

Zimmermann, R. R., C. R. Geist and D. A. Strobel. 1975. The behavioral deficiencies in protein deprived monkeys. *In* Nutrition: Its Contribution to Mental Function. (Advances in Behavioral Biology Series, vol. 14.) Plenum Publishing Co., New York.

Zimmermann, R. R., D. A. Strobel, P. Steere and C. R. Geist. 1975. Behavior and malnutrition in the rhesus monkey. *In* Primate Behavior, vol. 4, L. Rosenblum, ed. Academic Press, New York.

Geist, C. R. 1976. Drugs and Drug Dependence. *In* Correspondence Study Program, Continuing Education Program, Univ. of Alaska, Fairbanks.

Geist, C. R., R. R. Zimmermann, O. W. Smith and E. M. Geist. 1977. The emergence of a kwashiorkor-like syndrome associated with protein calorie malnutrition in the developing rhesus monkey (*Macaca mulatta*). Psychological Reports 40:1339-1344.

Smith, O. W., P. C. Smith, R. R. Zimmermann, and C. R. Geist. 1977. A ratio scale for comparison and evaluation of visual size constancy data and theory. Perceptual and Motor Skills, submitted.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

December 30, 1977

Dr. Vera Alexander
Institute of Marine Science
University of Alaska
Fairbanks, AK 99701

Reference: Contract 03-5-022-56, T. O. #1, RU#427

Dear Dr. Alexander:

I am pleased to notify you that your FY78 proposal as revised, entitled "Ice-Edge Ecosystem Study: Primary Productivity, Nutrient Cycling and Organic Matter Transfer", University of Alaska proposal number OCS 78-9, dated October 31, 1977, has been recommended to me for funding in the amount of $175,537, of which $43,750 has already been funded. Our Contracting Clerk, Kay Jentsch, will initiate contracting procedures as soon as possible for the remaining $131,787 and also the $5,000, which has been approved for analyzing the 66 zooplankton samples collected during FY77 in the Norton/Chukchi, under RU#426, as indicated in the memo dated 12-2-77 from Herb Bruce to myself. We are also notifying the Juneau Project Office and your institution business office by copy of this letter. The contract period will be from October 1, 1977 through September 30, 1978. If you have any funding questions, please call Kay Jentsch, 303-499-1000, ext. 6562, FTS 323-6562. Technical or scientific questions should be referred to your project office.

I thank you for your contributions to the OCSEA Program and look forward to another year of cooperative effort.

Sincerely,

Rudolf J. Engelmann, Director
Outer Continental Shelf Environmental
Assessment Program Office

cc: R. Ted Cooney
Ray Hadley
Juneau Project Office

bcc: RU#427
RU#426
read file
Jentsch

FILE COPY

CODE	SURNAME	DATE	CODE	SURNAME	DATE
	[illegible]	[illegible]			
	[illegible] RJE				

NOAA FORM 61-

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES

RFx41-427-989

Date: DEC [illegible] 1977

To : Rudy Engelmann, Director
OCSEAP, Alaska Program Office, Boulder

Herbert E. Bruce

From: Herbert E. Bruce, Project Manager
OCSEAP, Juneau Project Office

Subj: OCSEAP Research Unit 427

Required Acceptance Letter for R.U. 427, Drs. Alexander and Cooney

The enclosed revised FY 78 renewal proposal for R.U. 427, entitled "Ice-Edge Ecosystem study: Primary Productivity, Nutrient Cycling and Organic Matter Transfer", has been reviewed by the Juneau Project Office and judged acceptable at the funding level of $175,537. In addition, the supplementary funds of $5,000 required to analyze the 66 zooplankton samples collected during FY 77 in the Norton/Chukchi region under R.U. 426 (reference Page 8, item 2 of the proposal) will be provided from the Project Office budget for FY 78. Please send an acceptance letter to Drs. Alexander and Cooney and initiate contracting procedures based on the revised proposal for $180,537 with $175,537 from the Boulder Program Office and $5,000 from the Juneau Project Office (R7120610).

Enclosure: (1) Revised Proposal
(2) RFP letter
(3) Guidance letter

cc:
Ray Hadley

RFx41-427-806

SEP 16 1977

Dr. Vera Alexander
Dr. R. Ted Cooney
Institute of Marine Science
University of Alaska
Fairbanks, AK 99701

Reference: (1) OCSEAP R.U. 427 (formerly 426 and 427).
(2) U of AK, IMS Fy 78 Proposal for R.U. 427 dated 7-21-77.

Dear Drs. Alexander and Cooney:

Required Proposal Revisions for FY 78

Your FY 78 renewal proposal, entitled "Ice-edge Ecosystem Study: Primary Productivity, Nutrient Cycling and Organic Matter Transfer," has been reviewed by the Juneau Project Office. On July 29, after our guidance was developed for your original proposal, OCSEAP was informed by the Bureau of Land Management of a substantial budget reduction for FY 78. This reduction in budget requires a severe revision of overall program content, which has affected your research unit. The following revisions are required before your work statement can be sent to our Contracting Office for funding:

1. Your original requested funding level of $375,988 must be reduced to $175,000.

2. The following items are suggested as means for affecting this reduction in funds:

   a. Eliminate all proposed field work for FY 78. Your total effort should be devoted to the completion of phyto- and zooplankton data submissions with the production of a final report showing the results of cruises conducted during the period 1975-77. This will involve the final analysis, interpretation and reporting of plankton data collected in the St. George Basin, Bristol Bay, Norton Sound and Chukchi Sea lease areas.

   b. Reduce personnel, salaries, overtime, administrative overhead, travel, equipment, etc. commensurate with the deletion of your field effort.

3. Provide an inventory of samples held from past cruises. List the types and number of samples, by cruise, that will be analyzed and used to develop the results for your final report.

4. Indicate on the inventory the types and number of samples, by cruise, that you will be unable to analyze with the present funding level. Please indicate the man hours and funds that would be required to process, evaluate, and develop a final report incorporating all data for the Norton Sound lease area.

5. Describe in detail your modeling effort during FY 78.

6. Provide a detailed table of contents for your final report.

7. Increase the information content in your milestone chart to show estimated dates for completion of sample analysis, major types of data analysis data submissions in OCSEAP format, and major sections of your final report.

8. Prepare and include in your work statement a field by field identification of data that has been collected under your research unit. This should include fields for File Types 022, 024, 028 and 029 as requested in the proposal format. In this listing please indicate the expected range of values for each field when applicable.

9. When reporting species in the OCSEAP formats we request that you use the new NODC Taxonomic Code instituted in March, 1977 rather than the old Alaska Code.

10. Please correct the error in format number (024 to 029) for the category "Primary Productivity" in the "Data Products Schedule" pp. 10 of your original proposal.

11. We request a complete inventory of all equipment purchased with OCSEAP funds. You will be contacted at a later date as to the disposition of field sampling equipment.

The final funding commitment and level are contingent on approval of the FY 78 OCSEAP budget by the Bureau of Land Management.

If you have questions concerning any of the above guidance, please phone the Juneau Project Office, (907) 586-7436.

Your letter agreeing to these changes, or a revised work statement, must be sent to and received in the Juneau Project Office, with a copy to Boulder no later than September 28, 1977. If there are extenuating circumstances which prevent you from meeting this schedule, please phone the Project Office. The shoret deadline is required to ensure continuous funding of your project in FY 78.

Upon receipt of your work statement, revised in accordance with the above guidelines, we will initiate contracting procedures for FY 78. I look forward to your continued involvement in our program.

Sincerely,

Herbert E. Bruce, Ph.D.
Bering Sea-Gulf of Alaska Project Manager

cc:
Program Office
Ray Hadley

Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P.O. Box 1308
Juneau, Alaska 99802
PH: 907-586-7432

RFx41-427-374

Dr. Vera Alexander
Dr. R. Ted Cooney
Institute of Marine Science
University of Alaska
Fairbanks, AK 99701

Reference: OCSEAP Research Unit 427. (Formerly 426 and 427)

Dear Drs. Alexander and Cooney:

At this time we are soliciting renewal proposals for the 1978 fiscal year, starting 1 October 1977 and ending 30 September 1978. Requests for these proposals are based on a Five Year Program Development Plan for the environmental assessment of the Alaskan Continental shelf, which has been developed by our Research Planning Committee.

We invite you, Drs. Alexander and Cooney, to submit a renewal proposal for continued studies on the dynamics of the plankton communities and the regulatory mechanisms which govern the productivity of the seasonal ice system in the eastern Bering and Chukchi Seas. Your proposal should include additional FY 78 field studies in the Chukchi Sea, Norton Sound and Saint George Basin lease areas with the analysis and interpretation of data collected during FY 77. In addition, you will submit to OCSEAP a final report by October 1977 on all data collected during FY 75 and 76 in the southeastern Bering Sea including definition of the plankton communities, distribution and abundance of biomass (standing stock) and selected species, nutrient cycling, and annual cycle and magnitude of phytoplankton production.

The funding guidance for FY 78 is $377,000, to be distributed between the three lease areas approximately as follows:

13% Chukchi Sea
20% Norton Sound
67% Saint George Basin

Since the seasonal ice pack is heavily utilized by large populations of marine birds and mammals for feeding and breeding, it is essential to develop an understanding of the associated ecosystem dynamics, regulatory mechanisms, and transfer pathways and rates of organic matter prior to OCS development. Specifically, the objectives should be to:

1. Assess the significance of the ice edge region in the productivity of the lease areas by studying the dynamics and mechanisms regulating the phytoplankton populations.

2. Determine temporal and spatial density distributions and environmental requirements of the principal species of zooplankton, micronekton and ichthyoplankton associated with the ice-edge region.

3. Identify pathways and rates for organic matter transfer between primary producers and the pelagic and under-ice grazing communities.

4. Identify sensitive ecological parameters and information gaps by using a simulation model that represents the lower biotic components and dynamics of the ice-edge region.

Expected products from this research activity include:

1. Narrative reports containing a complete description of methods, spatial intensity of sampling, statistical tests, and the horizontal and vertical distribution of parameters. Data will be analyzed to identify the major factors controlling primary production and the flow of organic matter to primary consumers. Discussion of the model will include an operational description, documentation of the computer programs, and results defining information gaps and the sensitivity of selected parameters.

2. Digital data submitted in OCSEAP format under File Types: 022 -CTD Data, 024 - Zooplankton, 028 - Phytoplankton Species and 029 - Primary Productivity.

3. Visual data supplementing the narrative reports as follows:

   a. Maps identifying sampling locations.

   b. Charts illustrating:

      (1) Temporal changes in the location of the ice edge.

      (2) Temporal and spatial changes in the distribution and abundance of zooplankton.

      (3) Temporal and spatial changes in the distribution and abundance of chlorophyll.

      (4) Temporal and spatial changes in the levels of primary production.

   c. Figures and tables illustrating:

      (1) Vertical distributions of sigma t, temperature, salinity, nutrients, zooplankton biomass, species numbers, chlorophyll, light intensity and primary production, as related to the ice-edge ecosystem.

d. Computer graphics showing:

(1) Estimated daily energy demands for selected species or species groups.

(2) Summation of sensitivity analyses.

This year's proposal format is requesting information on future years' research efforts for those investigators who expect to continue into FY79 and beyond. We are asking for this additional information because: (1) We believe a better program will result when research can be viewed in a perspective longer than a single fiscal year, (2) we will be able to estimate future total program costs and the impact of different total budget levels, (3) our information base will be improved for writing research plans for FY79. Please be assured that we are well aware of the uncertainties associated with environmental research, and that no future commitment is implied by your furnishing this information.

Please prepare your renewal proposal according to the enclosed guidelines and mail it to the Juneau Project Office in time for delivery no later than 29 June 1977. We expect to have letters of final decisions on all proposals mailed by 22 August 1977. If, in preparation of this renewal proposal, you have specific questions regarding this request or the guidance provided, please call or write the Juneau Project Office. Your inquiry will be referred to a staff scientist for an immediate answer.

We have made our best estimate of what this project should accomplish during FY78 to meet BLM needs. However, we encourage you to bring to our attention specific aspects in which you feel that the above guidance might be modified or improved to enhance the overall scientific quality and output of the project. You should also keep in mind that OCSEAP must issue guidance and invite renewal proposals at this time in order to complete review and funding procedures before 1 October 1977. However, the schedule for BLM's final approval of the FY78 Technical Development Plans is 15 August 1977. Therefore, your comments on the above guidance will be useful in our coming discussions with BLM.

We would like to thank you for your contributions to the OCSEA Program and look forward to another year of cooperative effort.

Sincerely,

Herbert E. Bruce, Ph.D.
Bering Sea-Gulf of Alaska Project Manager

Encl. 1

cc: Program Office
Ray Hadley

ERIM

FORMERLY WILLOW RUN LABORATORIES, THE UNIVERSITY OF MICHIGAN

INTERTIDAL ALGAL ANALYSIS

Principal Investigator

Fabian C. Polcyn

Cost: $22,000

Environmental Research Institute of Michigan

July 15, 1977

Research Unit 428

Submitted by: Fabian C. Polcyn

Fabian C. Polcyn
ERIM
P.O. Box 618
Ann Arbor, MI 48107
Telephone: (313) 994-1200 Ext. 234

Approved by: Richard R. Legault

Richard R. Legault
Vice President and Director of
Infrared and Optics Division
ERIM
P.O. Box 618
Ann Arbor, MI 48107
Telephone: (313) 994-1200 Ext. 240

Howard W. Courtney

Howard W. Courtney
Director, Contracts Administration
ERIM
P.O. Box 618
Ann Arbor, MI 48107
Telephone: (313) 994-1200 Ext. 230

TECHNICAL PROPOSAL

I. INTERTIDAL ALGAL ANALYSIS

Follow-on to Contract 03-6-022-35225
Dates of Contract: July 31 to December 31, 1977

II. Principal Investigator:
Fabian C. Polcyn

III. Cost of Proposal: $22,000

IV. Background: In June 1976, a set of multispectral data was collected by aircraft over three test sites in the Gulf of Alaska. A first analysis of the data showed feasibility for using spectral signature analysis for mapping the intertidal algal communities along the Alaskan coastline. Mission was performed in cooperation with Dr. Zimmerman, the NOAA Auke Bay Laboratories who made ground observations of the test sites. If a cost effective method for inventorying algal communities along a wider area of the coastline could be developed, then a better environmental impact analysis of critical coastlines could be made relative to requests for exploration leases and development.

V. The Objectives of this program is to complete the analysis of the data set collected in 1976 by using all known ground truth at the three test sites. Specifically, the tasks would be to:

1. Classify by computer techniques the intertidal algal communities for Latouche, Zaikof Bay, and Cape Yakataga test sites, using the multispectral data stored on magnetic tape and ground truth provided by NOAA.

2. Construct maps of the test site showing by color coding, the geographical distribution of the algal communities specified by Dr. Zimmerman or his NOAA designate.

3. Test classification accuracies of algal classes for other conditions referenced in data set by altitude, scan rate or flight direction for at least one test area.

4. Prepare recommendations for cost effective operational approach to intertidal algal survey using remote sensing techniques for designated coastlines in Alaska.

VI. General Strategy and Approach: The multispectral data set is contained on five computer compatible tapes. The analysis procedure will be to use ERIM's user interactive MIDAS computer system to spectrally analyze each algal community at the three test areas. A NOAA scientist will be present during the computer analyses sessions. The scientist will specify the areas for training the computer memory. The results of that target classification will be immediately displayed on a TV monitor and the area classified as a given algal community will be shown. This will allow an assessment of the accuracy of the computer classification. Each algal class can be sequentially identified and displayed. After this initial setup period, a color ink jet printer will be used to construct a color coded map of the algal communities.

A separate printout is also provided giving the number of pixels for each algal communities. Since the area of pixel is known from the parameters of the scanner and the altitude of the flight, an area wide inventory of each class is provided in addition to the map showing the geographical distribution. Finally, comparisons can be made with aerial photographs and on site observation to assess the accuracy of the overall classifications. This process will be repeated for each of the three test areas; Zaikof Bay, Latouche, and Cape Yakataga.

Based on the success of classifications and knowledge of the costs of both collection and processing a set of recommendations as to the costs of doing large area surveys will be prepared.

VII. Not applicable

VIII. Not applicable

IX. Anticipated Problems: The technology of performing this program is in hand and a first analyses performed in the first year's effort has given indications of the potential value of the methodology. No problems in proceeding with the current program are foreseen.

X. Deliverable Products

A. Set of computer classifications maps in color of the three sites in the Gulf of Alaska, at approximate scale of 1:3,000.

B. Tables of areas of the designated algal communities at the three sites.

C. Symposium paper to be delivered between August 20-26, 1977.

D. Color aerial photographs of test areas have already been delivered to Sponsor. Scale is approximately 1:3,000.

XI. Dr. Steven Zimmerman of the NOAA Auke Bay Laboratory near Juneau, Alaska will provide the ground truth observations for both the computer training session and the classification assessment analysis. Plans have been made to conduct this computer analysis effort at the Environmental Research Institute of Michigan during the week of August 15 to 19, 1977.

XII. Quality Assurance Plans. The collaboration of the investigators who were part of the ground site team in June 1976 and the comparison with photography collected at the time and all field notes recorded will be a major source of verification of computer results to be obtained.

XIII. Not Applicable

XIV. Logistics Requirements: Not applicable at this time. The planning of future data collection missions is dependent on a variety of decisions, but currently must await the results of the computer analyses to be performed as proposed herein, and the assessments of cost effectiveness for larger scale operation.

XV. The project will be managed by Mr. Fabian C. Polcyn, Research Engineer and Head of Water Programs for the Resources and Technology Department in the Infrared and Optics Division of the Environmental Research Institute of Michigan. A milestone chart is shown as an attachment.

XVI. Outlook: It is expected that aircraft remote sensing techniques will be useful for inventorying Alaskan shorelines. It is one of the purposes of the proposed tasks to determine the final details of the computer processing procedures to achieve acceptable accuracies. If proven feasible than larger areas could be inventoried based on priority sites during a given season. A better estimate of costs will be forthcoming within the first three months of the proposed new program.

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly Reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, Annual Reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard:

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

MILESTONE CHART

△ Planned Completion Date

▲ Actual Completion Date

RU #: ____________ PI: Fabian C. Polcyn

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 A	S	O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Field Data Collection Completed June 1976																	
First Computer Analysis Completed January 1977																	
Report Completed March 1977																	
Follow-on Effort Approved July 1977																	
Computer Analysis Completed in collaboration with NOAA representative	▲																
Assessment of cost-effectiveness for using remote sensing techniques		▲															
Preparation of Final Report			←—	—→													
Delivery of Final Report					▲												

5/20/77

POLCYN, FABIAN C. RESEARCH ENGINEER

PUBLICATIONS

"Infrared", Co-author, International Science and Technology, April 1963.

"Infrared Scanner Observations of Volcanic Activity", Co-author, Proc. IRIS, Vol. 8, No. 3, August 1963.

"MORL Multispectral Experiment Definition", Co-author, The University of Michigan, IST, Report 6688-1-F, August 1964.

"Comparative Multispectral Sensing", Co-author, The University of Michigan, IST, Report 2900-484-S, March 1964.

"Multispectral Data Collection Program", Co-author, Proceedings of the Third Symposium on Remote Sensing of Environment, February 1965.

"Infrared Surveys of Hawaiian Volcanoes", Co-author, Science, Vol. 146, No. 3645, p. 733, 6 November 1964.

"Investigations of Multispectral Image Interpretation", Co-author, Proceedings of the Third Symposium on Remote Sensing of Environment, February 1965.

"Investigation of Spectrum Matching Sensing in Agriculture", Semi-annual Report, 2 Vol., September 1967.

"Investigation of Spectrum Matching Sensirg in Agriculture", Final Report, Vol. 1, November 1965.

"Remote Sensing Techniques for the Detection of Doubtful Shoals", Co-author, Ninth Meeting of Ad Hoc Spacecraft Oceanography Advisory Group, January 1968.

"How Multispectral Sensing Helps the Ecologist", Co-author, Remote Sensing in Ecology, First AIBS Interdisciplinary Meeting on Environmental Biology, June 1968, Published in Remote Sensing in Ecology, University of Georgia Press, 1969.

"Analysis of Lake Michigan Data", Preliminary Science Report, Co-author, Report 8973-13-L, November 1968.

"Remote Sensing Techniques for Location and Measurement of Shallow Water Features", Co-author, Report No. 8973-10-F, January 1969.

"Effects of Atmospheric Path on Airborne Multispectral Sensors", Co-author, Report 1674-5-T, January 1969.

"Applications of Multispectral Remote Sensing Techniques in Water Pollution Control", Co-author, 157th National Meeting of the American Chemical Society, April 1969.

"Analysis of Gulf of Mexico Data", Preliminary Science Report, Report No. 8973-19-L, 1969.

"Depth Determination by Surface Effects: NASA Second Annual Review Earth Resources Survey Program, Houston, Texas, September 1969.

"Taking a New Look at the Lakes", LIMNOS, Vol. 2, No. 2, p. 12, Summer 1969.

"Water Depth Determination Using Remote Sensing Techniques", Co-author, Proceedings of the Sixth International Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, October 1969.

PUBLICATIONS (Continued)

"Potential Applications of Remote Sensing to Oceanography and Hydrology", Co-author, presented at the Remote Sensing Principles and Applications to Earth Resources Survey Seminar, Paris, France, November 1969.

"Multispectral Remote Sensing Study of Industrial Discharges", Co-author, presented at the 25th Annual Purdue Waste Conference, Purdue University, May 1970.

"Analysis of Multispectral Data of the Santa Barbara Oil Slick", Co-author, Final Report 3340-4-F, October 1970.

"The Measurement of Water Depth by Remote Sensing Techniques", Co-author, Final Report 8973-26-F, October 1970.

"Multispectral Sensing", presented on WWJ-TV, Detroit, Country Living Program, November 1970.

"Water Depth Determination by Multispectral Ratio", NASA Third Annual Review Earth Resources Survey Program, Houston, Texas, December 1970.

"Pollution Surveillance and Data Acquisition Using Multispectral Remote Sensing", Co-author, Waste Resources Bulletin, Am. Water Resources Assoc. Vol. 6, No. 6, December 1970.

"Applications of Multispectral Sensing to Marine Resources Surveys", The University of Michigan, paper presented at the Symposium on Remote Sensing in Marine Biology and Fishery Resources, College Station, Texas, January 1971.

"Remote Sensing with Optical Mechanical Line Scanners to Detect Stress in Forests", Co-author, presented at the ASP/CSM 1971 Convention, Washington, D. C., March 1971, Published in Photogrammetric Engineering, February 1972, pp. 163-175.

"Application of Multispectral Sensing Using Electronic Processing Techniques", Presented at the ASP/CSM 1971 Convention, Washington, D. C., March 1971,

"Remote Optical Sensing Techniques", Co-author, in Instrumental Analysis for Water Pollution Control, K. H. Mancy Ed., Ann Arbor Science Publishers, Ann Arbor, Michigan, 1971, pp. 165-204.

"Water-Depth Measurements by Wave Refraction and Multispectral Techniques", Co-author, Infrared and Optics Division, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, prepared for National Aeronautics and Space Administration, NAS9-9784, WRL 3165-31-T, August 1971.

"Modern Approach to Coastal Zone Survey", Author, Tools for Coastal Zone Management Conference, Marine Technology Society, Washington, D. C. February, 1972.

"Multispectral Observations of Marine Environments", Author, Presented at the Fourth Annual Aircraft Program Review, NASA, Houston, Texas, January 20, 1972.

PUBLICATIONS (Continued)

"Multispectral Survey of Power Plant Thermal Effluents in Lake Michigan", Co-author, Infrared and Optics Division, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, prepared for Consumers Power Company, Indiana and Michigan Electric Company, and Northern Indiana Public Service Company, November 1971, and April 1972.

"Multispectral Survey of Power Plant Thermal Effluents in Lake Michigan", Author, presented at the Eighth International Symposium on Remote Sensing of Environment, October 1972, University of Michigan, Ann Arbor, Michigan.

"Eutrophication Assessment Using Remote Sensing Techniques", Co-author, presented at the Eighth International Symposium on Remote Sensing of Environment, October 1972, University of Michigan, Ann Arbor, Michigan.

"Calculating Water Parameters Using Remotely Sensed Scanner Data," Co-author, presented at the Eighth International Symposium on Remote Sensing of Environment, October 1972, University of Michigan, Ann Arbor, Michigan.

"Remote Sensing to Detect Stress in Forests", Printed in Photogrammetric Engineering, February 1972.

"Calculation of Water Depth from ERTS MSS Data," Co-author, presented at ERTS-1 Symposium on Significant Results, March 5-9, 1973.

"Multispectral Sensing of Water Parameters", Co-author, presented at International Symposium on the Remote Sensing of Water Resources, June 1973, Canada Centre for Inland Waters, Burlington, Ontario.

"Targets of Opportunity of Oceanographic and Hydrological Interest, Author, Environmental Research Institute of Michigan Report 102100-3-L, July 1973.

"Techniques for Measuring Light Absorption, Scattering, and Particle Concentrations in water", Co-author, Infrared and Optics Division, Willow Run Laboratories, Institute of Science and Technology, The University of Michigan, prepared for Spacecraft Oceanography Group, National Environmental Satellite Service, National Oceanic and Atmospheric Administration, Washington, D. C., 20233, N62306-71-C-0108.

"Updating Coastal and Navigational Charts Using ERTS-1 Data", Co-author, presented at Third ERTS Symposium, December, 1973, Washington, D. C.,

"Skylab Data and Water Resources Management, Co-author, Paper presented at the AAAS Meeting, February 1974, California.

"Power Plant Discharges and Thermal Anomalies in Southern Michigan - Program Summary,"Co-author, Environmental Research Institute of Michigan Report No. 290100-1-F, prepared for State of Michigan, Department of Natural Resources, Water Resources Commission, March 1974.

"Water Depth Measurements Using Spaceborne Sensors, Co-author, Environmental Research Institute of Michigan Report No. 102100-9-L, June 1974.

"Resource Inventory Research and Development: Major Issues, Techniques, and Recommendations, Environmental Research Institute of Michigan, June 1974.

LYZENGA, DAVID R. ASSISTANT RESEARCH ENGINEER

PUBLICATIONS

"Model Calculations of Contrail Effects on the Radiation Budget", 1972, Conference on Atmospheric Radiation, Fort Collins, Colorado.

"Note on the Modified Two-Stream Approximation of Sagan and Pollack", 1973, Icarus 19, 240-243.

"Environmental Effects of Aircraft Condensation Trails", 1973, PhD Thesis, University of Michigan.

"Techniques for Measuring Light Absorption, Scattering, and Particle Concentrations in Water" (with O.E. Prewett, F.C. Polcyn, and W.L. Brown), 1973, ERIM Report No. 190500-1-F.

"Calculation of Water Depth from ERTS-MSS Data" (with F.C. Polcyn), 1973, ERTS-1 Symposium on Significant Results, New Carrollton, MD.

"Multispectral Sensing of Water Parameters" (with F.C. Polcyn), 1973, in Remote Sensing and Water Resources Management.

"Remote Bathymetry and Shoal Detection with ERTS" (with F.C. Polcyn), 1975, ERIM Report No. 193300-51-F.

"Analysis of Cladophora Distribution in Lake Ontario Using Remote Sensing" (with C.T. Wezernak), 1975, Remote Sensing of Environment 4, 37.

"Skylab Remote Bathymetry Experiment" (with F.C. Polcyn), 1976, ERIM Report No. 102100-21-F.

"Spectral Reflectance and Radiance Characteristics of Water Pollutants" (with C.T. Wezernak and R.E. Turner), 1976, NASA Report No. CR-2665.

"Spectral Band Positioning for Purposes of Bathymetry and Mapping Bottom Features from Satellite Altitudes" (with C.T. Wezernak and F.C. Polcyn), 1976, ERIM Report No. 115300-5-T.

"Detectability of Black Submerged Objects" (with F.J. Thomson), 1976, ERIM Report No. 123500-1-F.

"Landsat Data Processing and Analysis for Beach Environment Assessment" (with R. Shuchman), 1977, ERIM Report No. 121400-5-T.

"Reflectance of a Flat Ocean in the Limit of Zero Water Depth", 1977, Applied Optics 16, 282.

Research Unit #429

I. TITLE: Faulting, Sediment Instability, Erosion, and Deposition Hazards of the Norton Basin Seafloor

II. PRINCIPAL INVESTIGATOR: C. Hans Nelson

U. S. Geological Survey
Pacific Arctic Branch of Marine Geology
Menlo Park, California 94025

III. GEOGRAPHICAL AREA AND INCLUSIVE DATES:

October 1, 1977 - September 30, 1978

The statements of work had not been received in finally approved form in time for publication.

Research Unit #430

I. TITLE: Bottom and Near-Bottom Sediment Dynamics: Norton Basin

II. PRINCIPAL INVESTOGATORS: David A. Cacchione
David Drake

U. S. Geological Survey
Menlo Park, California 94025

III. GEOGRAPHICAL AREA AND INCLUSIVE DATES:

October 1, 1977 - September 30, 1978

Norton Basin

The statements of work had not been received in finally approved form in time for publication.

Research Unit #431

I. TITLE: Coastal Processes of the Eastern Bering Sea

II. PRINCIPAL INVESTOGATORS: Asbury H. Sallenger
John Dingler
Ralph Hunter

U. S. Geological Survey
Menlo Park, California 94025

III. GEOGRAPHICAL AREA AND INCLUSIVE DATES:

October 1, 1977 - September 30, 1978

Alaskan Coast - Eastern Bering Sea

The statements of work had not been received in finally approved form in time for publication.

Proposal for

MODELING OF TIDES AND CIRCULATIONS OF THE BERING SEA

(OCSEAP Research Unit 435)

Jan J. Leendertse and Shiao-Kung Liu
(Principal Investigators)

Estimated Cost: $100,000

by

The Rand Corporation
1700 Main Street
Santa Monica, California 90406
ID No. 95-1958142

August 1977

Principal Investigators:

J. J. Leendertse date
Telephone: (213) 393-0411
Ext. 523

Shiao-Kung Liu date
Telephone: (213) 393-0411
Ext. 7882

Organization Approval:

J. S. King, Jr. date
Treasurer
Telephone: (213) 393-0411
Ext. 251

TECHNICAL PROPOSAL

I. TITLE: Modeling of Tides and Circulations of the Bering Sea (Phase II)

RESEARCH UNIT NUMBER: OCSEAP 435

CONTRACT NUMBER: 03-6-022-35249

PROPOSED DATES OF CONTRACT: October 1, 1977 - September 30, 1978

II. PRINCIPAL INVESTIGATORS

Jan J. Leendertse

Shiao-Kung Liu

III. COST OF PROPOSAL

	FY1978		
TOTAL	$ 98,134	$ 99,730	$ 99,843

D. Distribution of Effort by Lease Area:

30% Norton Sound

35% St. George Basin

35% Bristol Bay

BACKGROUND

A comprehensive OCSEAP investigation of southeastern Bering Sea shelf water mass dynamics and its driving mechanisms, underway since September 1975, has shown that semidiurnal tidal currents contribute about three-fourths of the observed variance in Eulerian current records. Episodic current pulses, attributed to water movements on and off the shelf, are at least in part responsible for the residual circulation. The current pulses are presumed to be responses to meteorological forcing in the form of regional pressure differences and sea surface wind stresses.

The above features are considered in numerical predictive models of the Bristol Bay/St. George Basin region and Norton Sound. The models presently under development include the effect of tides, wind stress, density stratification, bottom friction and mass and momentum transfers in horizontal and vertical directions.

V. OBJECTIVES

A. LONG-RANGE OBJECTIVES

The long-range objectives of the modeling studies are:

1. To provide risk planning data for the Outer Continental Shelf Petroleum Development of the Bristol Bay Area, St. George Basin and Norton Sound. (Such planning data could be generated, for example, for water level data resulting from extreme storm wind fields. Such data are of importance for safe construction of oil processing and distribution facilities.)
2. To provide a method to compute contaminant trajectories for selected locations from wind and tide data. This method should make possible the determination of the landfall location of certain contaminants introduced in the area considered. The method should generate data which may be needed for pollution event countermeasures. Such data may be the approximate landfall location of certain contaminants introduced in the area to be modeled.

B. OBJECTIVES OF THE PROPOSED STUDY IN THE 1978 FISCAL YEAR (PHASE II)

To accomplish the long-range objectives, models of pertinent sections of the Eastern Bering Sea are being developed. As an intermediate step in obtaining the long-range objectives, the proposed study for FY1978 will have the following objectives:

1. Adjustment and verification of the models based upon tide and wind data provided by others.
2. Determination of local current and water level responses to wind fields.
3. The providing of environmental monitoring station and site location planning information.

VI. GENERAL STRATEGY AND APPROACH

A. INTRODUCTION

In Phase I of the study, two three-dimensional models were set up--namely, a Bristol Bay model and a Norton Sound model (Figs. 1 and 2). These models are three-dimensional finite difference models based upon model developments sponsored by the Office of Water Research and Technology of the U.S. Department of the Interior.

The main fluid flow processes are computed on a grid system. On this grid system we are expressing the different conservation laws quite accurately. The assumption is made that the vertical accelerations can be neglected; thus the pressures are assumed to be hydrostatic.

The model contains two momentum balance equations, balance equations for salinity and temperature, equations representing the conservation of fluid mass and an equation of state.

In the model we are computing the variables at a finite number of points. Since fluid motions occur on scales much smaller than the finite distances we are using in the grid representation, the model formulation contains subgridscale mass and momentum exchanges.

Traditionally these exchanges are taken as functions of the local mass and momentum gradients. In the horizontal motions we assumed that these functions were linear with the gradients; thus, constant horizontal momentum and mass exchange coefficients were used. In the vertical the exchange coefficients were taken as a function of the square of the vertical velocity gradient. In this manner we were trying to relate the vertical exchanges with the local turbulence. In addition, the vertical exchange was taken a function of the Richardson number, thus inhibiting vertical exchange with increasing stratification.

B. PROGRESS IN FY1977

Under the present contract the emphasis of the research and development effort has been directed toward making the model system operational and setting up models of sections of the Eastern Bering Sea, namely, a model of Bristol Bay and a model of Norton Sound.

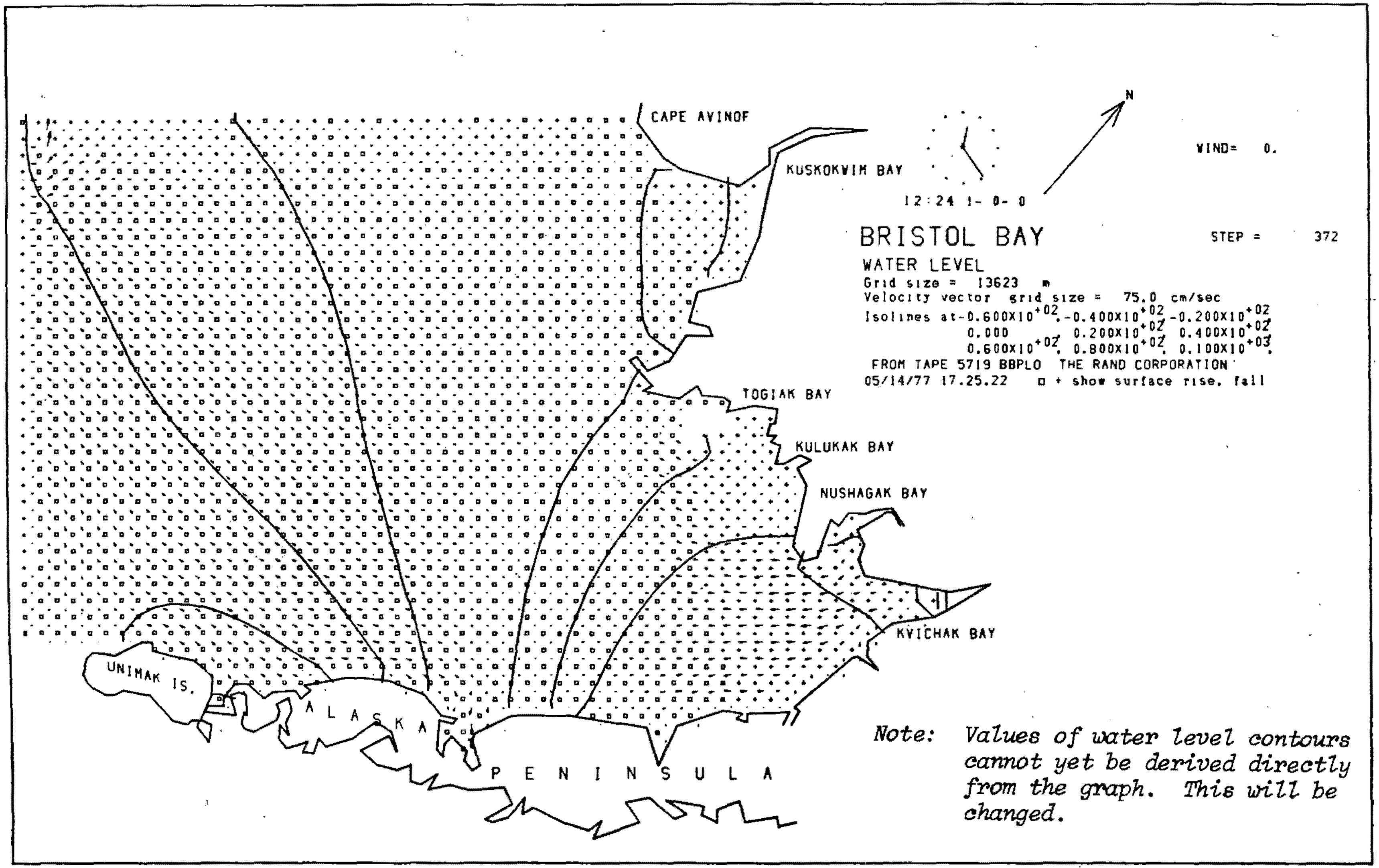
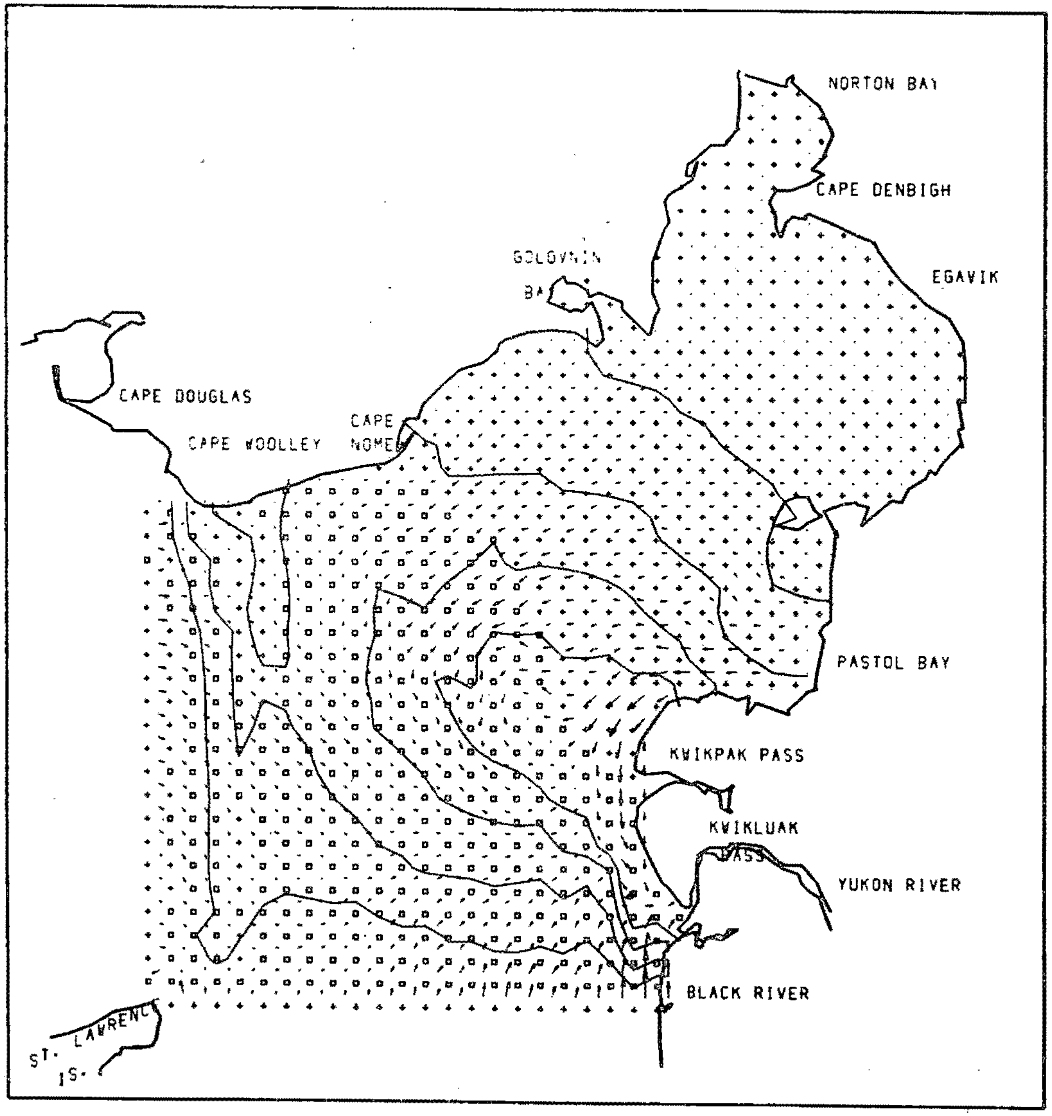
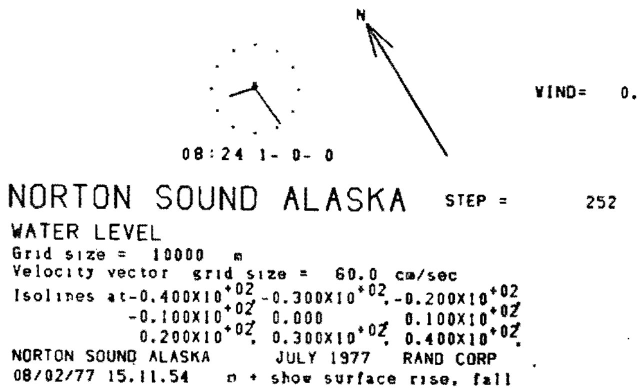


Fig. 1--Graphical output of the Bristol Bay model showing isocontours of water levels, rise and fall of the water surface and currents in the top layer at a particular time in a simulation





Note: *Values of water level contours cannot yet be derived directly from the graph. This will be changed.*

Fig. 2--Graphical output of the Norton Sound model showing isocontours of water levels, rise and fall of the water surface and currents in the top layer at a particular time in a simulation

Much of the work has been in code development for documentation and representation of model results in graphical form, documentation of input conditions and code development for insertion of the open boundary conditions in the model.

Two models have now been set up; examples of graphical outputs are presented in Appendix A.

In recent studies for the Office of Water Research and Technology, Department of the Interior, we extended the method of computation of the three-dimensional model. Implicit computations were introduced. All momentum and mass balance equations in a vertical are now solved simultaneously. This implicit method of computation eliminated a stability condition. More importantly, however, we introduced computation of the subgridscale energy. This subgridscale energy is a measure of the turbulence level at scales which cannot be represented on the computational grid.

Since the vertical mass and momentum exchanges are functions of the turbulence, we are now able to compute the vertical exchange coefficient. This concept is similar to approaches used by Marchuk* for the computation of the boundary layer in the ocean. A description of the computation method is presented in Appendix B.

The computation of the subgridscale energy and the implicit computation of the variables are now incorporated in the models of Bristol Bay and Norton Sound.

To start our first simulations of the tide in Bristol Bay for the initial simulations, we intend to use the results of two tide charts which were received this last month from PMEL (Figs. 3 and 4). Difficulties are expected when using this data, as described in Chapter IX. The accuracy of this data for modeling purposes is low. For example, the M2 tide at the southwestern boundary of the model has an amplitude of about 30 cm. This is amplified about five times in the eastern part of Bristol Bay. Thus, a relatively small error on the boundary will induce considerable deviation of computed water levels.

C. STUDY APPROACH FOR FY 1978

1. Bristol Bay Model

The tide data which were received on July 11, 1977 from the Pacific

*Marchuk, G. I., et al., "Mathematical Modeling of Surface Turbulence in the Ocean," *Izv., Atmospheric and Ocean Physics*, Vol. 12, No. 8, 1976, pp. 841-849.

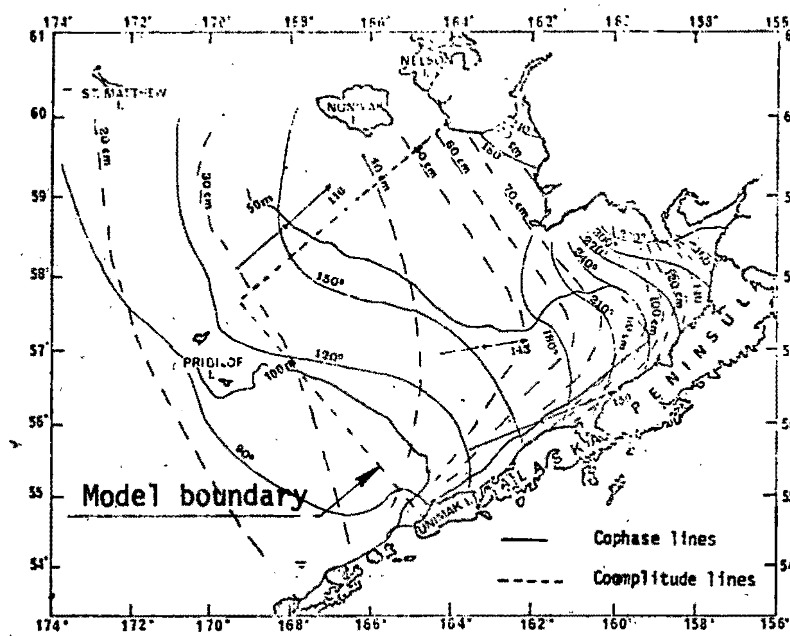


Fig. 3--M2 Cotide chart of Bristol Bay
(compiled by PMEL)

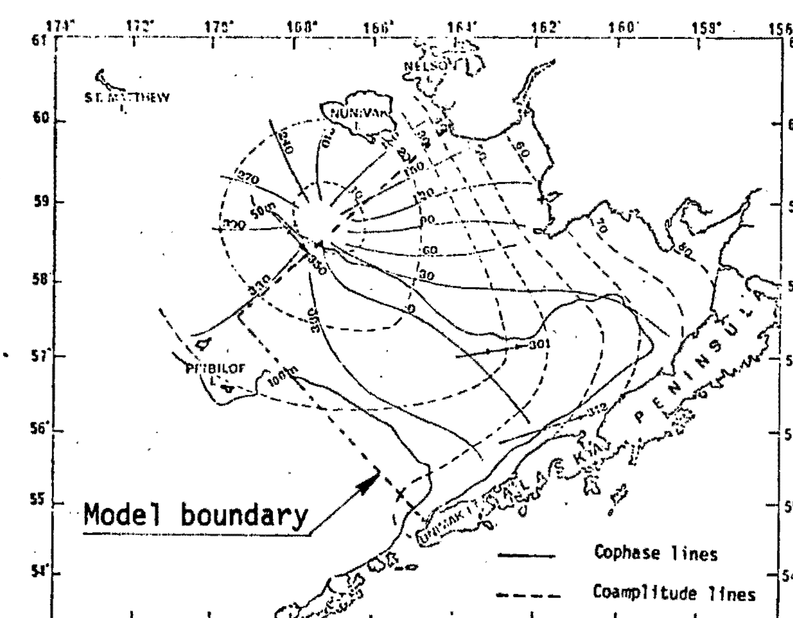


Fig. 4--K1 Cotide chart of Bristol Bay
(compiled by PMEL)

Marine Environmental Laboratory now make it possible to determine the layout of the model boundaries (Fig. 5). Since the northwestern boundary of the model passes through an amphidromic point of the major diurnal tide component (K1), this boundary has to be described in considerable detail. For this reason the tidal components will be described at several locations on this boundary as functions of amplitude, frequency and phase. Between these locations, the amplitudes and phases will be linearly interpolated for all available tidal components (Q1, O1, P1, K1, U2, N2, M2, S2). Similarly, the southwestern boundary will be described by linear interpolation between different stations. This boundary is now somewhat more inland. The area near this boundary is now somewhat flatter, which can be better described. By moving this boundary we reduced computer memory requirements considerably.

Once all boundary tide data are available, simulations will be made for a homogeneous sea. Bottom friction as well as the coefficients of the subgridscale energy generation and decay will be adjusted until tidal amplitudes and phases in the interior of the model are in approximate agreement with observation. All these experiments will be made without wind. Subsequently, salinity distributions as observed will be inserted in the model. The model will first be tested for stability of the computation and approximate stability of the density field. If these conditions are satisfied, responses of wind fields from the north, northwest and west will be determined.

If field data according to our specifications are obtained, that data will be used for boundary description and for verification. The required data are described in Chapter XI.

2. Norton Sound Model

The layout of the Norton Sound model is shown in Fig. 6. Presently we have only a very rudimentary understanding of the tidal propagation of the main diurnal and semidiurnal components. We are presently planning to describe the two open boundary sections of this model in three sections. In each section a linear interpolation of tidal amplitude and phase of each component will be used. The progress of the investigation will follow the one described for Bristol Bay. First, boundary conditions will be

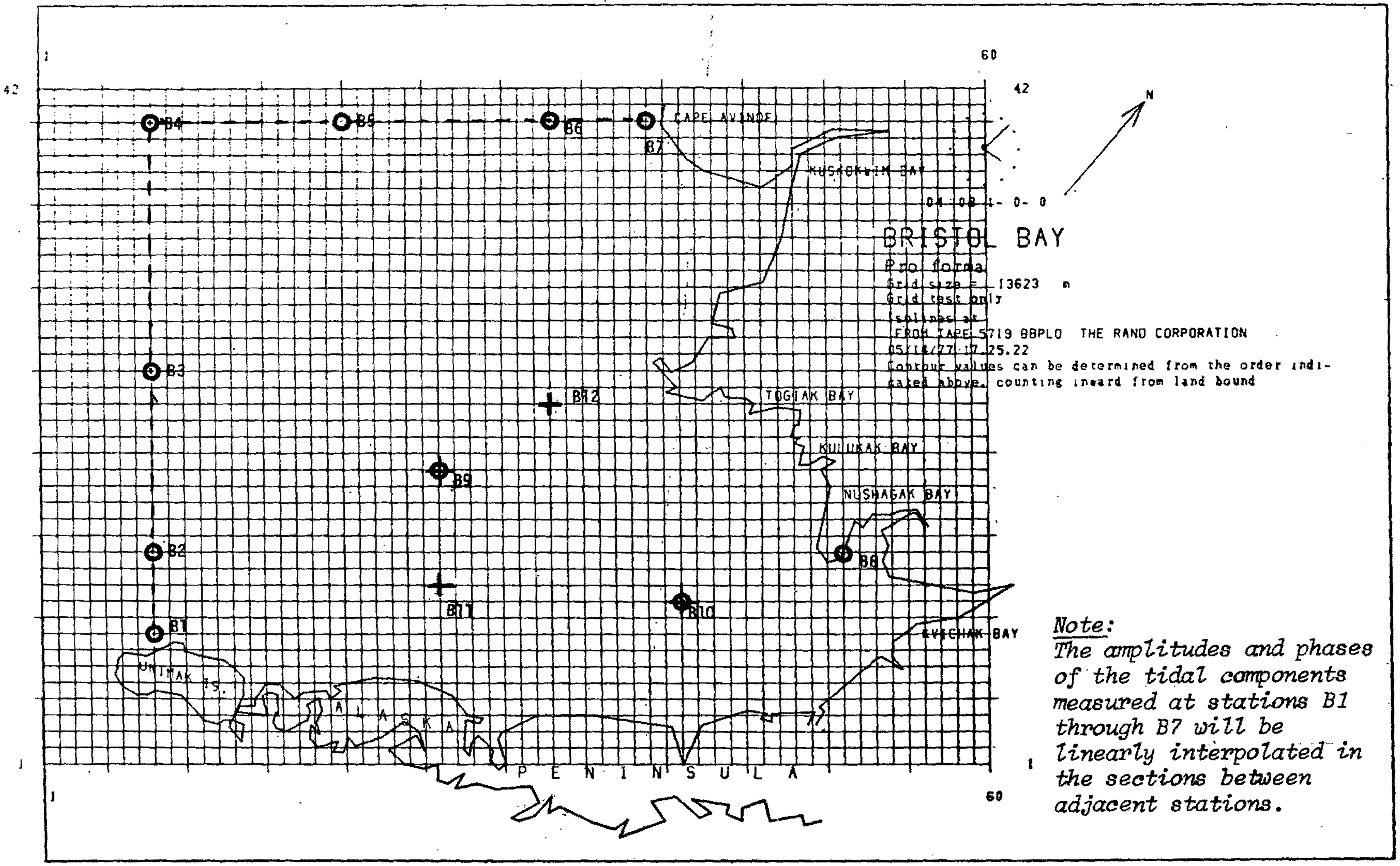


Fig. 5--Layout of the Bristol Bay model

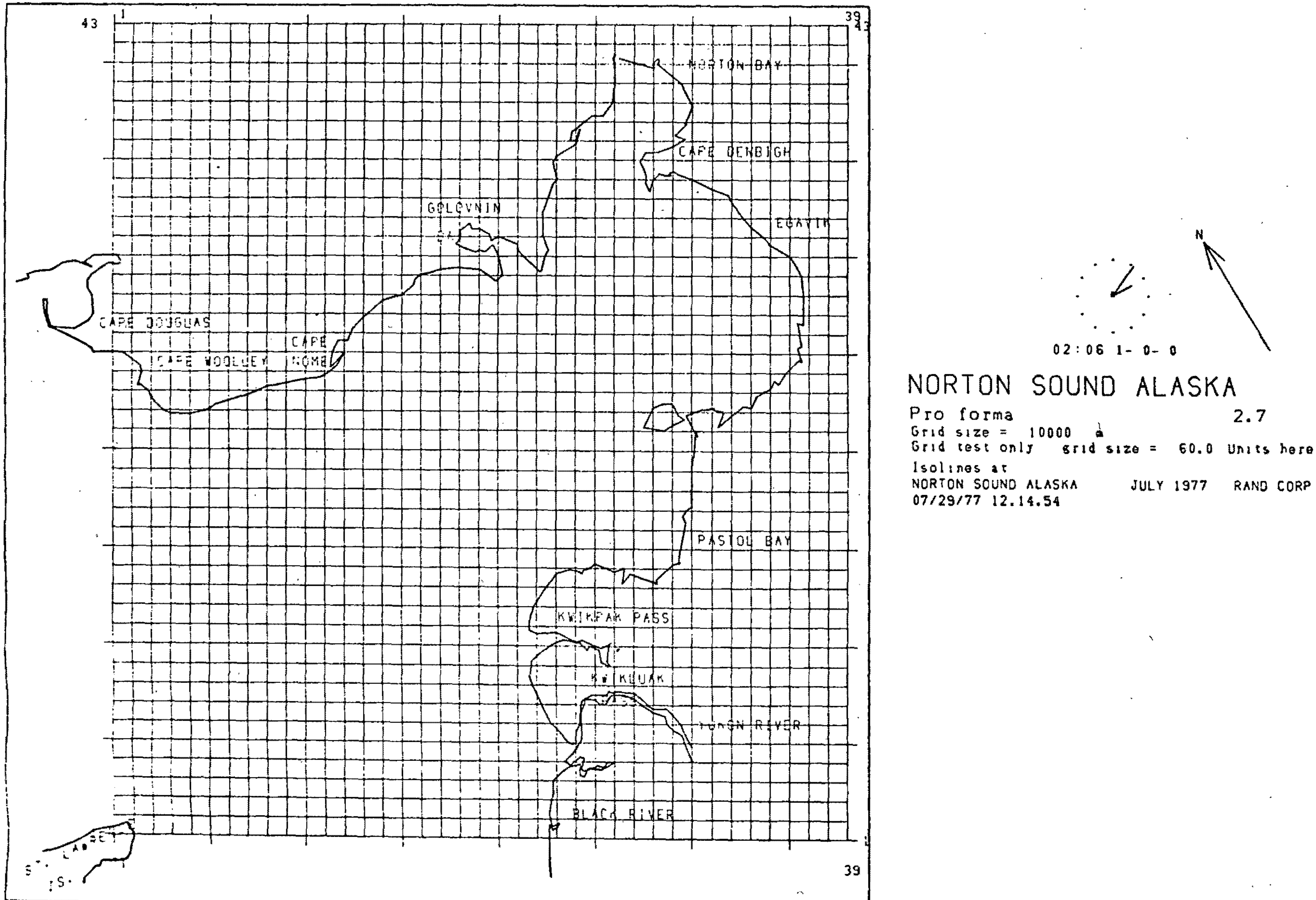


Fig. 6--Layout of the Norton Sound model

determined; subsequently, computations will be made with a homogeneous sea, after which the approximate salinity field will be introduced. Finally, the responses to wind from significant directions will be simulated. All model results will be presented in graphical form. The required data are described in Chapter XI.

IX. ANTICIPATED PROBLEMS IN FY1978

One of the major problems which we expect to face during the investigation is instabilities in the computation near the boundary. These instabilities occur when the boundary conditions are ill-posed by our interpretation of the field data, or by the assumptions we make if such data are not available from the field data collection program.

The generation of these conditions can be imagined by considering flow in the direction perpendicular to the open boundary. We assume that no flow in the V direction exists, thus there is no flow component parallel to the boundary. It is also assumed that water depth is uniform. In the computation flow perpendicular to the boundary generates a water level gradient just inside the boundary. This computed gradient should match the imposed gradient on the boundary, as otherwise a local discontinuity would be generated and the problem would be ill-posed mathematically.

As a result of such an ill-posed boundary condition, the flow pattern becomes irregular, as shown in Fig. 7. If this ill-posed condition is severe and of long duration, an error wave will radiate from it and the computation may fail. If the estimated boundary condition deviates only slightly from the one which is compatible with the flow field, the computation generally can be continued, as some damping exists in the system. To reduce these problems, we are considering introducing radiative boundary conditions. With these conditions we hope to be able to radiate error waves out of the computational field rather than locking them into a model with rigidly described open boundaries.

It is anticipated that accurate data, as requested in Chapter XI, will eliminate or reduce this boundary problem considerably, as the boundaries will then match the internal flow field of the model.

Since our model with the exchange coefficients computed from the turbulent energy is relatively new, we do not yet have extensive experience with the stability of density differences. If a considerable density gradient in the vertical exists, the vertical mass and momentum exchanges are reduced and the upper and lower layers become uncoupled. We have still to experience the implications of that condition.

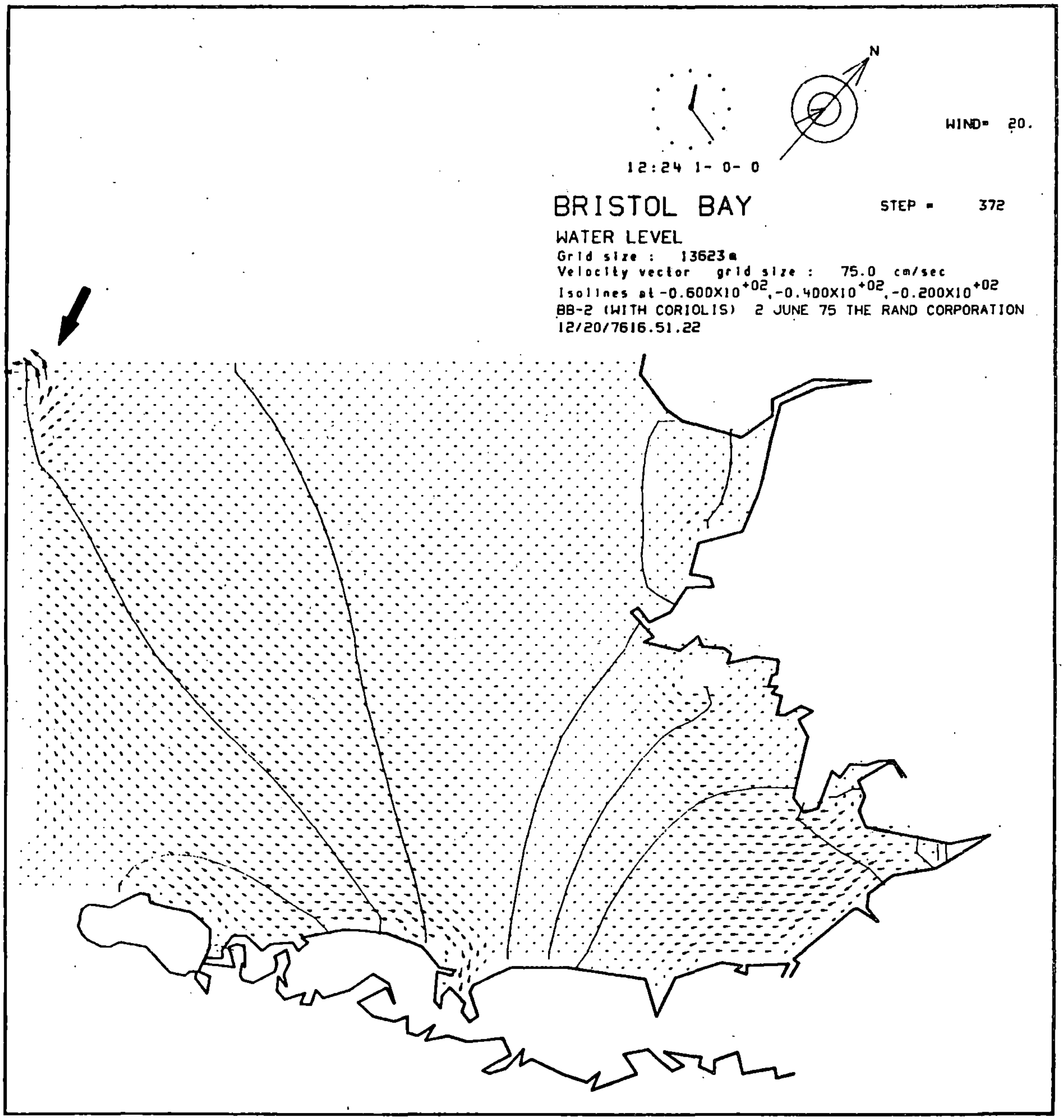


Fig. 7--Incipient instability near ill-posed open boundary in western part of the Bristol Bay model

X. DELIVERABLE PRODUCTS

The results of the investigation will be reported in a Rand report. The draft of the report will be made available at the end of the contract period. This report will describe the computational procedures used, the method of tidal adjustment and verification, the experiments to obtain the response of the water body to wind fields and a discussion. The report will be widely distributed, not only to the sponsor, but also to Rand subscription libraries in the U.S. and abroad.

The report will be illustrated with computer-made graphs of model results. Graphs will be presented of isocontours of water levels, areas of rise and fall of the tide at certain time intervals, current intensities at different depths at certain time intervals, and time histories of velocities, water levels and transport at different locations. Also, computed cotidal charts of the principal components of the tide will be prepared.

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

Simultaneous water level data (pressure data) are required for several stations on the boundary of the models, together with pressure and current data at several stations inside the model areas.

The data series for each model should be simultaneous for a period of at least 15 days, preferably for a period of 30 days. The interval of sampling should be at least 15 min. Particular emphasis should be placed on the accuracy of time in the observations.

It will be noted that land-based tide level stations are included in the station requirements. These data are important for the determination of wind effects.

Figure 8 presents a chart of the required locations for the Bristol Bay model, and Fig. 9 a chart of the required locations for the Norton Sound model. Tables 1 and 2 present the coordinates of the required stations.

In addition to the pressure and current data, wind and barometric pressure data are required for a few stations in or adjacent to the model area. We have assumed that hourly surface weather observations are made routinely at St. Paul Island in the Pribilof and on one or two stations on the Alaska Peninsula.

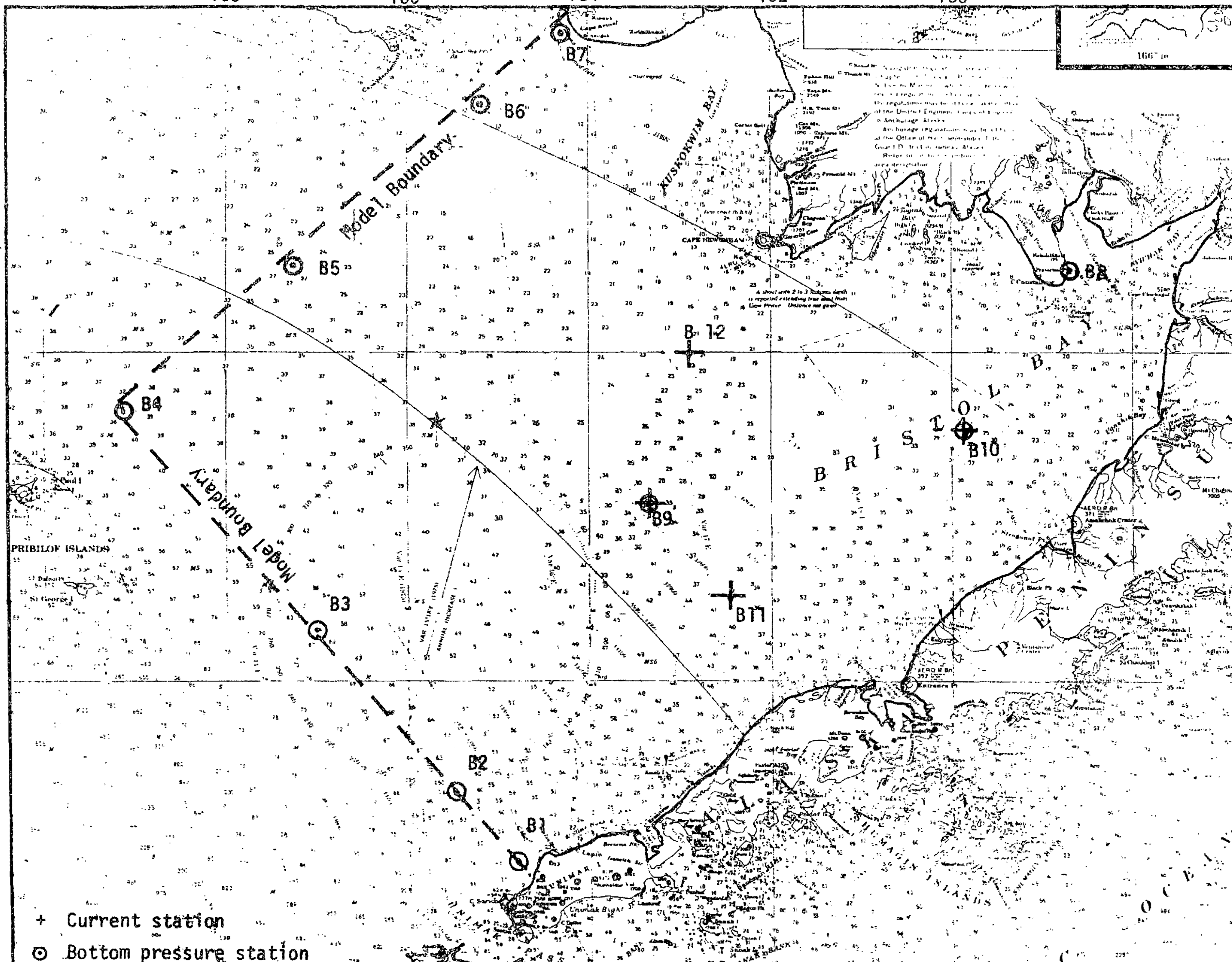


Fig. 8--Location of desired water level and current measurement stations in Bristol Bay

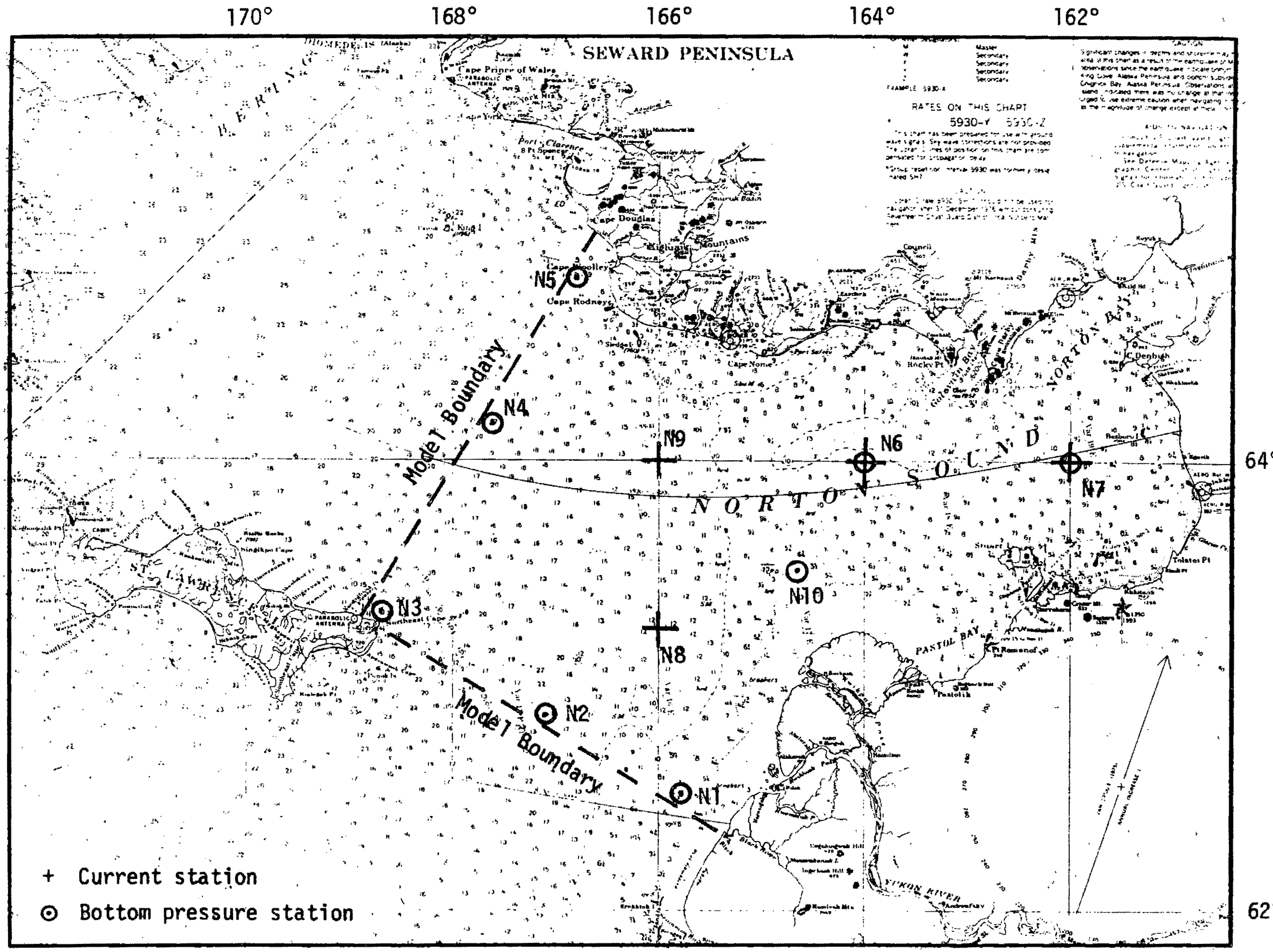


Fig. 9--Location of desired water level and current measurement stations in Norton Sound

Table 1

OBSERVATION STATIONS REQUIRED FOR BRISTOL BAY MODEL

Station Number	Type	Location on Vertical	Latitude	Longitude
B1	Pressure	Bottom	54°55′	164°50′
B2	Pressure	Bottom	55°20′	165°30′
B3	Pressure	Bottom	56°14′	167°00′
B4	Pressure	Bottom	57°37′	169°04′
B5	Pressure	Bottom	58°33′	167°11′
B6	Pressure	Bottom	59°31′	165°10′
B7	Pressure	Bottom	59°59′	164°14′
B8	Level gauge	Surface	58°30′	158°41′
B9	Pressure gauge Current meter	Bottom 0.2 & 0.8 of depth	57°04′	163°20′
B10	Pressure gauge Current meter	Bottom 0.2 & 0.8 of depth	57°30′	159°50′
B11	Current meter	0.2 & 0.8 of depth	56°30′	162°22′
B12	Current meter	0.2 & 0.8 of depth	58°00′	162°50′

Table 2

OBSERVATION STATIONS REQUIRED FOR NORTON SOUND MODEL

Station Number	Type	Location on Vertical	Latitude	Longitude
N1	Pressure	Bottom	62°30′	165°46′
N2	Pressure	Bottom	62°54′	167°05′
N3	Pressure	Bottom	63°21′	168°40′
N4	Pressure	Bottom	64°10′	167°36′
N5	Pressure	Bottom	64°51′	166°46′
N6	Pressure Current meter	Bottom 0.2 & 0.8 of depth	64°00′	164°00′
N7	Pressure Current meter	Bottom 0.2 & 0.8 of depth	64°00′	162°00′
N8	Current meter	0.2 & 0.8 of depth	64°00′	166°00′
N9	Current meter	0.2 & 0.8 of depth	63°14′	166°00′
N10	Pressure	Bottom	63°32′	165°38′

XV. MANAGEMENT PLAN

The sequence of the different steps in the investigation follows quite naturally, for example, input data has to be prepared before adjustment simulation can be made. Since this investigation is performed simultaneously with other similar investigations for other sponsors, the main task is scheduling the different steps according to availability of certain computer system analysts.

Experience has shown that progress in this type of investigation is quite regular. Financial control and control over the manpower effort of all project personnel is exerted by the project leader through biweekly financial statements on the project which are available one week after each fortnightly accounting period. In these statements actual manpower, computing, travel and overhead charges are indicated, as well as the projected charges. In addition, the total expenditures are graphed.

The major steps of the investigation are indicated in Table 3.

MILESTONE CHART

△ Planned Completion Date

▲ Actual Completion Date

RU #: 435

PI: J. J. Leendertse and S. K. Liu

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES		1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D			
BRISTOL BAY MODEL:	Tide adjustment	---	---	---	△														
	Adjustment density field					---	△												
	Determination wind responses							---	---	△									
	Model verification on new FY1978 data										---	△							
NORTON SOUND MODEL:	Boundary tide determination	---	---	△															
	Tide adjustment				---	---	△												
	Adjustment density field							---	△										
	Determination wind responses									---	△								
	Model verification on new field data										---	---	△						
REPORTING:	Draft submittal											---	---	△					
	Review and printing													---	---	△			

5/20/77

Table 3

XVI. OUTLOOK

After the adjustment of the models to tidal inputs on the boundaries of the model and to the determination of responses of the water body to wind fields, the research can logically proceed towards prediction of movements of dissolved and floating substances.

In order to take protective measures in case of oil spills, an effective method should become available for prediction. Since these predictions have to be made suddenly, it seems prudent to develop a method which is relatively simple and easy to apply. It is our proposal to develop such a method from system characteristics obtained from model results and also from field data. It is also our proposal to evaluate this method by use of observed data (e.g., surface drifters).

The pathways of floating substances are determined by tides, by residual currents and by the transient movement of the top layers as a whole under influence of wind fields. In addition, the pathways are a result of the direct influence of wind shear (surface movement).

The model would provide vital data for determining the first three effects mentioned above.

The approach proposed here would determine response functions for pathways from wind and tide data. To illustrate our approach we will first discuss estimation by use of response functions.

For the propagation of tides, amplitude and phase relationships between two stations can be determined by cross-spectral analysis. Once this relation is established, the tide elevation of a station can be determined from the others by so-called convolution. This estimation technique will also give the expected error of the prediction. Something similar can be done for the relation between short duration wind fields over a certain area and the fluid motions (or fluid surface motions) in that field. This analysis can be made most effectively by use of a properly adjusted and verified model.

It is our intention to express response functions relating the causes and effects for a set of locations under a few typical conditions. The actual response of an arbitrary time-varying wind field can then be predicted by use of these functions. In addition, we intend to account for the direct influence of the wind shear and the dispersion effect. The final result of this research effort would be a relatively simple computer program with instructions for its use.

At the end of FY1979 we would have advanced sufficiently to show the effectiveness of the approach based upon field experiments which have already been executed. At the end of FY1980, the computer program would have been refined, thoroughly tested and an instruction manual prepared.

An estimate of the cost has been provided in the cost section of this report. The level of the present effort will be approximately maintained.

For this investigation no major equipment purchases are required. The field tests with drifters which can be used for evaluation are already planned.

XVII. ACTIVITIES, REPORTS AND PUBLICATIONS

1. Updated Activity Management Charts will be submitted quarterly.
2. Quarterly Reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, Annual Reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.
3. At the option of the Project Office the Principal Investigator is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.
4. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.
5. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard:

   "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

Appendix A

SAMPLES OF GRAPHICAL OUTPUTS OF THE NORTON SOUND AND BRISTOL BAY MODELS

Note: The simulations were made with open boundaries estimated from tide tables and a homogeneous density.

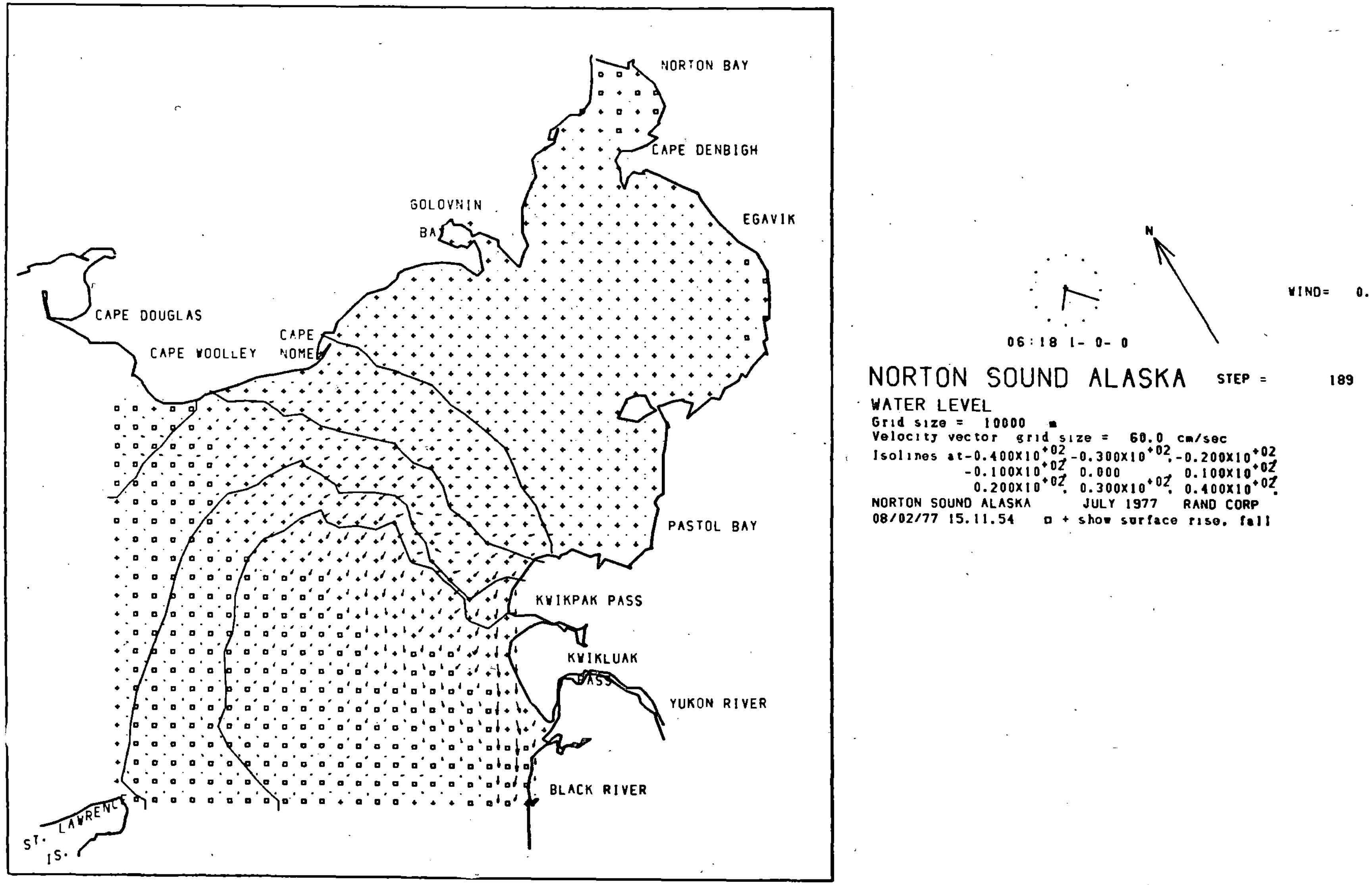


Fig. A-1--Computed water levels and rise or fall of the tide at a particular time in the Norton Sound model

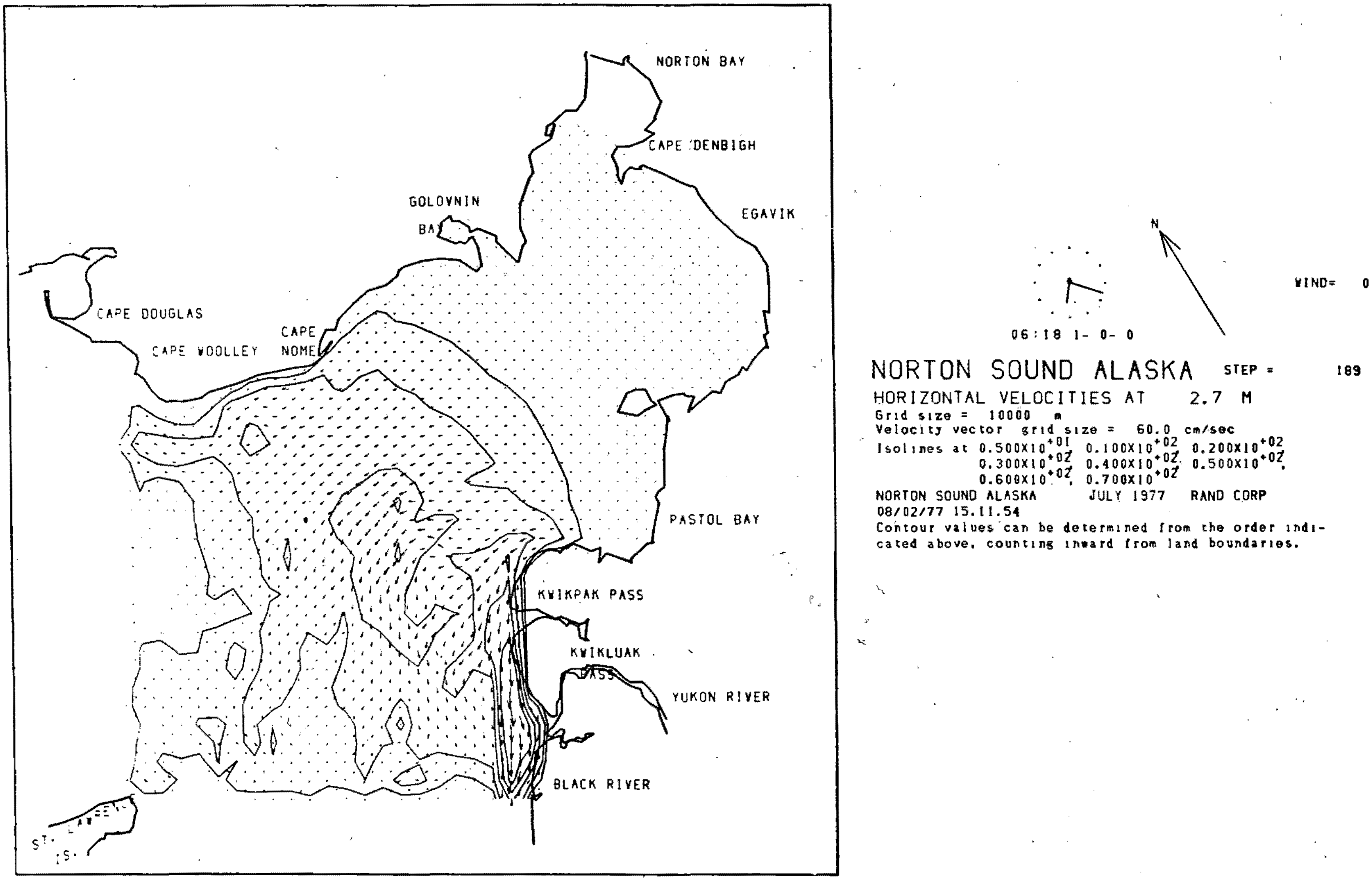


Fig. A-2--Computed horizontal velocities at 2.7 m at a particular time in the Norton Sound model

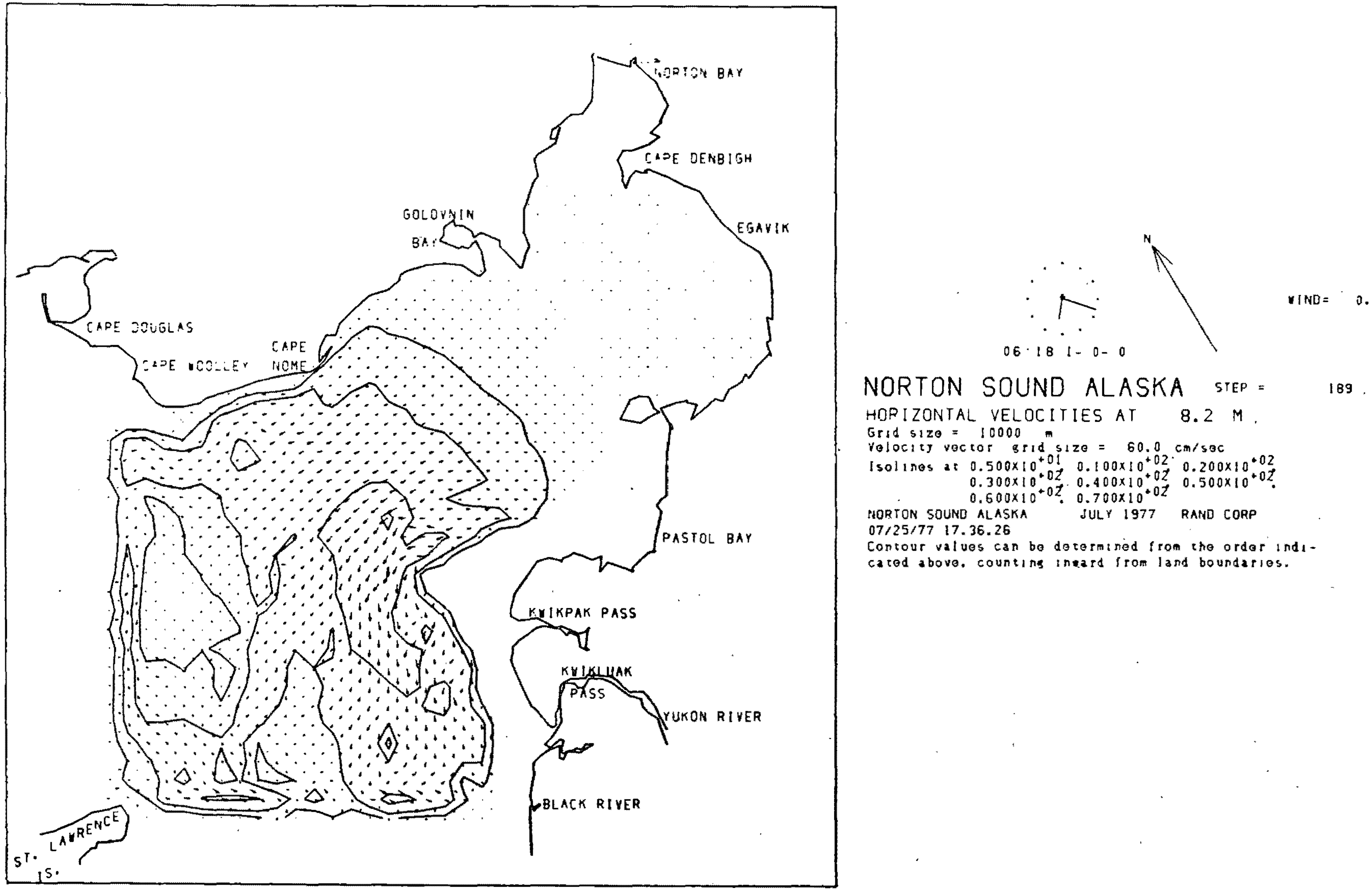


Fig. A-3--Computed horizontal velocities at 8.2 m at a particular time in the Norton Sound model

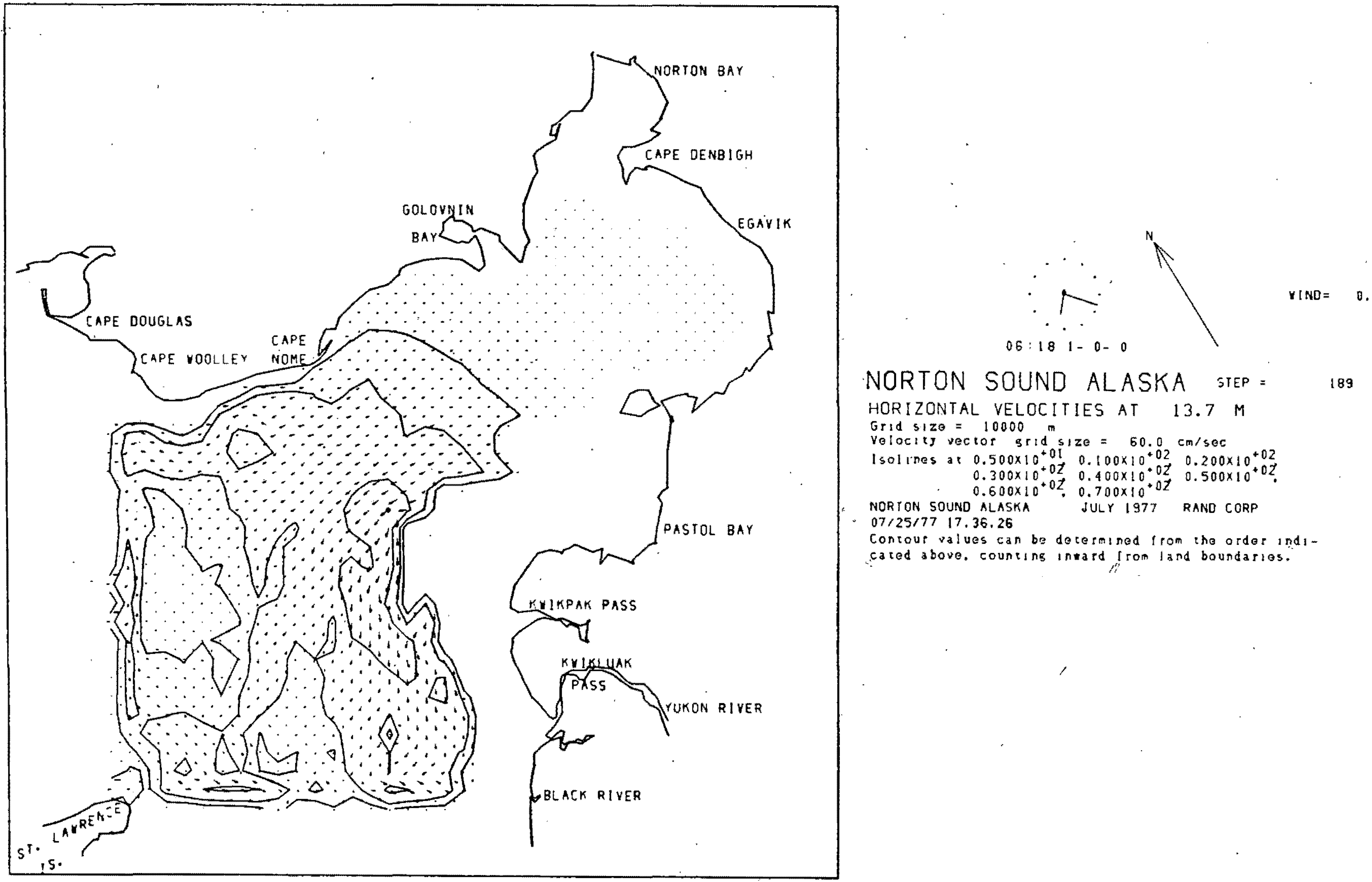


Fig. A-4--Computed horizontal velocities at 13.7 m at a particular time in the Norton Sound model

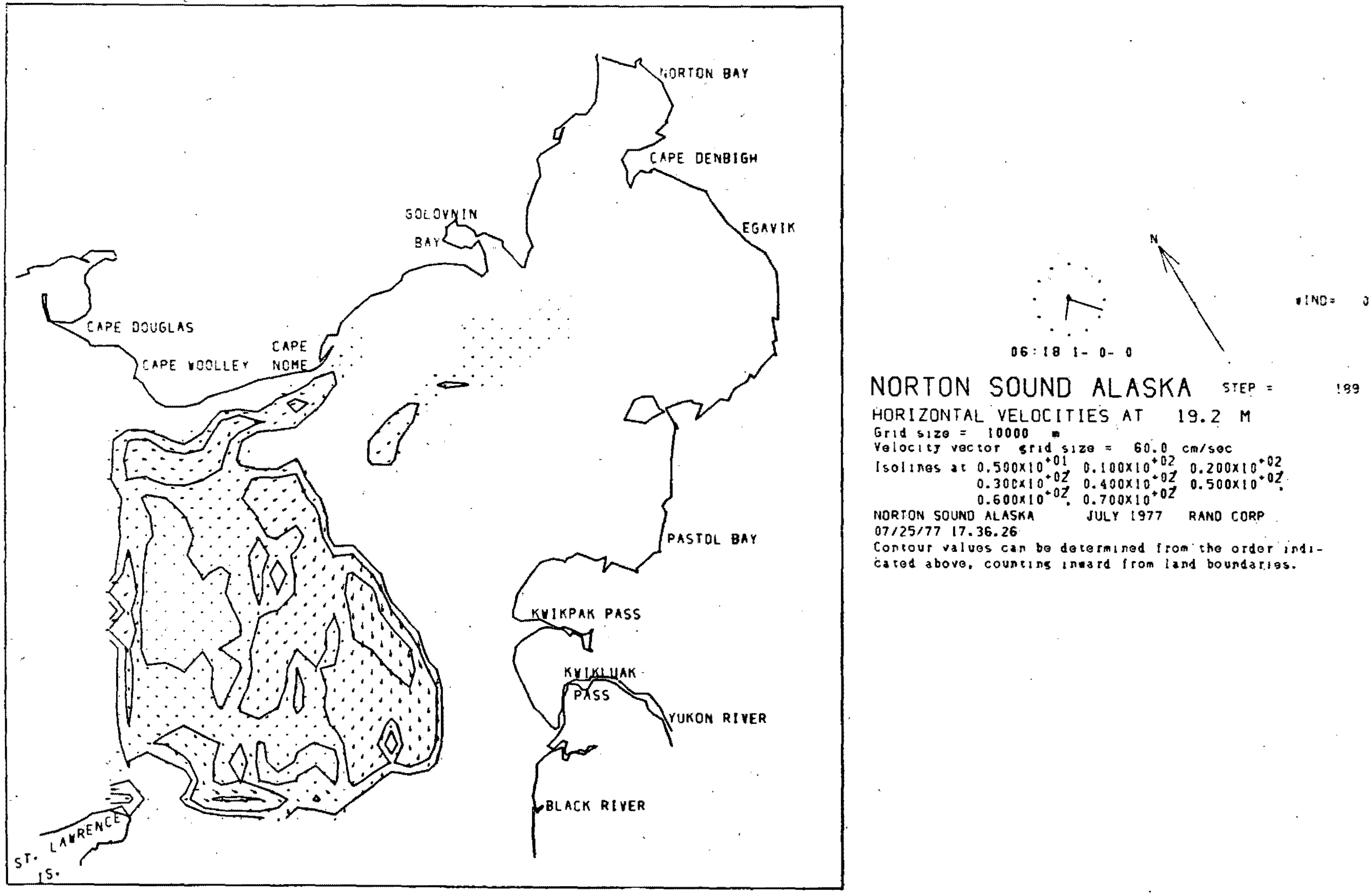


Fig. A-5--Computed horizontal velocities at 19.2 m at a particular time in the Norton Sound model

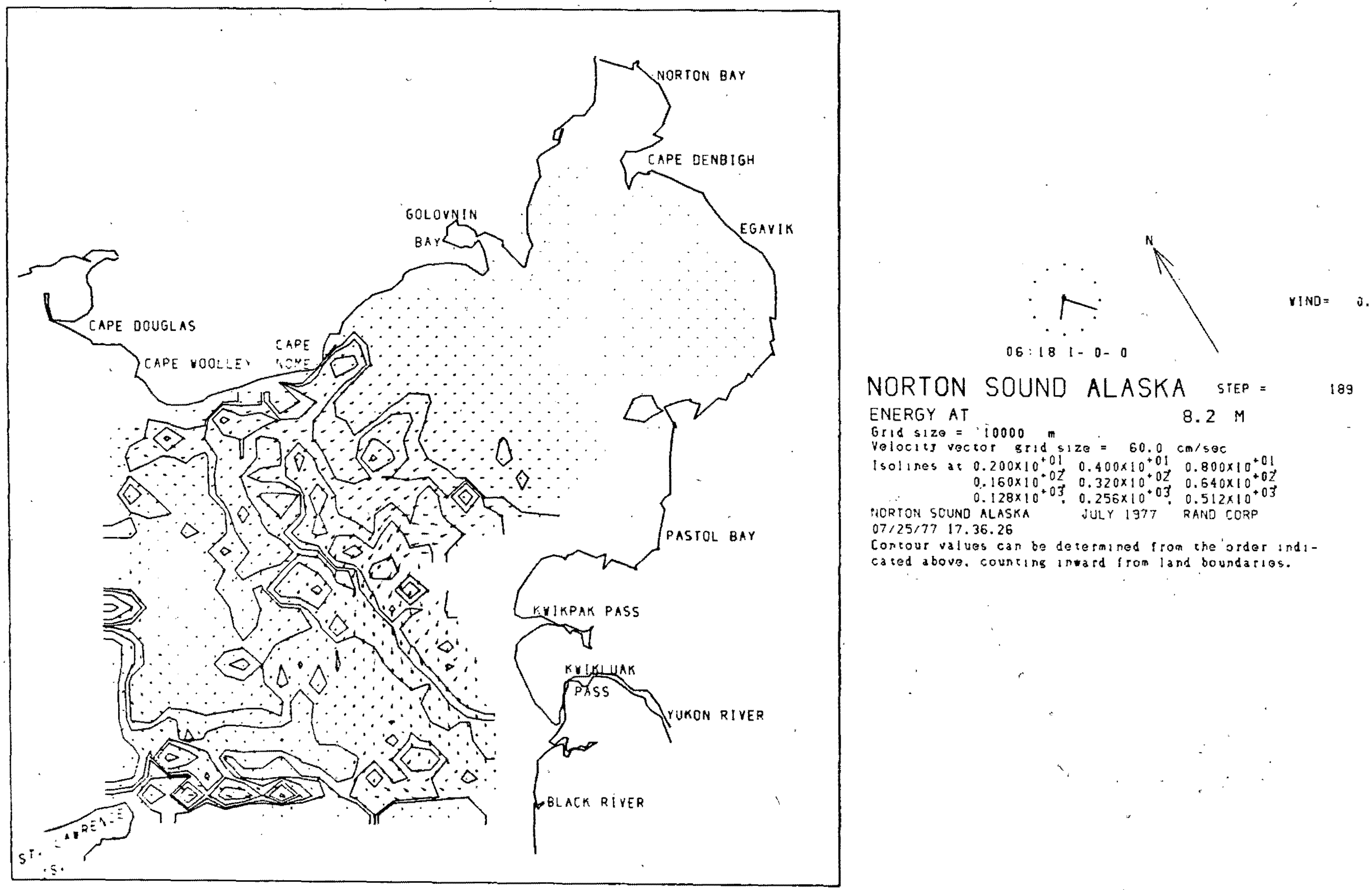


Fig. A-6--Computed subgridscale energy at 8.2 m in the Norton Sound model

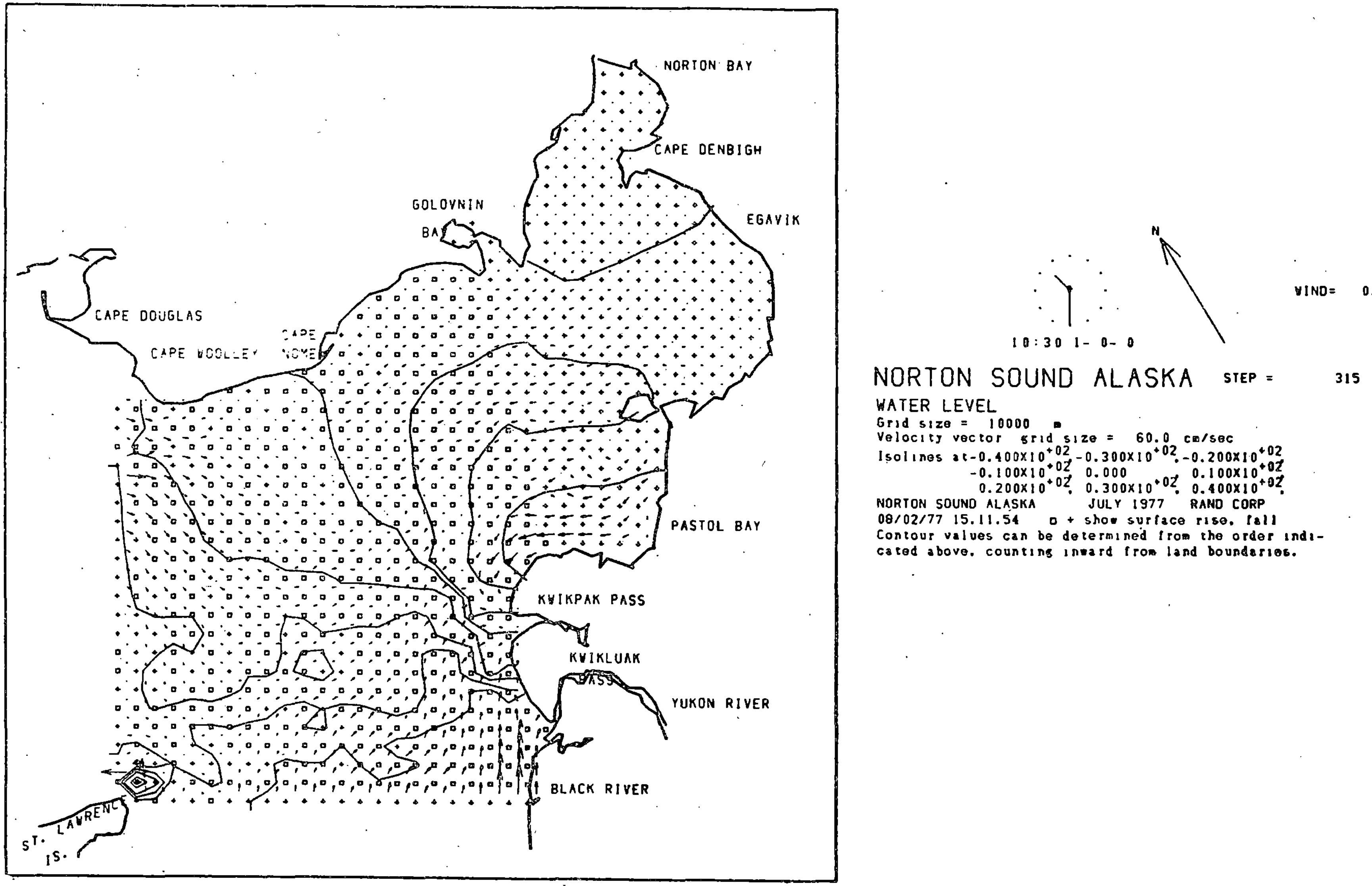


Fig. A-7--Computed water levels and rise or fall of the tide at a particular time in the Norton Sound model

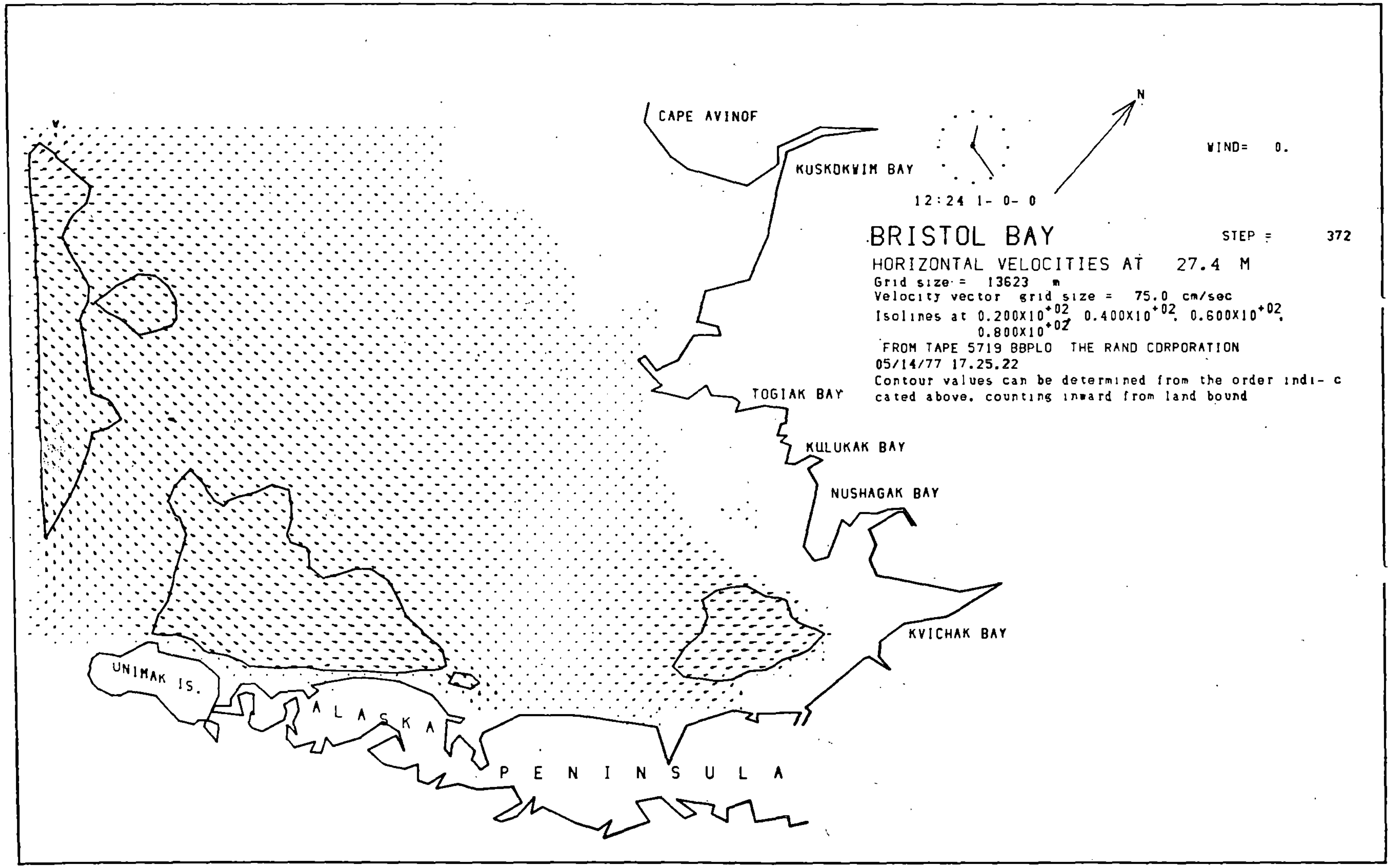


Fig. A-9--Computed horizontal velocities at 27.4 m in the Bristol Bay model

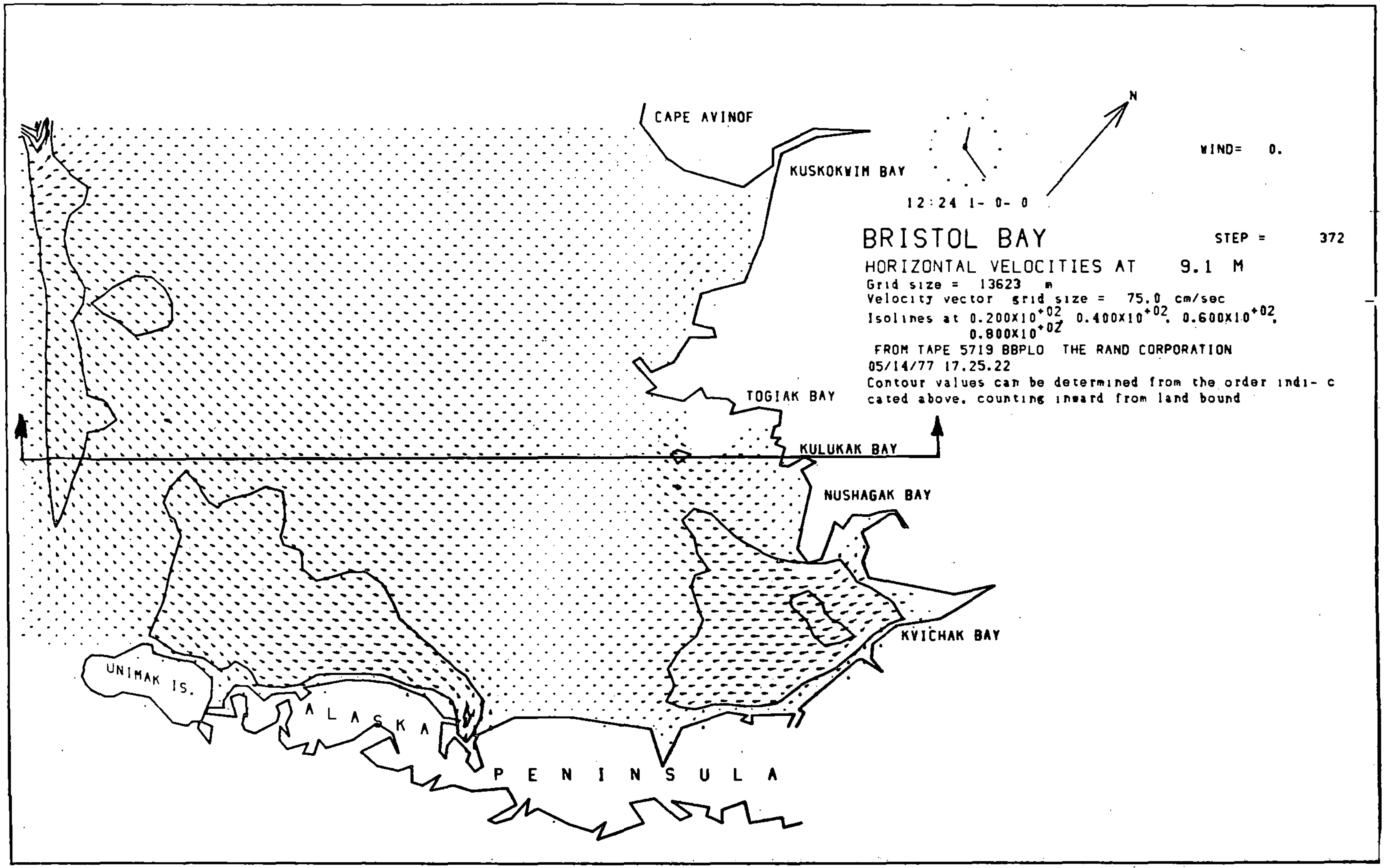


Fig. A-8--Computed horizontal velocities at 9.1 m in the Bristol Bay model

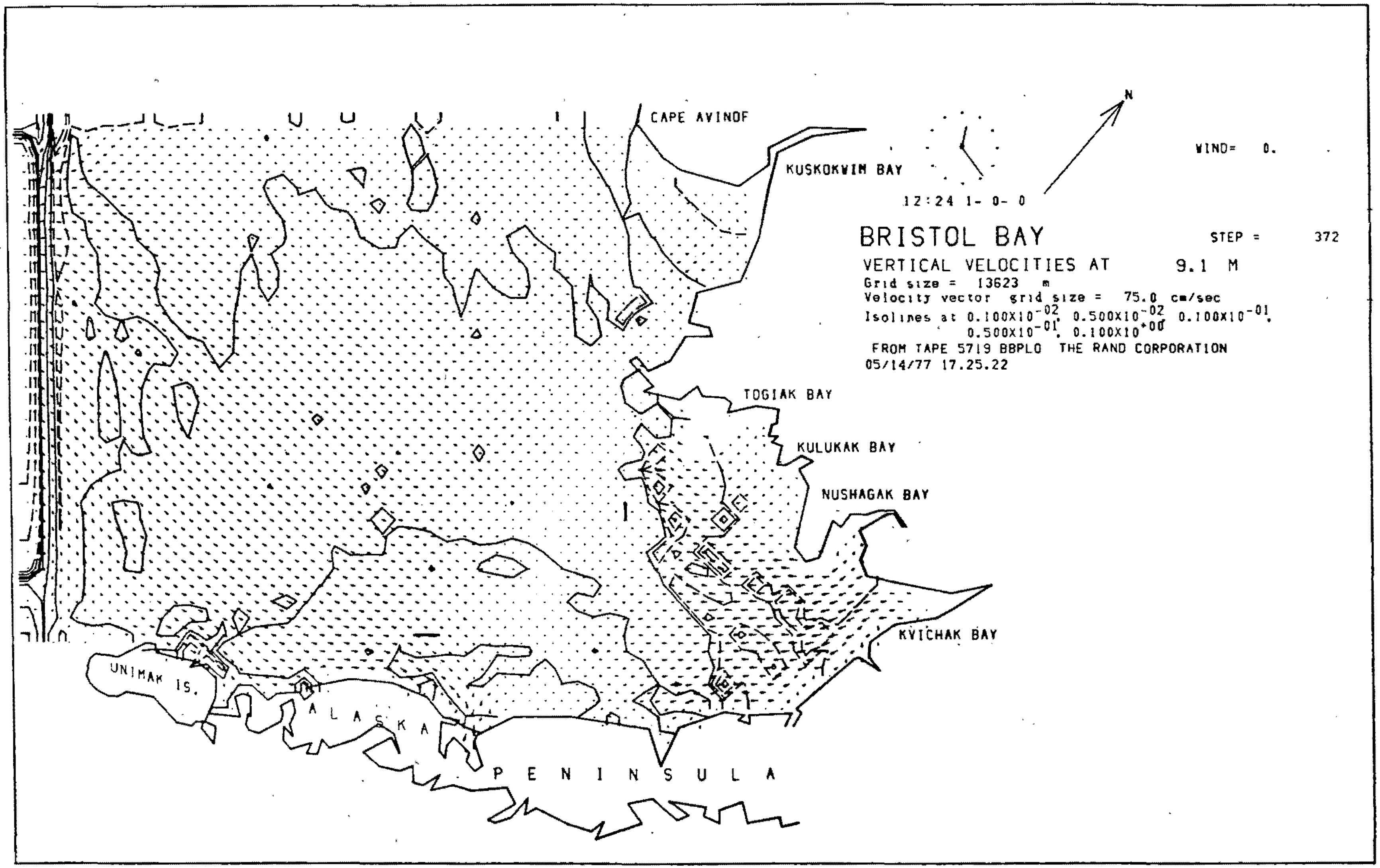


Fig. A-10--Isocontours of computed vertical velocity components in the Bristol Bay model. (Dashed contours refer to downward movements)

Fig. A-11--Computed velocity components in a vertical plane of the Bristol Bay model. (The location of the section is shown in Fig. A-8)

Appendix B

METHOD OF COMPUTATION OF THE THREE-DIMENSIONAL MODEL USED FOR THE BRISTOL BAY AND NORTON SOUND MODELS

The finite difference equations used in the models are very similar to those described in Refs. 1 and 2. In addition to salinity and temperature, constiuents and SGS energy are now also computed. If one constituent is computed, then the model simultaneously solves seven partial differential equations together with an equation of state for various complicated boundary conditions.

The expressions for the equations of momentum and mass balance have been changed from those described in Refs. 1 and 2, but their location on the grid is unchanged (Fig. 1). The terms with the vertical exchange coefficients are now computed implicitly rather than explicitly. Consequently, all concentrations, momentum components and SGS energy values are computed simultaneously for each series of points in a vertical. This computation method eliminated stability conditions related to the value of the exchange coefficients.

The continuity equation, the mass, momentum and SGS energy balance equations for the interior of the water body and the equation of state are:

$$\overline{\delta_t \zeta}^t = - \sum_k \left\{ \delta_x(\overline{h}^x u) + \delta_y(\overline{h}^y v) \right\} \qquad \text{at } i, j, n \tag{1}$$

$$\overline{\delta_t(\overline{h}^x u)}^t = - \delta_x(\overline{\overline{h}^x u}^x \overline{u}^x) - \delta_y(\overline{\overline{h}^y v}^x \overline{u}^y) - \overline{h}^x \delta_z(\overline{u}^z \overline{w}^x) + f\overline{h}^x \overline{v}^{xy} - \frac{1}{\overline{\rho}^x} \overline{h}^x \delta_x p$$
$$+ \frac{1}{\overline{\rho}^x} \left[h\delta_z E_x \delta_z \overline{u}^{2t} + \delta_x \left\{ hA_x \delta_x u \right\}_- + \delta_y \left\{ \overline{\overline{h}^x \overline{A_y}^x}^y \delta_y u \right\}_- \right] \qquad \text{at } i + ½, j, k, n \tag{2}$$

$$\rho = \left[5890 + 38T - 0.375T^2 + 3s\right] \Big/ \Big[\left(1779.5 + 11.25T - 0.0745T^2\right) - \left(3.8 + 0.01T\right)s + 0.698\left(5890 + 38T - 0.375T^2 + 3s\right)\Big] \quad \text{at } i,\ j,\ k,\ n+1 \qquad (8)$$

The finite-difference equation used to compute the vertical velocities is

$$\delta_z w = -\,\delta_x\left(\overline{h}^x u\right) - \delta_y\left(\overline{h}^y v\right) \quad \text{at } i,\ j,\ k,\ n+1 \qquad (9)$$

This equation gives directly the velocities by starting the computation at the bottom layer (K). At the bottom the velocity is zero, thus the velocity between the bottom layer and the layer above can be computed. This velocity (at K - ½) in turn can be used for the application of Eq. (9) and K - 1.

The horizontal pressure gradients in the top layer are:

$$\delta_x p = g\overline{\rho}^x \delta_x \zeta + \tfrac{1}{2}\, \overline{h}^x \delta_x \rho \quad \text{at } i + \tfrac{1}{2},\ j,\ 1,\ n+1 \qquad (10)$$

$$\delta_y p + g\overline{\rho}^y \delta_y \zeta + \tfrac{1}{2}\, \overline{h}^y \delta_y \rho \quad \text{at } i,\ j + \tfrac{1}{2},\ 1,\ n+1 \qquad (11)$$

Once these pressure gradients are known, then the gradients for the other layers are computed with increasing k by use of

$$\delta_z(\delta_x p) = g\delta_x \overline{\rho}^z \quad \text{at } i + \tfrac{1}{2},\ j,\ k + \tfrac{1}{2},\ n+1 \qquad (12)$$

$$\delta_z(\delta_y p) = g\delta_y \overline{\rho}^z \quad \text{at } i,\ j + \tfrac{1}{2},\ k + \tfrac{1}{2},\ n+1 \qquad (13)$$

THE EQUATIONS FOR THE TOP AND BOTTOM LAYERS

In the top layer, the momentum equations now contain the effect of the surface wind, and the equations are now written

$$\overline{\delta_t(\overline{h}^y v)}^t = -\delta_x(\overline{\overline{h}^x u}^y \overline{v}^x) - \delta_y(\overline{\overline{h}^y u}^y \overline{v}^y) - \overline{h}^y \delta_z(\overline{v}^z \overline{w}^y) - f\overline{h}^y \overline{u}^{xy} - \frac{1}{\overline{\rho}^y} \overline{h}^y \delta_y p$$

$$+ \frac{1}{\overline{\rho}^y} \left[h\delta_z E_y \delta_z \overline{v}^{2t} + \delta_x \left\{ \overline{\overline{h}^y A_x}^y{}^x \delta_x v \right\}_- + \delta_y \left\{ hA_y \delta_y v \right\}_- \right] \quad \text{at } i,\ j + \tfrac{1}{2},\ k,\ n \tag{3}$$

$$\overline{\delta_t(hs)}^t = -\delta_x(\overline{h}^x u \overline{s}^x) - \delta_y(\overline{h}^y v \overline{s}^y) - h\delta_z(w\overline{s}^z)$$

$$+ \delta_x \left\{ \overline{h}^x D_x \delta_x s \right\}_- + \delta_y \left\{ \overline{h}^y D_y \delta_y s \right\}_- - h\delta_z \left\{ \kappa \delta_z \overline{s}^{2t} \right\} \quad \text{at } i,\ j,\ k,\ n \tag{4}$$

$$\overline{\delta_t(hT)}^t = -\delta_x(\overline{h}^x u \overline{T}^x) - \delta_y(\overline{h}^y v \overline{T}^y) - h\delta_z(w\overline{T}^z)$$

$$+ \delta_x \left\{ \overline{h}^x D_x \delta_x t \right\}_- + \delta_y \left\{ \overline{h}^y D_y \delta_y T \right\}_- + h\delta_z \left\{ \kappa' \delta_z \overline{T}^{2t} \right\} \quad \text{at } i,\ j,\ k,\ n \tag{5}$$

$$\overline{\delta_t(he)}^t = -\delta_x(\overline{h}^x u \overline{e}^x) - \delta_y(\overline{h}^y v \overline{e}^y) - h\delta_z(w\overline{e}^z)$$

$$+ \delta_x\left\{\overline{h}^x D_x \delta_x e\right\}_- + \delta_y\left\{\overline{h}^y D_y \delta_y e\right\}_- + h\delta_z\left\{E_e \delta_z \overline{e}^{2t}\right\}$$

$$+ S - Dh \qquad \text{at } i, j, K, n \qquad (6)$$

$$\overline{\delta_t(hP)}^t = -\delta_x(\overline{h}^x u \overline{P}^x) - \delta_y(\overline{h}^y v \overline{P}^y) - h\delta_z(w\overline{P}^z)$$

$$+ \delta_x\left\{\overline{h}^x D_x \delta_x P\right\}_- + \delta_y\left\{\overline{h}^y D_y \delta_y P\right\}_- + h\delta_z\left\{\kappa \delta_z \overline{P}^{2t}\right\} + S_P$$

$$\text{at } i, j, K, n \qquad (7)$$

$$\overline{\delta_t(\overline{h}^x u)}^t = -\delta_x(\overline{\overline{h}^x u}^x\,\overline{u}^x) - \delta_y(\overline{\overline{h}^y v}^x\,\overline{u}^y) - \overline{h}^x\delta_z(\overline{u}^z\overline{w}^x) + f\overline{h}^x\overline{v}^{xy} - \frac{1}{\overline{\rho}^x}\overline{h}^x\delta_x p$$
$$+\frac{1}{\overline{\rho}^x}\left[C^*\rho_a w_a^2 \sin\psi - \left(E_x\delta_z\overline{u}^{2t}\right)_{k=3/2} + \delta_x\left\{hA_x\delta_x u\right\}_- + \delta_y\left\{\overline{\overline{h}^x A_y}^y\,\delta_y u\right\}_-\right]$$

at $i+\frac{1}{2}$, j, 1, n (14)

$$\overline{\delta_t(\overline{h}^y v)}^t = -\delta_x(\overline{\overline{h}^x u}^y\,\overline{v}^x) - \delta_y(\overline{\overline{h}^y v}^y\,\overline{v}^y) - \overline{h}^y\delta_z(\overline{v}^z\overline{w}^y) - f\overline{h}^y\overline{u}^{xy} - \frac{1}{\overline{\rho}^y}\overline{h}^y\delta_y p$$
$$+\frac{1}{\overline{\rho}^y}\left[C^*\rho_a w_a^2 \sin\psi - \left(E_y\delta_z\overline{v}^{2t}\right)_{k=3/2} + \delta_x\left\{\overline{\overline{h}^y A_x}^x\,\delta_x v\right\}_- + \delta_y\left\{hA_y\delta_y v\right\}_-\right]$$

at i, $j+\frac{1}{2}$, 1, n (15)

where C^* = wind coefficient

ρ_a = density of air

w = wind speed

If it is assumed that no mass and temperature exchanges occur at the surface, then Eqs. (4), (5) and (8) are also applicable if the vertical exchange term is set to zero. Equation (6) is also valid for the subgridscale energy if no wind is present. If wind is present, then the subgridscale energy level is maintained by use of a special equation, which will be described later.

At the bottom layer, the momentum equations become:

$$\overline{\delta_t(\overline{h}^x u)}^t = -\delta_x(\overline{\overline{h}^x u}^x\,\overline{u}^x) - \delta_y(\overline{\overline{h}^y v}^x\,\overline{u}^y) - \overline{h}^x\delta_z(\overline{u}^z\overline{w}^x) + f\overline{h}^x\overline{v}^{xy} - \frac{1}{\overline{\rho}^x}\overline{h}^x\delta_x p$$
$$+\frac{1}{\overline{\rho}^x}\left[\left(E_x\delta_z\overline{u}^{2t}\right)_{k=K-\frac{1}{2}} - \overline{\rho}^x g u_-\left\{u_-^2 + (\overline{v}_-^{xy})^2\right\}^{\frac{1}{2}} \Big/ \left(\overline{C}^x\right)^2 + \delta_x\left\{hA_x\delta_x u\right\}_- + \delta_y\left\{\overline{\overline{h}^x A_y}^y\,\delta_y u\right\}_-\right]$$

at $i+\frac{1}{2}$, j, K, n (16)

$$\overline{\delta_t(\overline{h}^y v)}^t = -\delta_x(\overline{\overline{h}^x u}^y \overline{v}^x) - \delta_y(\overline{\overline{h}^y v}^y \overline{v}^y) - \overline{h}^y \delta_z(\overline{v}^z \overline{w}^y) - f\overline{h}^y \overline{u}^{xy} - \frac{1}{\overline{\rho}^y} \overline{h}^y \delta_y p$$

$$+ \frac{1}{\overline{\rho}^x}\left[\left(E_y \delta_z \overline{v}^{2t}\right)_{k=K-\frac{1}{2}} - \overline{\rho}^y g v_- \left\{(\overline{u}_-^{xy})^2 + v_-^2\right\}^{\frac{1}{2}} \Big/ \left(\overline{C}^y\right)^2 + \delta_x\left\{\overline{\overline{h}^y \overline{A_x}^y}^x \delta_x v\right\}_- + \delta_y\left\{h A_y \delta_y v\right\}_-\right]$$

$$\text{at } i,\ j+\tfrac{1}{2},\ K,\ n \qquad (17)$$

At the bottom no sources or sinks exist for constituents and temperature, thus Eqs. (4), (5) and (7) are valid, provided that the exchange terms at the bottom are set to zero. The subgridscale energy is not diffused out of the bottom layer, thus the vertical energy exchange coefficient can be set locally zero. However, SGS energy is generated at the bottom, as will be described later.

VERTICAL EXCHANGE COEFFICIENTS

For the vertical exchange coefficients in the model we make use of concepts independently introduced by Kolmogorov [3] and Prandtl [4]. According to these hypotheses, the turbulent eddy viscosity (ε) in a homogeneous fluid is directly related to the local energy:

$$\varepsilon = L\sqrt{e} \qquad (18)$$

where e is the kinetic energy per unit mass associated with turbulent fluctuations and L is a length scale.

In the model, the turbulent energy, thus the energy which is not represented by the computed (mean) flows in the grid system, is computed as a constituent (SGS energy). Consequently, the eddy viscosity can be computed by use of Eq. (18), provided that we have values for the length scale.

If vertical density differences exist, the exchange terms also become a function of the turbulent Richardson number (Ri). Consequently, we can write for the vertical momentum exchange coefficient:

$$E = L\sqrt{e}\ f(Ri) \qquad (19)$$

The turbulent Richardson number is expressed as

$$Ri = -\frac{g}{\rho}\,\frac{\partial\rho/\partial z}{e}\,L^2 \tag{20}$$

where ρ = density of the fluid.

In the finite difference model, the exchange coefficients can be expressed in many different ways. We are using a space staggered grid, with the pressure, salinity, temperature and SGS energy computed at integer values (i,j,k) of the orthogonal grid (Fig. 1). The momentum exchange coefficients are located at the interface of two layers between two horizontal velocities, as indicated in Fig. 2. As the locations at which the SGS energies are computed do not coincide with the location of the momentum exchange coefficients, averages of energy values at adjacent points have to be used. The expression for the vertical exchange coefficient in the momentum equation in X direction is:

$$E_x = \overline{\rho}^{xz}\;\overline{L\sqrt{e_-}}^{xz}\;\exp\left[m\,\frac{g}{\overline{\rho}^{xz}}\,\frac{(\overline{L}^z)^2\delta_z(\overline{\rho}^x)}{\overline{e}_-^{xz}}\right] \tag{21}$$

The exponential term in this equation describes the Richardson number dependency. It will be noted that the energy and the length scale are introduced in order to avoid the use of mean velocity data. The latter would not reflect the intensity of turbulence, as we are dealing with nonsteady flow.

No negative sign appears in the experimental terms as the Z axis is taken positive upward. The SGS energy is used at a lower time level than the other terms in the equation. This appeared to be necessary for stability. Similarly, the expression for the vertical exchange in the momentum equation in the Y direction is:

$$E_y = \overline{\rho}^{yz}\;\overline{L\sqrt{e_-}}^{yz}\;\exp\left[m\,\frac{g}{\overline{\rho}^{yz}}\,\frac{(\overline{L}^z)^2\delta_z(\overline{\rho}^y)}{\overline{e}_-^{yz}}\right] \tag{22}$$

where m = a constant.

The mass exchange coefficients are computed at a different location, namely, at the layer interface between the points where the concentrations are computed, as shown in Fig. 3.

Consequently, the expression for the mass-exchange coefficient is somewhat different than the momentum exchange coefficients. In the model we are using:

$$\kappa = a_4 \overline{L\sqrt{e_-}}^z \exp\left[r \frac{g}{\overline{\rho}^z} (\overline{L}^z)^2 \frac{\delta_z \rho}{\overline{e_-}^z} \right] \tag{23}$$

where r = a constant.

A factor a_4 appears in this formula, as the mass exchange is not the same as the momentum exchange.

The subgridscale energy is transported in a similar manner as the transport of constituents, thus the energy exchange coefficient can be written in the same form as the mass exchange.

$$E_e = a_1 \overline{L\sqrt{e_-}}^z \exp\left[m \frac{g}{\overline{\rho}^z} (\overline{L}^z)^2 \frac{\delta_z \rho}{\overline{e_-}^z} \right] \tag{24}$$

The length scale L which appears in all the exchange coefficients is taken as a function of the distance from the bottom and surface boundaries as follows:

$$L = k' z(1 - z/d)^{\frac{1}{2}} \tag{25}$$

where k' = Von Karman constant

z = vertical distance from the bottom to the point considered

d = vertical distance from surface to bottom

In the model this length scale is determined at the pressure points, namely, at i, j, k.

GENERATION AND DISSIPATION OF SUBGRIDSCALE ENERGY

In the interior of the fluid in our model, it is assumed that the interlayer shear generates the subgridscale energy. This source can be expressed as:

$$S = \varepsilon\left(\frac{\delta\bar{u}}{\partial z}\right)^2 \tag{26}$$

where $\bar{u}$ = mean velocity

$\varepsilon = L\sqrt{e}$

In the model this source is determined at the interface between the layers at i, j, k + ½.

$$S = a_3\overline{L\sqrt{e}_-}^z\left\{\left(\delta_z\overline{u}^x\right)^2 + \left(\delta_z\overline{v}^y\right)^2\right\}^{\frac{1}{2}}$$

$$\text{at } i,\ j,\ k + 1/2,\ n \tag{27}$$

It will be noted that only the energy is computed at the lower time level. This was necessary for stability of the computation.

The energy generated at this location is assumed to be distributed equally into the adjacent layers.

In the bottom layer another source exists. It is assumed that energy which is taken out of the mean flow through the bottom stress immediately enters the subgridscale energy system.

The stress term in the momentum equation in the direction of the mean flow is

$$\frac{\tau}{\rho} = gU^2/C^2 \tag{28}$$

where U = velocity in bottom layer in the direction of flow.

If this term is multiplied by U, we obtain the energy which is taken out of the mean flow system and the local source (S) for the subgridscale energy.

$$S = gU^3/C^2 \tag{29}$$

In the model, the subgridscale energy generation is computed at the layer interfaces and the local finite difference source term becomes

$$S = g\left[(\overline{u}^x)^2 + (\overline{v}^y)^2\right]^{3/2} \Big/ C^2$$

$$\text{at } i,\ j,\ K + \tfrac{1}{2},\ n \qquad (30)$$

The energy is completely introduced in the layer K.

At the water surface the generation of the subgridscale energy is different. Here the energy source is the wind which generates surface waves, and through these waves, turbulence. Wave and swell conditions depend on wind intensity, duration of the wind and the fetch. In the test cases a fully-developed sea under moderate wind speed was used as inputs. Under these conditions the waves are so-called deep water waves, and the total wave energy can be found from the Pierson-Moskowitz spectral sets (Neumann and Pierson [5]). Per unit area, the total wave energy is

$$E_t = 5.6 \times 10^{-9} u_w^4 \qquad (31)$$

where u_w = wind speed in cm/sec at 19.5 m above mean sea surface
E = wave energy

Half of this energy is kinetic energy. If we assume that all this kinetic energy is in the top layer (h_1) of the model, then the vertically-average subgridscale energy intensity in this layer is

$$e = 2.8 \times 10^{-9} u^4 / h_1 \quad \text{at } i,\ j,\ 1,\ n \qquad (32)$$

As the wave theory presents an energy intensity for a given wind condition, we are not concerned with influx of the subgridscale energy into the system, but with maintaining this energy level during the duration of the wind condition in the simulation.

We have assumed that all the kinetic wave energy is in the top layer. From deep water wave theory it is known that the wave-induced water motions are effectively zero at a depth which is half the wave length.

This puts an upper limit upon the wind speed which we were able to allow in the simulation. This wind speed can be estimated from the average wave period belonging to the wind speed (Neumann and Pierson [5]).

$$\bar{\tilde{T}} = .81 \times 2\pi u_w/g \tag{33}$$

and from the wave-length-wave-period relation

$$\bar{\tilde{L}} = g\bar{\tilde{T}}^2\ 2\pi \tag{34}$$

The maximum wind that is allowed in a model with an upper layer thickness h for use in Eq. (32) can then be found from Eqs. (33) and (34):

$$u_w = \left[\frac{2g\sqrt{\pi}}{.81\sqrt{g}\cdot 2\pi}\right]\sqrt{\tfrac{1}{2}\bar{\tilde{L}}} < 21.8\sqrt{h} \tag{35}$$

Higher wind velocities would also involve subgridscale energy inputs in lower layers. The model at present does not include inputs other than in the surface layer.

For the dissipation of energy, use is made of the now classical concepts developed by Kolmogorov [3] and Prandtl [4] that the dissipation rate depends on the transfer process from larger eddies to smaller eddies according to

$$D = a_2\, \underline{e}^{3/2}/L \tag{36}$$

REFERENCES

1. Leendertse, Jan J., Richard C. Alexander, and Shiao-Kung Liu, *A Three-Dimensional Model for Estuaries and Coastal Seas: Volume I, Principles of Computation*, The Rand Corporation, R-1417-OWRR, December 1973.

2. Leendertse, Jan J., and Shiao-Kung Liu, *A Three-Dimensional Model for Estuaries and Coastal Seas: Volume II, Aspects of Computation*, The Rand Corporation, R-1764-OWRT, June 1975.

3. Kolmogoroff, A. N., *Compt. rend. acad. sci. USSR*, 30. 301 and 32. 16, 1941.

4. Prandtl, L., "Uber eln neues Formelsystem fur die ausgebildete Turbulenz," Nachr. Akad. Wliss., Gottingen, 6-19, 1945.

5. Neumann, G., and W. J. Pierson, *Principles of Physical Oceanography*, Prentice-Hall, New Jersey, 1966.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P. O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

RFx41-435-901

Date: NOV 3 1977

To : Rudy Engelmann
Alaska Program Office

From: Herbert E. Bruce
Juneau Project Office

Subj: Acceptance of Renewal Proposal-R.U. 435

We have reviewed the enclosed proposal, Modelling of Tides and Circulations of the Bering Sea, and recommend its continued funding at the level requested; 98,134 for FY 78. Plans for acquisition of sufficient data to drive and verify the model have been initiated and it appears feasible to meet his minimum requirements for data.

Please send an acceptance letter to Dr. Leendertse and initiate contracting with the Rand Corporation.

cc: Dr. Leendertse

Rand
SANTA MONICA, CA. 90406

August 19, 1977

Proposal No. 77-154

C

Dr. Herbert E. Bruce
Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P.O. Box 1808
Juneau, Alaska 99802

Dear Dr. Bruce:

O

The original and nine copies of our proposal for the continuation of modeling work of the Eastern Bering Sea and the Northern Sound are enclosed.

P

The work, which was outlined in your request for proposal by letter dated May 18, 1977, RFx41-435-272, assumes that our present contract work would have advanced up to a point that the models would be more or less adjusted. According to our previous planning for a period of 48 months by our proposal No. 76-010-1 submitted by our letter of November 14, 1975, to Mr. J. Fletcher, we would only enter adjustment of the model extensively in the second phase (second year of our study). In that phase we would also perform a series of experiments to determine influence of wind and tide conditions on transports, determine response functions for water levels and currents for a number of stations and report on the adjustment and new locations of the model. In the third phase of a 24-month duration, we would more extensively deal with the pollution problem.

Y

In view of the fact that our investigators are now working with two models and also that it is becoming apparent that the boundary data will be difficult to obtain, it is not realistic to assume that extensive risk planning data, contaminant trajectory data and other data needed for pollution event countermeasures would become available already at the end of the proposed contract period ending September 30, 1978, as you suggested in your letter.

The enclosed proposal for the continuation of modeling work contains our proposal not only for the next 12-month period, but also for the

THE RAND CORPORATION, 1700 MAIN STREET, SANTA MONICA, CALIFORNIA 90406, PHONE: (213) 393-0411

following years. Naturally, the proposals for the final years 1979 and 1980 are tentative depending on the outcome of the 1978 studies.

It is assumed that the resultant contract for the study now proposed will be on a cost-plus-fixed-fee basis. For fiscal year 1978 starting October 1, 1977, and ending September 1978, the cost-plus-fixed-fee will be $98,134; for the second year (1979) the cost-plus-fixed-fee is now estimated at $99,730; and for the final year (1980) the cost-plus-fixed-fee is now estimated at $99,843. This proposal will remain firm for a period of sixty (60) days from the date of this letter.

If there are any questions of a substantive nature, please contact Dr. Leendertse; administrative or contractual matters should be referred to Mrs. Ann F. Dunbar, Contract Administrator, at (213) 393-0411.

Very truly yours,

THE RAND CORPORATION

ORIGINAL SIGNED BY
J. S. KING, JR.

J. S. King, Jr.
Treasurer

AFD:mw

Enclosures: Proposal No. 77-154, Original and 9 copies

A. Cover Page

Title of Proposal:	Accumulation of Organic Constituents and Heavy Metals from Petroleum Impacted Sediments by Marine Detritivores
Research Unit Number:	454
Contract Number:	2311102778
Proposed Dates of Contract:	
Principal Investigator(s):	J. W. Anderson (Project Director) E. A. Crecelius R. G. Riley G. Roesijadi
Institution & Department:	Battelle-Northwest Laboratories Ecosystems Department Marine Sciences Section Route 5, Box 1000 Sequim, Washington 98382
Date of Proposal:	

Required Signatures:

Principal Investigator
Name Jack W. Anderson Date 6/20/77
Address Battelle Marine Research Lab. Route 5, Box 1000
Sequim, WA 98382 Telephone Number 206/683-4151

Required Organization Approval:
Name Date 6/24/77
Address Battelle, Pacific Northwest Laboratories, P. O. Box 999,
Richland, WA 99352 Telephone Number 509/946-2426

Organization Financial Officer:
Name Date 6/24/77
Address Battelle, Pacific Northwest Laboratories, P. O. Box 999,
Richland, WA 99352 Telephone Number 509/946-2212

C. TECHNICAL PROPOSAL

I. Title and Research Unit Number:

Accumulation of Organic Constituents and Heavy Metals from Petroleum Impacted Sediments by Marine Detritivores

NOAA 454

II. Principal Investigator(s):

J. W. Anderson (Project Director)
E. A. Crecelius
R. G. Riley
G. Roesijadi

III. Cost of Proposal:

Total: $117,000

IV. BACKGROUND: During the past year, we have been investigating the ~~bioavailability~~ of hydrocarbons and trace metals from marine sediments impacted wi~~th~~ petroleum. At the time that our study was initiated, the basic question of whether benthic organisms actually take hydrocarbons from sediment had not been addressed ~~in a systematic fashion. Previous research by Anderson and~~ co-workers indicated little uptake of naphthalenes, the only class of compounds examined at the time ~~(Rossi, 1977; Anderson et al., 1977)~~. Our initial ~~studies~~ with the clam, ~~*Macoma inquinata*~~, confirmed the results with ~~the naphthalenes~~. Other aromatic compounds (Phenanthrene, chrysene, dimethylbenzanthracene, and benzo[a]pyrene) were found in the past year to be accumulated from sediment at a relatively low rate (Table 1, ~~Appendix~~). A major portion of the uptake of most compounds ~~could be attributed to compounds~~ released ~~from sediments~~ to seawater. We also found that feeding type played an important role in the bioavailability of hydrocarbons in sediment. For example, when exposed simultaneously to oil-contaminated sediment (600 ppm) for 40 days, a filter-feeding clam (*Protothaca staminea*) did not accumulate detectable levels of aliphatic and di- and tri-aromatic hydrocarbons; whereas, two species of deposit-feeders, the clam, *Macoma inquinata*, and sipunculid, *Phascolosoma agassizii*, contained approximately 5 ppm of the three classes of compounds (Fig. 1, Appendix). Also shown in this summary illustration is the uptake of these species at 60 days and the subsequent depuration during 7 days in clean water. Trace metals concentrations in animals used in initial tests were apparently not altered by oil exposure (see Annual Report), but the process should be examined in greater detail by use of more sophisticated approaches.

In the original 1976 RFP, it should be noted that NOAA/BLM wished the contractor to provide data on the effects of sediment-bound hydrocarbons and the presence and possible effects of metabolic products. We explained in our proposal that such research was beyond the scope of a 15-month project funded at $150,000, and, furthermore, these data would be more readily derived after some knowledge of hydrocarbon uptake had been obtained. We have progressed to the point that we know the magnitude of uptake for several specific compounds under closely controlled conditions. We are now emphasizing longer-term studies (40 to 60 days) in order to establish whether continued uptake occurs during prolonged exposure. This research will incorporate uptake determinations of C^{14}-labeled compounds and their metabolites, other petroleum hydrocarbons in contaminated sediment, and trace metals. In addition, the duration of exposure will be sufficient to elicit effects measured by alterations in the "condition index," and the tissue levels of specific amino acids.

V. OBJECTIVES: By both laboratory and field experiments, the uptake of petroleum hydrocarbons and heavy metals from oil-impacted sediment will be measured. Prudhoe Bay Crude (PBC) oil will be used in all experiments, and a fiberglass-lined cement mixer will be used to mix all large batches of sediment with PBC. Two detritivores (*Macoma inquinata* and *Phascolosoma agassizii*) have proven to be suitable for this research and will, therefore, be utilized in subsequent work. In addition to describing the rates and magnitude of heavy metals and hydrocarbon uptake by both animals, we will determine the effects of living in an oiled substrate for 40 to 60 days on the "condition index" and levels of specific amino acids in *Macoma*.

When C^{14}-labeled hydrocarbons are used, we will be periodically measuring the levels of C^{14}-activity in water, sediment and tissue. Final and intermediate tissue samples will be extracted and the solvent analyzed simultaneously by high-pressure liquid chromatography (HPLC) and liquid scintillation counter (LSC) to determine the percent of total activity produced by contamination from the parent compound. While it would be of interest to identify the various metabolites in tissues produced from the parent hydrocarbon, it is beyond the scope of research and funding in FY1978.

Analyses of sediment and tissues from field experiments will be conducted by use of capillary gas chromatography (CGC) and mass-spectrometry (when necessary). As shown in Table 3 (Appendix), we have already used CGC to determine the concentration of saturates and aromatics, through dimethylphenanthrenes in sediment samples. HPLC methods are being developed to analyze aromatics of higher molecular weight.

As our Annual Report illustrates, the use of x-ray florescence for detection of a wide range of heavy metals in oil, sediment and tissues (Tables 12 and 15, Appendix), has proven to be very efficient. We will continue to utilize this approach, but supplement these field studies with laboratory exposures incorporating radio-labeled heavy metals. By neutron-activation of oil, detritus and sediment, isotopes of metals including Co, Zn, Fe, Cr, and Sc will be produced. We will, therefore, be able to use very sensitive tracer techniques to determine both accumulation and possible exchange (with or without actual accumulation) of metals from the sediment environment to organisms.

The data generated in these studies will provide much needed information of the bioavailability of sediment-sorbed hydrocarbons and their effects on the benthos. They will also show whether or not heavy metals in oil or oiled substrate are bioavailable or toxic.

VI. GENERAL STRATEGY AND APPROACH: Our general approach to the uptake of metals and hydrocarbons from oil-impacted sediment will be very much like that of FY1977, since that research has been quite productive.

Laboratory Studies

When radio-labeled organic compounds or metals are used, exposures must be conducted in our laboratory flowing seawater system, with proper precautions taken to retain isotopes in a closed system or adsorb them on charcoal filters (hydrocarbons). One or both of two exposure systems will be utilized in these laboratory studies. To determine the relative amounts of C^{14}-labeled hydrocarbon uptake from sediment and the overlying water, closed aquarium exposures will be conducted. Two groups of animals will be present within a given aquarium, but only one will have access to contaminated substrate. The second group, which will be suspended in clean sediment above the oiled substrate, will serve as a monitor for uptake from the water column. This same basic approach will be used in studies involving uptake of metals isotopes, since a portion of these may also be released from sediment to interstitial space and finally to the water column. In these isotope uptake studies, there will be no need for other types of tissue controls, but quench tests will be conducted before attempting to prepare a balance sheet for isotope transfer. Since metals may very well be exchanged between the sediment environment and benthic organisms, without a net transfer, this exposure system is designed to evaluate this possibility. Even if there is no accumulation we will be able to describe the rates of exchange from activated oil and detritus to organisms.

A second laboratory exposure system which will be utilized, is a flowing-tidal flux apparatus. An example of research conducted in this system is the benzo[a]pyrene uptake study shown in Fig. 2 (Appendix). Sediment trays with fiberglass-mesh bottoms, containing substrate contaminated with oil plus C^{14}-hydrocarbons, will receive flowing clean water, except during periods at which our intertidal zone would be exposed to air. With a timing device, a pump on each tank is activated and, thus, the water level slowly drops below suspended trays and remains at "low tide" stage for one hour. This serves to simulate the environment of these intertidal detritivores and also aerates the interstitial spaces of the sediment, inhibiting the formation of an anaerobic layer. During the course of the 40 to 60-day exposure, tissue samples and sediment cores will be taken to determine the fate of compounds in the sediment and the uptake rates by organisms. Any C^{14}-activity released from the sediment to the water in this flowing system will not be accounted for, but will be collected on charcoal filters for safety purposes. Tissue extracted will be analyzed by both LSC and HPLC to determine the extent of total C^{14}-activity, and the percent present as original parent compound. Where time and reference compounds are available, preliminary identification of metabolites will be conducted. This type of research should be expanded in FY1979, when other aspects of this investigation are well understood.

Field Studies

Obviously, the natural environment is the best location for determining the fate of oil and effects of oil-contaminated sediment. We have demonstrated the usefulness of field exposures to oiled sediment during FY1977. Uptake of di- and tri-aromatic compounds by both *Macoma* and *Phascolosma* has been observed and reported (Fig. 1, Appendix). Preliminary results indicate that the "condition index" of *Macoma* may be reduced by exposure to oiled sediment for long periods (1 to 2 months). We intend to continue these experiments with larger numbers of organisms so that uptake of both hydrocarbons and metals and effects can be more closely defined. In addition, the specific characteristics of tissue hydrocarbon contamination will be determined by use of CGC and HPLC analyses. In each experiment, two to three hundred *Macoma* will be placed in both clean and oil-contaminated sediment, contained within fiberglass trays with mesh bottoms. As before, oil will be uniformly mixed with sediment in our fiberglass-lined cement mixer, thus, avoiding contamination by metals. These will be set into ~~the intertidal~~ zone near the laboratory. At 40 to 60-day intervals, animals will be removed for analyses of heavy metals (x-ray florescence), petroleum hydrocarbons (CGC and/or HPLC) and condition. The condition of the exposed and control clams will be determined by measurements of shell length vs. ash-free dry weight (deWilde, 1975), and by amino acid analyses of fresh tissues. While fluctuations in the condition of bivalves during the year is considered normal (Trevallion, 1971; Ansell and Sivadas, 1973), we will be comparing control and exposed organisms over the same time period. As early as 1972, Jeffries noted that the bivalves, *Mercenaria*, collected from clean and contaminated regions~~, show different ratios of one amino acid to another~~. Ba~~yne et al., (1976a)~~, recently reported that this was also the case for *Mytilus edulis* under conditions of temperature, salinity or food stress. It is, therefore, likely that analyses of amino acid content of exposed vs. control *Macoma* will provide ratios such as taurine:glycine, which differ significantly. Unlike the results of Jeffries (1972), we will be able to closely describe the characteristics of the exposure in a qualitative and quantitative fashion. Other aspects of the biology of bivalves, including "scope for growth" and cytochemical alterations (Bayne et al., (1976), would be suitable parameters to measure, but time and funding will not allow the studies to be conducted until FY1979.

As noted above, subsamples of the clams will be analyzed for both metals and hydrocarbon content, such that correlations between uptake and effect can be determined. As illustrated in our Annual Report, x-ray florescence analyses provide quantitative data on Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Se, Pb, As, Co, Ga, Hg, Br, Rb, and Sr. In Table 15 (Appendix) of this report, we have shown the natural levels of these metals in *Macoma* and an estimation of sample variability. We need only to compare the content of clams from future exposures to these "baseline" values to evaluate the extent of metals uptake when exposed to oil-impacted sediment for long periods.

Additional tissue subsamples as well as sediment cores will be analyzed by CGC and/or HPLC for content of specific petroleum hydrocarbons. As in other studies (Table 3, Appendix), we will provide data on the changes in sediment contamination levels over the course of the field exposure. Clam tissue will be analyzed in a similar fashion to determine the extent of uptake by specific saturate and aromatic compounds. Results of these experiments can then be compared to those of laboratory tests (C^{14}-hydrocarbons) and earlier field experiments to validate present findings (Table 1 and Figs. 1 & 2, Appendix) and expand our knowledge to other hydrocarbons. It is expected that some time and funds will be available to utilize HPLC for determinations of polynuclear aromatics in tissue and sediment, but the majority of this effort should be put forth in FY1979.

VII. SAMPLING METHODS: In general, this category is not applicable to our experimental study, as all sampling will be conducted within our exposure containers.

VIII. ANALYTICAL METHODS: Biological analyses will include determinations of "condition index" (de Wilde, 1975) and tissue amino acids. The condition index of Macoma will be derived from the following:

$$\frac{\text{ash-free dry weight}}{\text{length}^3} \times 1000 \quad \text{(de Wilde, 1975)}$$

Tissue samples for amino acid analysis will be homogenized in 7% TCA, centrifuged to remove particulates, and TCA removed by extraction with diethylether before freeze-drying the sample. The frozen sample will be shipped to AAA Laboratory, Mercer Island, Washington, and taken up in citrate buffer for analysis by ion-exchange chromatography, using either a Durrum Analyzer (D-500) or a Beckman, Spinco 120B. Lowell H. Ericsson, also a research associate at the University of Washington, will be responsible for producing and reporting data similar to that shown in the Appendix.

Triplicate 20-gram sediment samples will be extracted by shaking glass bottles with Teflon-lined caps for 24 hours at room temperature (21°C). The bottles will contain 20 grams of anhydrous sodium sulfate (for water removal) and 50 ml of hexane (Burdick & Jackson). Tissue samples will be digested and extracted following the methods of Warner (1976). Appropriate amounts of each sample will be concentrated to 1 ml and column-chromatographed according to the method of Warner (1976). Saturate and aromatic fractions will be analyzed by gas chromatography on a 30-meter SE-30 glass capillary column (J&W Scientific) programmed from an initial temperature of 70°C to 250°C at a rate of 4C/min. Internal standards will include 2,6,10-trimethyldodecane and hexamethylbenzene and peak areas, and internal standard calibrations will be determined with an Autolab Systems IV computer-integrator. Where identifications are required, a Hewlett Packard 5980A quadrapole mass spectrometer, operating in the argon chemical ionization mode and employing single ion monitoring will be utilized.

Where the use of HPLC may be productive, hexane, or perhaps other solvents, will be used to extract sediment and/or tissues. Sediment hydrocarbons have been analyzed in the past by injection of 3 microliters of hexane in 3 - series-coupled 1/8 inch x 2 feet Durapak oxypropionitrile on porasil C columns (Waters Assoc.) using hexane as mobile phase and 2.0 ml/min flow rate. Validation was obtained with dodecane, benzene, naphthalene and anthracene to demonstrate separation into saturate, monoaromatics, diaromatics and polyaromatic fractions. Saturates were detected with a Waters R-401 differential refractometer, and aromatics with a Schoeffel variable wavelength U.V. detector set at 221 μm.

Heavy metals in tissue samples will be determined by the method described by Nielson (1977), utilizing x-ray florescence analysis. Gamma counting techniques will be used to determine the extent of metals exchange from sediment to organisms. Oil, detritus and sediment containing gamma-emitting isotopes will be produced by neutron activation of these substrates (Shah et al., 1970a, b).

IX. ANTICIPATED PROBLEMS: The only problems anticipated regard the generation of all the data on biological effects, as well as uptake of hydrocarbons and metals for the amount of funding requested. Certainly, this much research can not be produced for $90,000, but with very careful allocation of time and effort we expect to accomplish our objectives for $124,604. The enclosed Budget Justification will explain the expense of "state-of-the-art" research proposed and indicate the cost of each task.

X. DELIVERABLE PRODUCTS: Products which will be supplied include narrative reports describing experimental methods, results and a discussion of the significance, as compared to other data and the literature. Within reports will be tabular and graphical presentations of hydrocarbons and metals accumulation under well defined exposure conditions. We also plan to submit manuscripts for NOAA/BLM review and approval before sending such to journal or symposium editors.

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS: There are no absolute requirements for data from other researchers, but information of hydrocarbon and metals analyses of tissue and sediment will be helpful. We would expect to see these data in the Monthly Roports of OCSEAP investigators.

XII. QUALITY ASSURANCE PLANS: As an ERDA laboratory, we have well defined quality assurance procedures and representatives to monitor these precautions. Battelle's quality assurance program is set forth in the manual (BNWL-MA-65 REV.) entitled "Quality Assurance." It sets general guidelines under which each department develops a quality assurance program to meet the specific needs of their research. The Ecosystems Department guidelines are set forth in the Departmental Quality Assurance Procedures manual, BNWL-MA-590. The manuals are available to sponsors, or potential sponsors, upon request.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLANS: It is our normal procedure to retain replicate sediment samples in our low-temperature (-75°C) freezer in the event they are required. Normally, all tissue samples are analyzed, but in some cases, replicates may be retained in the same freezer.

XIV. LOGISTICS REQUIREMENTS: Not Applicable

XV. MANAGEMENT PLAN: The project director will be Jack W. Anderson, and he will be responsible for coordinating the proposed research and reporting the findings. It is of particular significance that we intend to conduct research on biological effects, hydrocarbon metabolism (from microbial activity), uptake of heavy metals and uptake of petroleum hydrocarbons. In both field and laboratory studies, more samples will be generated than we have the manpower and funding to analyze. One of Dr. Anderson's most important tasks will be selection of most significant samples, based on experience and findings from recent and past analyses.

The time schedule for production of milestones is shown in the following chart, and it is assumed that reports which fall on January 1, April 1 (Annual Report), July 1, and October 1 will incorporate data generated during the preceeding quarter. Of course, the Annual Report (April 1) will contain a summary of all research conducted through March 1978.

XVI. OUTLOOK: Much of the research proposed in FY1978 is that which attempts to enhance "state-of-the-art" methods of analysis. It is likely, therefore, that techniques such as HPLC separation of metabolites from the C^{14}-labeled parent compounds will require time for development. We expect to produce a limited number of analyses of this type during FY1978, but rate studies and metabolite identifications must be conducted during FY1979. Limitations will also be placed on the identification of specific hydrocarbons in exposed tissues, since the funds available will not allow extensive capillary GC-MS analysis. By retaining tissues and extracts from FY1978 studies for later identification, we will be able to rapidly generate these GC-MS data during FY1979. Once identification and verification has taken place, we can glean much more from our CGC analyses, both present and future.

Research on heavy metals uptake during FY1978 should allow us to reach a reasonably sound conclusion regarding the impact of oil. If present findings on uptake are verified, and exchange from sediment (isotope research) is not significant, we believe this phase of the program can be terminated. This would provide the needed funds (assuming approximately the same level of funding) for further research on identification of metabolites and specific aromatic compounds in tissues.

Emphasis in biological studies during FY1979 must await the findings of present research. It is anticipated that both "condition index" and amino acid analyses will provide valuable information on the stress of hydrocarbon contaminated sediment. Logical extensions of this research are analyses of cytochemical alterations and "scope for growth" (Bayne et al., 1976a-b). Both of these parameters appear to be very sensitive to natural stresses, but they require a significant effort to evaluate. Only if present biological effects studies prove successful, will we attempt to investigate these parameters in FY1979.

Since each phase of our experimental approach must be based on the findings of the last phase, it is only possible to outline studies for FY1979 at this time. It would appear that during FY1980, we would be able to construct models for transport of hydrocarbons and heavy metals from water and sediment. At this time, it would be possible to see where data are lacking to fully evaluate the fate and effects of petroleum hydrocarbons in the marine environment.

Recommended Research in FY1979

Topic		Cost
Biological studies on cytochemical alterations, "scope for growth" and metabolite uptake and effects		70K
Hydrocarbon Studies Metabolite identification and separation (HPLC and CGC)		40K
Identification of polynuclear aromatics in organisms exposed to oiled sediment (CGC and CGC-MS)		40K
	TOTAL	150K

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October; annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when they are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office, the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3-month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements.

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23 will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

MILESTONE CHART

RU #: 454 PI: J. W. Anderson

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978																
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D					
1. 60 day laboratory uptake of radio-labeled metals in oiled-sediment.				Δ																
2. HPLC analyses of *Macoma* C^{14}-activity from benz(a)pyrene 60 day sediment exposure.					Δ															
3. 60 day field exposure to oil-contaminated sediments on *Macoma*, *Phascolosoma* and *Protothaca*.			Δ																	
4. Analyses of "condition index" and tissue amino acids from *Macoma* (5 below) (3 above).					Δ															
5. Analyses of heavy metals and hydrocarbons in *Macoma* from (3) above.							Δ													
6. 60 day laboratory uptake of C^{14}-Phenanthrene and metabolites by *Macoma*.						Δ														
7. 60 day laboratory uptake of C^{14}-Chrysene and metabolites by *Macoma*.									Δ											
8. Initiate 2nd field exposure of 3 species and terminate 2 months later.							Δ		Δ											
9. Analyses of *Macoma* condition index and amino acids from 2nd field experiment.										Δ										
10. Analyses of metals and hydrocarbons in tissues and sediment from (8).											Δ									

Δ Planned Completion Date ▲ Actual Completion Date

PROVISIONS FOR
GOVERNMENT CONTRACTS

It is planned that the research program, or some part thereof, will be performed at the Pacific Northwest Laboratory, owned by the Energy Research and Development Administration (hereafter referred to as ERDA) and operated for ERDA by Pacific Northwest Laboratories, a division of Battelle Memorial Institute (hereafter referred to as Battelle-Northwest) under Contract EY-76-C-06-1830. Battelle-Northwest is authorized to use the Pacific Northwest Laboratory facilities and property for performance of the proposed research program, under the terms of the Use Permit Contract EY-76-C-06-1831. To implement the provisions of the Use Permit, the following clauses should be incorporated into any contract resulting from this proposal.

1. SOLE ACCOUNT OF BATTELLE-NORTHWEST

This agreement is not entered into by Battelle-Northwest for the account of the Government or ERDA, but is for the sole account of Battelle-Northwest.

2. USE OF GOVERNMENT FACILITIES AND PROPERTY

Performance of the work hereunder shall be contingent upon the continuing availability to Battelle-Northwest of the Government facilities and property, and the personnel necessary to conduct the work. Neither Battelle-Northwest, the Government or ERDA, nor their officers, employees, or authorized representatives shall be liable for any loss sustained by

OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM (hereinafter referred to as "Sponsor") or others, where such loss is directly or indirectly attributable to the cessation or suspension of activities under this agreement at the request of the Government under Contract EY-76-C-06-1831.

3. PATENTS

(a) ERDA has waived any and all claim, rights and title which it may have or be entitled to pursuant to Section 152 of the Atomic Energy Act of 1954, as amended, with respect to any invention or discovery made or conceived by Battelle-Northwest or its employees or consultants, or by the employees or consultants of the Sponsor in the course of or under the agreements or activities undertaken hereunder pursuant to Use Permit Contract EY-76-C-06-1831, excepting, however, that where scientific or technical information and data developed by Battelle-Northwest after January 1, 1975, in the performance of work for ERDA under Operating Contract EY-76-C-06-1830, but not reported to ERDA on an unrestricted basis, (hereinafter referred to as "ERDA

Information and Data"), were specifically necessary for the making of any invention or discovery useful in the production or utilization of special nuclear material or atomic energy, or specifically necessary and actually used to demonstrate operability of such invention or discovery, ERDA has specifically reserved a nonexclusive, irrevocable, royalty-free license for use in the production or utilization of special nuclear material or atomic energy for Governmental purposes in any such invention or discovery and any patent application or patent that may result; provided, however, that nothing in this agreement shall be deemed to modify or alter ERDA's rights with respect to any invention or discovery made or conceived in the course of or under Operating Contract EY-76-C-06-1830, wherein ERDA has the sole power to determine title to and rights under any invention or discovery made or conceived by Battelle-Northwest, its employees, and certain subcontractors in the course of or under Operating Contract EY-76-C-06-1830. For purposes of this clause scientific or technical information and data which are publicly available, or available to Battelle-Northwest other than through its performance of the Operating Contract EY-76-C-06-1830, or obtained by Battelle-Northwest from other ERDA contractors without limitations as to use, shall not be deemed to be "ERDA Information and Data." To the extent necessary to enable ERDA to determine the Government's rights under this clause, Battelle-Northwest shall afford ERDA the right to inspect the original records of inventions based on said "ERDA Information and Data."

(b) Battelle-Northwest shall promptly report to the Sponsor and to ERDA any invention or discovery covered by the exception in paragraph (a) above and will advise ERDA within six months of such reporting as to whether Battelle-Northwest or the Sponsor intends to file a patent application with respect to such invention or discovery; provided, however, if Battelle-Northwest or the Sponsor advises ERDA that neither desires to file, ERDA may file any patent application, domestic or foreign, as it determines appropriate. If Battelle-Northwest or the Sponsor does not file a United States patent application within one year of reporting such invention or discovery, ERDA, if it desires to file any patent application, will so notify Battelle-Northwest and Battelle-Northwest will notify the Sponsor, and if Battelle-Northwest or the Sponsor does not file within 60 days after date of such notification by ERDA, ERDA may file any patent application, domestic or foreign, as it determines appropriate. If ERDA files a patent application, all right, title, and interest in and to such invention or discovery shall be assigned to ERDA, subject to retention by Sponsor or

Battelle-Northwest of at least a nonexclusive, irrevocable, royalty-free license for its own uses. With respect to any such filing, the Sponsor agrees that it will execute all documents and do all things necessary and proper to assist ERDA, and will use its best efforts to secure from its employees and consultants the execution of all documents and have them do all things necessary and proper to assist ERDA.

(c) No claim for pecuniary award or compensation under the provisions of the Atomic Energy Act of 1954, as amended, shall be asserted by Battelle-Northwest or its employees and consultants, and employees and consultants of the Sponsor with respect to any invention or discovery based on said "ERDA Information and Data" to the extent described in paragraph (a) of this clause in the course of or under the arrangements or activities undertaken pursuant to Use Permit Contract EY-76-C-06-1831.

(d) Except as otherwise authorized in writing by ERDA, Sponsor will obtain patent agreements to effectuate the purposes of paragraphs (a), (b), and (c) of this clause from employees or consultants of the Sponsor while assigned to work at the Government-owned facilities or while utilizing the Government-owned property, except such clerical and manual labor personnel as will not have access to technical data.

4. ACCESS AND TECHNICAL DATA

(a) To the extent necessary to fulfill the responsibilities of ERDA under the Atomic Energy Act of 1954, as amended, or any other law, or for the purposes of determining compliance by Battelle-Northwest with terms of Use Permit EY-76-C-06-1831, ERDA, at all reasonable times, shall have access to all or any part of the Government-owned facilities and shall have the right to inspect all activities conducted therein; provided, however, that ERDA's right to inspect shall not include the right to obtain technical data, except as hereinafter provided.

(b) The Government shall have the right to use, in the production or utilization of special nuclear material or atomic energy, for Governmental purposes, any information or knowledge contained in any drawings, sketches, designs, data, specifications, technical and scientific data, photographs, negatives, reports, findings, recommendations, and memoranda of every description (hereinafter called technical data), made in the course of or under the arrangements or activities undertaken hereunder pursuant to the Use Permit which specifically results from the use of said "ERDA Information and Data."

(c) Battelle-Northwest shall furnish to ERDA one copy of any technical data as to which the Government has rights under paragraph (b) above. ERDA shall have the right to inspect technical data specifically resulting from the use of said "ERDA Information and Data" which is made in the course of or under the arrangements or activities undertaken hereunder pursuant to the Use Permit, for the purposes of paragraphs (a) and (b) above.

(d) When furnishing any technical data referred to in paragraph (c) above, Battelle-Northwest or the Sponsor, as the case may be, will make reasonable efforts to identify any invention in the field of atomic energy made by Battelle-Northwest or the Sponsor, if not previously reported.

5. ACCOUNTING AND REPORTING

Battelle-Northwest follows cost allocation practices prescribed by the Cost Accounting Standards Board in accumulating the costs of work performed for the Government. If, during the period of performance of this work, Battelle-Northwest must change its cost allocation practices as a result of the promulgation of Cost Accounting Standards Board Rules and Regulations, such new practices may be applied prospectively in reporting the costs of work hereunder. Battelle-Northwest agrees to notify the Government of the impact of such change on the estimated cost of this work, and to enter good faith negotiations to effect an equitable price adjustment for this work.

October 1976

TECHNICAL FACILITIES COSTS

Technical Facilities Costs are costs incurred by each organizational cost center for the operation of the experimental research facilities which support the organization center's research efforts. These costs include laboratory supplies such as chemicals, glassware, small tools, and laboratory operating and maintenance costs. Where a nuclear hazard is present, these costs also include decontamination and disposal, radiation monitoring, criticality, laundering, and similar expense.

Technical Facilities Costs are allocable to all cost center cost objectives based on cost center direct staff labor hours.

Pursuant to understandings between Battelle and the Energy Research and Development Administration (ERDA), the allocation rate(s) for each cost center is(are) periodically adjusted as necessary to distribute actual costs on a current basis to all active ERDA and non-ERDA work of the cost center. Any incidental variance between actual cost and allocated cost as of fiscal year-end allocable to non-ERDA work is accounted for as General and Administrative Expense.

E. OTHER INFORMATION

Research on the fate and effects of hydrocarbons in the marine environments has been conducted at the Marine Research Laboratory, Sequim, Washington, since 1972. Several of us have been investigating chemical and/or biological aspects of hydrocarbon contamination for over 5 years (see publications of Anderson and Blaylock). Roesijadi and Riley have, after obtaining considerable experience in related subjects, been involved in petroleum research for about 2 years. Crecelius has obtained considerable expertise in the study of heavy metals in the environment during research at the University of Washington and within Battelle-Northwest.

Petroleum research at Sequim has been funded by API, ERDA, EPA and NOAA/BLM. We presently have projects underway which are funded by the latter three government agencies. A majority of EPA/ERDA research concerns the fate and effects of hydrocarbons in water, utilizing our flowing oil delivery system. There is one task included in this research which regards the effects of oil-contaminated sediment on the recruitment of benthic organisms in the field. This is a task which includes some evaluation of hydrocarbon uptake from oiled sediment, and is the only area of overlap with NOAA/BLM proposed research. It is indeed complementary, since analytical techniques (CGC and CGC-MS) have been developed under EPA/ERDA funding, which will be utilized in producing the sediment and tissue analyses proposed.

We anticipate receiving additional research funds from NOAA/BLM during FY1978, for conducting subcontract research in collaboration with Scott Warner (Battelle-Columbus) and Bori Olla (NOAA-Sandy Hook, N.J.). The research for these projects is clearly defined in the proposals, and the specific tasks do not relate to this proposed research, with the exception that it concerns effects of hydrocarbons. Both Anderson and Blaylock are funded for a portion of their time, but the responsibilities relate to other goals. We are requesting funds for static bioassays with fractions furnished by Warner, and for behavioral research (with some hydrocarbon analyses) in collaboration with Olla.

Listed in the Cost Justification section of this proposal are principal investigators, their responsibilities and time committed to the project. The enclosed resumes provide information on the education, background, experience and accomplishments of the key individuals.

Any questions of a technical nature should be referred to Dr. J. W. Anderson on (206) 683-4151. Questions of a contractual nature should be referred to Mr. C. A. Counts on (509) 946-2642.

F. LITERATURE CITED

Anderson, J. W. 1977. Responses to sublethal levels of petroleum hydrocarbons: Are they sensitive indicators and do they correlate with tissue contamination? In: *Fate and effects of Petroleum in Marine Ecosystems and Organisms;* Proceedings of NOAA Symposium, Seattle, Nov. 10-12, 1976 (D. Wolfe, ed.). Pergamon Press, New York. (In press).

Ansell, A. D., and P. Sivadas. 1973. Some effects of temperature and starvation on the bivalve *Donax vittatus* (da Costa) in experimental laboratory populations. *J. exp. mar. Biol. Ecol. 13*:229-252.

Bayne, B. L., D. R. Livingstone, M. N. Moore, J. Widdows. 1976a. A cytochemical and a biochemical index of stress in *Mytilus edulis* L. *Mar. Pollut. Bull. 7*: 221-224.

Bayne, B. L., J. Widdows, and R. J. Thompson. 1976b. Physiological integrations. pp. 261-291 in: *Marine Mussels; Their Ecology and Physiology* (B. L. Bayne, ed). International Biological Program 10. Cambridge University Press, Great Britain.

de Wilde, P.A.W.J. 1975. Influence of temperature on behavior, energy metabolism, and growth of *Macoma balthica* (L.) pp. 239-256 in: *Ninth European Marine Biology Symposium* (H. Barnes, ed.). Aberdeen University Press, Great Britain.

Jeffries, H. P. 1972. A stress syndrome in the hard clam, *Mercenaria mercenaria*. *J. invert. pathol.*, *20*:242-287.

Nielson, K. K. 1977. Matrix corrections for energy dispersive X-ray fluorescence analysis of environmental samples with coherent/incoherent scattered X-rays. *Analyt. Chem. 49*:641.

Rossi, S. S. 1977. Bioavailability of petroleum hydrocarbons from water, sediments, and detritus to the marine annelid, *Neanthes arenaceodentata*. pp. 621-625 in: *Proceedings of 1977 Oil Spill Conference* (API, EPA, USCG), New Orleans, Mar. 8-10, 1977. American Petroleum Institute, Wash., D.C.

Shah, K. R., R. H. Filby, and W. A. Haller. 1970a. Determination of trace elements in petroleum by neutron activation analysis. I. Determination of Na, S, Cl, K, Ca, V, Mn, Ca, Ga, and Br. *J. Radioanal. Chem. 6*:185-192.

Shah, K. R., R. H. Filby, and W. A. Haller. 1970b. Determination of trace elements in petroleum by neutron activation analysis. II. Determination of Sc, Cr, Fe, Co, Ni, Zn, As, Se, Sb, Eu, An, Hg and U. *J. Radioanal. Chem. 6*:413-422.

Trevallion, A. 1971. Studies on *Tellina tenuis* Da Costa. III. Aspects of general biology and energy flow. *J. Exp. Mar. Biol. Ecol. 7*:95-122.

Warner, J. S. 1976. Determination of aliphatic and aromatic hydrocarbons in marine organisms. *Analyt. Chem. 48*:578-583.

G. Publications and Presentations derived from work on NOAA/BLM #454 Project for the first fiscal year

Roesijadi, G., J. W. Anderson, and D. L. Woodruff. 1977. Bioavailability of naphthalenes from marine sediments artifically contaminated with Prudhoe Bay Crude oil. *Environ. Pollut.* (In press).

Roesijadi, G. Bioavailability of petroleum hydrocarbons from marine sediments contaminated with Prudhoe Bay Crude oil. Presented at AAAS-ASLO, Annual Meeting, Pacific Division, San Francisco, Calif., June 12-16, 1977.

Roesijadi, G. Bioavailability of petroleum hydrocarbons from marine sediments contaminated with Prudhoe Bay Crude oil. To be presented at symposium entitled, "Long-Term Recovery Potential of Coldwater Marine Environment after Oil Spill." Dartmouth, Nova Scotia, Canada, October, 1977. Sponsored by Bedford Institute of Oceanography.

APPENDIX

TABLE 1. Uptake of ^{14}C-polyaromatic hydrocarbons from sediment by *Macoma inquinata*. Clams were exposed to sediment containing 2000 ppm crude oil spiked with 10 μC of the hydrocarbon indicated in the table.

Parameter	2-Methyl-Naphthalene	Phenanthrene	Chrysene	Dimethyl-Benzanthracene	Benzo(a)pyrene
Net Uptake From Sediment[1] *(ug/g)*	0	0.096	0.308	0.297	0.059
Uptake From Seawater *(ug/g)*	0.048	0.038	0.297	0.856	0.037
Sediment Magnification Factor[2]	0	0.056	0.029	0.039	0.057
Seawater Magnification Factor[3]	3.2	5.89	105	295	420

[1] Calculated As Indicated In Text (Annual Report).

[2] Sediment Magnification Factor = Net Uptake/Geometric Mean Concentration In Sediment.

[3] Seawater Magnification Factor = Uptake From Seawater/Geometric Mean Concentration In Seawater.

TABLE 3*. Concentrations of saturate and aromatic hydrocarbons (parts per million, PPM) in sediment from the day of installation of the field experiment.

Saturates	Concentration (PPM)	Aromatics	Concentration (PPM)
C_{11}	13.34 ± 1.21	Naphthalene	7.20 ± 0.77
C_{12}	16.11 ± 1.53		
C_{13}	17.79 ± 1.82	2-MN	14.31 ± 3.10
C_{14}	17.44 ± 2.39	1-MN	10.51 ± 2.90
C_{15}	19.39 ± 2.94	Total	24.82 ± 5.32
C_{16}	18.84 ± 3.00		
C_{17}	17.03 ± 2.92	1-ethyl + 2-ethyl	
Pristane	10.74 ± 1.95	Naphthalene	6.93 ± 0.35
C_{18}	16.20 ± 3.22		
Phytane	8.05 ± 1.43	2,6 + 2,7-DMN	9.52 ± 0.75
C_{19}	18.79 ± 3.00	1,3 + 1,6-DMN	9.93 ± 0.94
C_{20}	16.40 ± 2.88	1,7-DMN	7.81 ± 0.64
C_{21}	17.56 ± 3.09	1,4 + 2,3 + 1,5 DMN	9.14 ± 0.72
C_{22}	16.02 ± 3.37	1,2-DMN	1.60 ± 0.45
C_{23}	15.18 ± 2.65	Total	42.68 ± 2.74
C_{24}	13.80 ± 2.84		
C_{25}	11.71 ± 2.47	TMN-1	3.80 ± 0.64
C_{26}	10.21 ± 1.97	TMN-2	3.65 ± 0.55
		TMN-3	5.69 ± 1.11
Total saturates		TMN-4	4.26 ± 0.76
measured	274.61 ± 42.32	2,3,6-TMN	2.08 ± 0.24
		TMN-5	5.99 ± 0.77
		Total	28.44 ± 6.10
		Phenanthrene	3.05 ± 0.85
		MP-1	2.74 ± 0.56
		MP-2	2.34 ± 0.40
		MP-3	3.94 ± 1.71
		MP-4	3.49 ± 1.67
		Total	12.53 ± 4.31
		C_2-phenanthrene-1	7.30 ± 1.56
		C_2-phenanthrene-2	2.36 ± 0.68
		C_2-phenanthrene-3	2.56 ± 0.44
		C_2-phenanthrene-4	2.47 ± 0.87
		Total	14.70 ± 3.52
		Total aromatics measured	140.35 ± 23.96

MN = Methylnaphthalene

DMN = Dimethylnaphthalene

TMN = Trimethylnaphthalene

MP = Methylphenanthrene

* From Proceedings of the EPA Workshop on Interagency Energy/Environment Program, Newport, Rhode Island, March, 1977.

TABLE 12.* Trace element concentrations in Prudhoe Bay Crude oil. Samples represent oil from two different barrels and were analyzed by neutron activation analysis.

Element	Concentration (μg/g)	
	Sample 1	Sample 2
Na	<0.06	0.097
Mg	<30	<33
Al	<0.5	<0.5
Cl	<1	0.95
K	<4	<1.4
Sc	<0.001	<0.001
V	20.9	18.0
Cr	<0.21	<0.15
Mn	<0.04	<0.02
Fe	<1.6	<1.7
Co	0.018	0.017
Cu	<5	<3
Zn	0.31	0.31
As	<0.03	<0.01
Se	--	<0.3
Br	5.73	2.75
Rb	<0.06	<0.08
In	<0.005	<0.003
Sb	<0.002	<0.002
Cs	<0.002	<0.001
Ba	<23	<8
La	<0.01	<0.01
Sm	<0.002	<0.001
Eu	<0.001	<0.001
Tb	<0.007	<0.006
Ta	<0.04	--
Hg	<0.03	<0.03
Th	<0.008	<0.006

* From the Annual Report to the NOAA, Contract No. 2311102778, April, 1977.

TABLE 15.* Analysis of trace elements in *Macoma inquinata* by x-ray fluorescence. Estimation of sample variability.

Element	Sample size[1]	Concentration (μg/g) $\bar{x} \pm 2$ S.E.
P	10	4,651 ± 686
S	10	15,374 ± 591
Cl	10	53,859 ± 3,695
K	10	13,504 ± 245
Ca	10	2,003 ± 140
Ti	10	23.7 ± 9.5
V	3	3.58 ± 0.45
Cr	5	3.92 ± 0.60
Mn	10	9.136 ± 1.043
Fe	10	315.2 ± 31.3
Co	4	2.497 ± 0.442
Ni	10	3.282 ± 0.391
Cu	10	8.108 ± 0.374
Zn	10	195.2 ± 12.5
Ga	10	n.d.[2]
Hg	10	n.d.
Se	10	3.177 ± 0.188
Pb	3	0.815 ± 0.680
As	10	10.319 ± 0.368
Br	10	262.5 ± 17.8
Rb	10	n.d.
Sr	10	29.59 ± 2.46

[1]In sample size <10, the remaining samples (= 10-n) were below detection limits. Nine to ten clams comprised a single sample.

[2]n.d. = not detectable.

* From the Annual Report to the NOAA, Contract No. 2311102778, April, 1977.

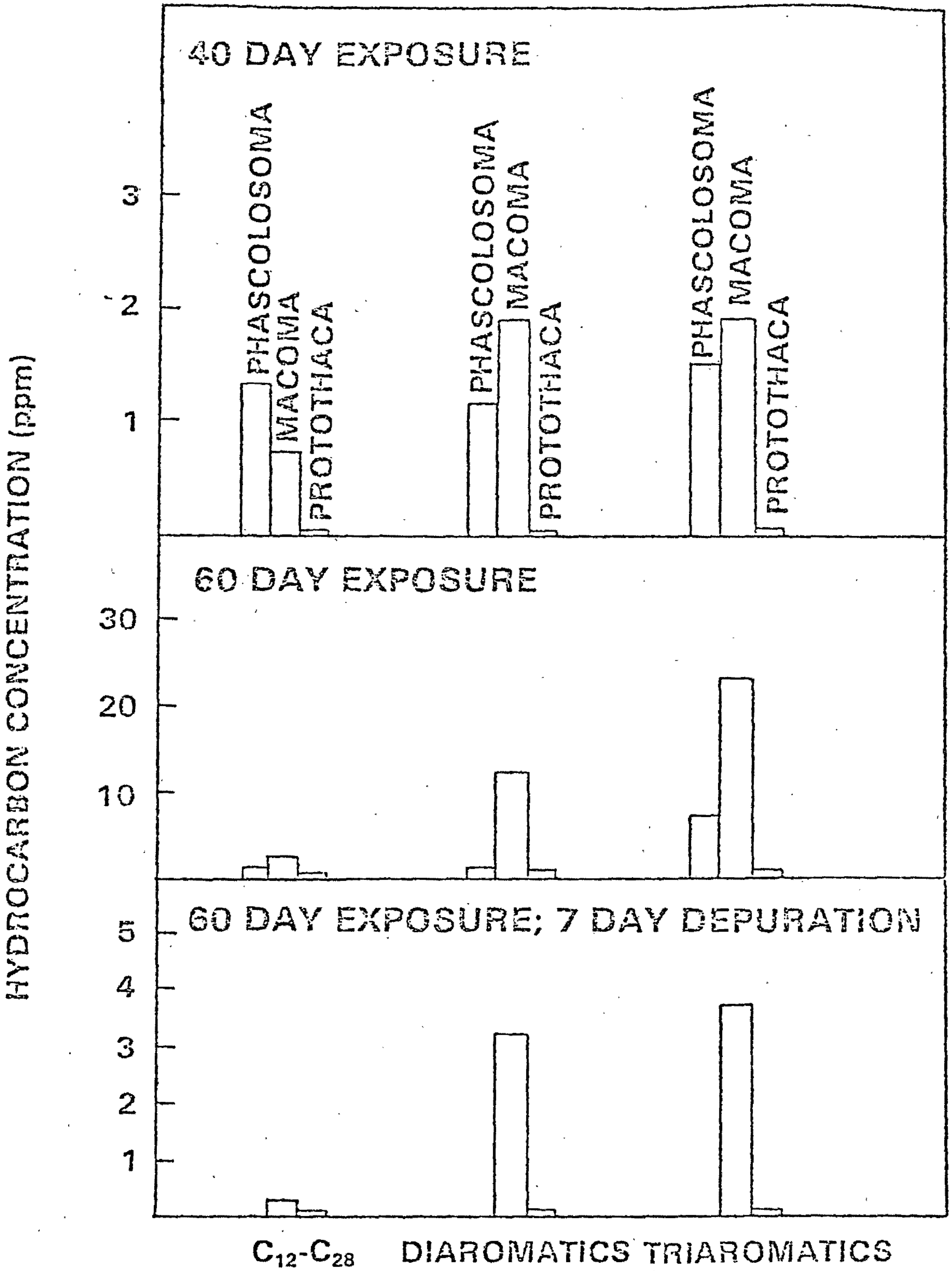


Figure 1. Concentrations of aliphatic (C_{12} - C_{28}), diaromatic, and triaromatic hydrocarbons in *Phascolosoma*, *Macoma*, and *Protothaca* exposed to sediment contaminated with Prudhoe Bay crude oil.

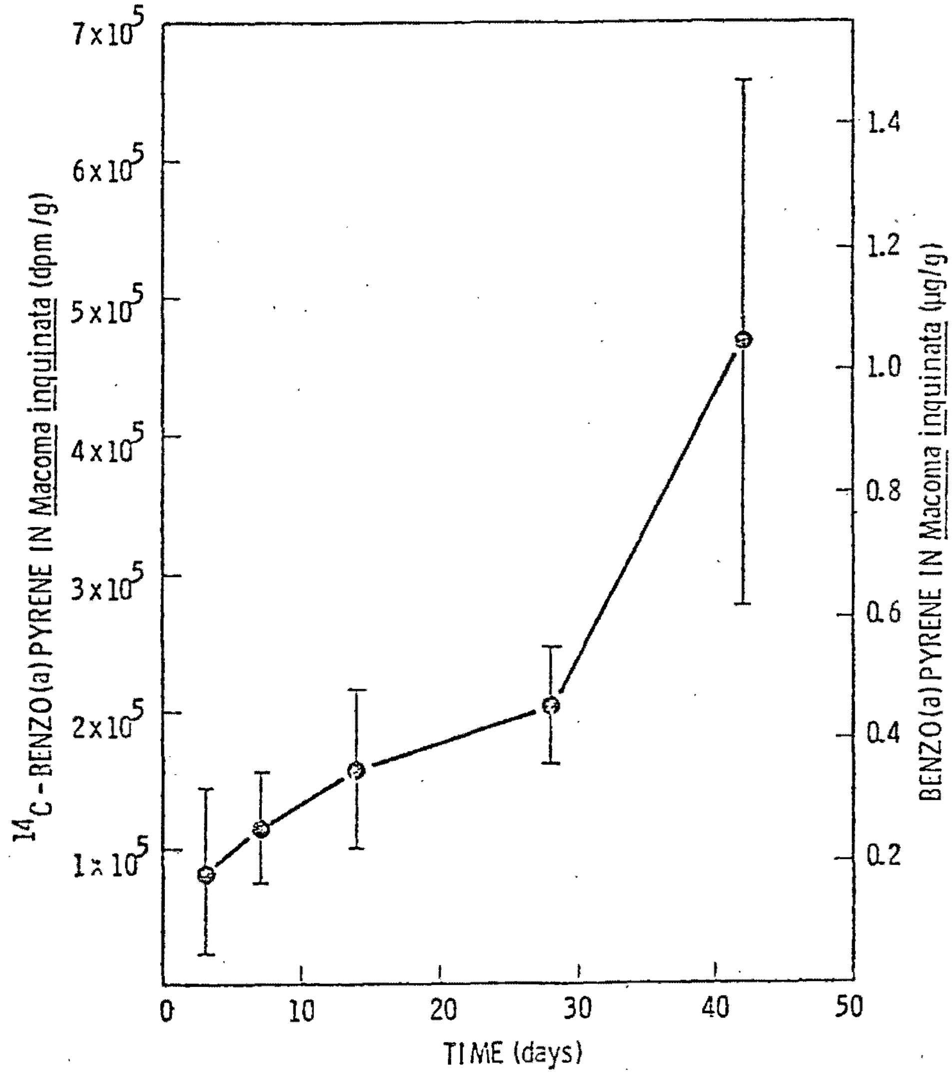


Fig. 2.* Concentrations of ^{14}C-benzo(a)pyrene in *Macoma inquinata* during exposure to sediment contaminated with ^{14}C-benzo(a)pyrene and Prudhoe Bay Crude oil. Vertical bars indicate 1 standard deviation. (See Table 8 for hydrocarbon concentrations in exposure sediment.)

* From the Annual Report to the NOAA, Contract No. 2311102778, April, 1977.

Rossi, S. S., and J. W. Anderson. 1977. Accumulation and release of fuel oil derived aromatic hydrocarbons by the polychaete, *Neanthes arenaceodentata* (Moore). *Mar. Biol.* 39:51-55.

Books:

Anderson, J. W. 1975. *Laboratory Studies on the Effects of Oil on Marine Organisms: An Overview.* API Publication No. 4249. American Petroleum Institute, Wash., D.C.

Petrocelli, S. R., and J. W. Anderson. 1976. Chapter 11: Distribution and translocation of residues of a chlorinated hydrocarbon insecticide, Dieldrin, among water, sediments and estuarine organisms from San Antonio Bay, Texas. pp. 185-218 in: *Shell Dredging and Its Influence on Gulf Coast Environments* (A. Bouma, ed.). Gulf Publishing Company, Houston, Texas.

Petrocelli, S. R., J. W. Anderson, and J. M. Neff. 1977. Chapter 20: Radiochemical Tracers in Marine Biology. pp. 921-968 in: *Radiotracer Techniques and Applications, Vol. II* (E.A. Evans & M. Muramatsu, ed.). Marcel Dekker, N.Y.

Technical Reports:

Anderson, J. W. 1973. *Uptake and Depuration of Specific Hydrocarbons from Oil by the Bivalves* Rangia cuneata *and* Crassostrea virginica. Background paper submitted to the National Academy of Science Workshop on Inputs, Fates and Effects of Petroleum in the Marine Environment, Airlie, Virginia, May 22-25, 1973.

Hopkins, S. H., J. W. Anderson, and K. Horvath. 1973. *The Brackish Water Clam* Rangia cuneata *as Indicator of Ecological Effects of Salinity Changes in Coastal Waters.* Contract Report H-73-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Petrocelli, S. R., and J. W. Anderson. 1973. Effects of shell dredging on the distribution and accumulation of chlorinated hydrocarbons in estuarine organisms, Vol. IV. In: *U.S. Army Corps of Engineers Environmental Impact Assessment of Shell Dredging in San Antonio Bay, Texas.*

AAA LABORATORY • amino acid analysis - composition & sequence

June 9, 1977

Amino Acid Analysis for Dr. Guri Roesijadi

Amino Acid	Total umoles 3	4	5	6
Alanine	13.9	2.09	2.26	7.35
Arginine	3.17	1.05	1.27	2.17
Aspartic acid	2.60	1.04	1.01	1.56
Cystine/2				
Glutamic acid	1.64	.420	.479	1.10
Glycine	29.3	8.21	8.90	20.3
Histidine	.291			
Isoleucine	.342	.0964	.113	
Leucine	.570	.172	.202	.225
Lysine	.425	.0809	.122	
Methionine				
Phenylalanine				
Proline	.647	.0513	.0791	.311
Serine*	2.30	.553	.809	1.52
Threonine	.674	.174	.192	.389
Tryptophan				
Tyrosine				
Valine				
Taurine	16.5	7.85	7.57	10.4
Total	72.4	21.8	23.0	45.3

* Serine, glutamine, and asparagine cochromatograph.

6206 89th Avenue Southeast Mercer Island, Washington 98040 Phone (206) 364-3446

Lowell H. Ericsson, Richard R. Granberg, Partners

Publications

Journal Articles:

Anderson, J. W., and D. J. Reish. 1967. The effects of varied dissolved oxygen concentrations and temperatures on the wood-boring isopod genus *Limnoria*. *Mar. Biol.* *1:*56-59.

Anderson, J. W., and G. C. Stephens. 1969. Uptake of organic material by aquatic invertebrates. VI. Role of epiflora in the apparent uptake of glycine by marine crustaceans. *Mar. Biol.* *4:*243-249.

Bedford, W. B., and J. W. Anderson. 1972. Physiological response of the estuarine clam, *Rangia cuneata,* to salinity. I. Osmoregulation. *Physiol. Zool.* *45:*225-260.

Anderson, J. W., and W. B. Bedford. 1973. The physiological response of the estuarine clam, *Rangia cuneata,* to salinity. II. Uptake of glycine. *Biol. Bull.* *144:*229-247.

Petrocelli, S. R., A. R. Hanks, and J. W. Anderson. 1973. Uptake and accumulation of an organochlorine insecticide (Dieldrin) by an estuarine mollusc, *Rangia cuneata*. *Bull. Environ. Contam. Toxicol.* *10:*315-320.

Anderson, J. W., J. M. Neff, B. A. Cox, H. E. Tatem, and G. M. Hightower. 1974. Characteristics of dispersions and water-soluble extracts of crude and refined oils and their toxicity on estuarine crustaceans and fish. *Mar. Biol.* *27:*75-88.

Petrocelli, S. R., A. Hanks, and J. W. Anderson. 1974. DDT and Dieldrin residues in selected biota from San Antonio Bay, Texas - 1972. *Pestic. Monit. J.*

Roesijadi, G., S. R. Petrocelli, J. W. Anderson, B. J. Presley, and R. Sims. 1974. Survival and chloride ion regulation of the porcelain crab *Petrolisthes armatus* exposed to mercury. *Mar. Biol.* *27:*213-217.

Anderson, R. D., and J. W. Anderson. 1975. Effects of salinity and selected petroleum hydrocarbons on the osmotic and chloride regulation of the American oyster, *Crassostrea virginica*. *Physiol. Zool.* *48:*420-430.

Neff, J. M., and J. W. Anderson. 1975. An ultraviolet spectrophotometric method for the determination of naphthalene and alkylnaphthalenes in the tissues of oil-contaminated marine animals. *Bull. Environ. Contam. Toxicol.* *14:*122-128.

Petrocelli, S. R., J. W. Anderson, and A. R.Hanks. 1975. Controlled food chain transfer of Dieldrin residues from phytoplankters to clams. *Mar. Biol.* *31:*215-218.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1975. Biomagnification of Dieldrin residues by food chain transfer from clams to blue crabs under controlled conditions. *Bull. Environ. Contam. Toxicol.* *13:*108-116.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1975. Seasonal fluctuations of Dieldrin residues in the tissues of the marsh clam *Rangia cuneata* from a Texas estuary. *Texas J. Sci. 26:*443-448.

Green, F. A., Jr., J. W. Anderson, S. R. Petrocelli, B. J. Presley, and R. Sims. 1976. Effect of mercury on survival, respiration and growth of postlarval white shrimp *Penaeus setiferus*. *Mar. Biol. 37:*75-81.

Neff, J. M., D. Dixit, B. A. Cox, and J. W. Anderson. 1976. Accumulation and release of petroleum-derived aromatic hydrocarbons by four species of marine animals. *Mar. Biol. 38:*279

Roesijadi, G., J. W. Anderson, S. R. Petrocelli, and C. S. Giam. 1976. Osmoregulation of the grass shrimp *Palaemonetes pugio* exposed to polychlorinated biphenyls (PCBs). I. Effect on chloride and osmotic concentrations and chloride and water exchange kinetics. *Mar. Biol. 38:*343-355.

Roesijadi, G., J. W. Anderson, and C. S. Giam. 1976. Osmoregulation of the grass shrimp *Palaemonetes pugio* exposed to polychlorinated biphenyls (PCBs). II. Effect on free amino acids. *Mar. Biol. 38:*357-363.

Roesijadi, G., S. R. Petrocelli, J. W. Anderson, C. S. Giam, and G. E. Neff. 1976. Toxicity of polychlorinated biphenyls (Aroclor 1254) to adult, juvenile and larval stages of the shrimp *Palaemonetes pugio*. *Bull. Environ. Contam. Toxicol. 15:*297-304.

Rossi, S. S., J. W. Anderson, and G. S. Ward. 1976. Toxicity of water-soluble fractions of four test oils for the polychaetous annelids, *Neanthes arenaceodentata* and *Capitella capitata*. *Environ. Pollut. 10:*9-18.

Rossi, S. S., and J. W. Anderson. 1976. Toxicity of water-soluble fractions of No. 2 Fuel oil and South Louisiana Crude oil to selected stages in the life history of the polychaete, *Neanthes arenaceodentata*. *Bull. Environ. Contam. Toxicol. 16:*18-24.

Tatem, H. E., J. W. Anderson, and J. M. Neff. 1976. Seasonal and laboratory variations in the health of grass shrimp, *Palaemonetes pugio:* dodecyl sodium sulfate bioassay. *Bull. Environ. Contam. Toxicol. 16:*368-375.

Ernst, V., J. M. Neff, and J. W. Anderson. 1977. Effects of water-soluble fractions of No. 2 Fuel oil on the development of the fish *Fundulus similis*. *Environ. Pollut.* (In press)

Lee, R. F., and J. W. Anderson. 1977. Fate and effect of naphthalenes in controlled ecosystem enclosures. *Bull. Mar. Sci.* (In press)

Lucu, C., G. Roesijadi, and J. W. Anderson. 1977. Sodium kinetics in the shrimp *Palaemonetes pugio*. I. Steady state and non-steady state experiments. *J. Comp. Physiol.* (In press)

Anderson, J. W., R. G. Riley, R. M. Bean, J. W. Blaylock, and S. L. Kiesser. 1977. *Laboratory and Field Studies on the Effects of Petroleum Hydrocarbons on Benthic Marine Invertebrates.* Progress Report to the U.S. Environmental Protection Agency, Energy Office, Wash., D.C.

Symposium Proceedings:

Anderson, J. W., J. M. Neff, and S. R. Petrocelli. 1974. Sublethal effects of oil, heavy metals, and PCBs on marine animals. pp. 83-121 in: *Survival in Toxic Environments* (M.A.Q. Khan and J. P. Bederka, Jr., ed.). Academic Press, New York.

Anderson, J. W., J. M. Neff, B. A. Cox, H. E. Tatem, and G. M. Hightower. 1974. The effects of oil on estuarine animals: Toxicity, uptake and depuration, respiration. pp. 285-310 in: *Pollution and Physiology of Marine Organisms* (F. J. and W. B. Vernberg, ed.). Academic Press, New York.

Anderson, J. W., R. Clark, and J. Stegeman. 1974. Petroleum hydrocarbons. pp. 36-75 in: *Marine Bioassays Workshop Proceedings* (API, EPA, MTS). Marine Technological Society, Wash., D.C.

Anderson, J. W. 1975. The uptake and incorporation of glycine by the gills of *Rangia cuneata* (Mollusca: Bivalvia) in response to variations in salinity and sodium. pp. 239-258 in: *Physiological Ecology of Estuarine Organisms* (F. J. Vernberg, ed.). University of South Carolina Press, Columbia, S.C.

Cox, B. A., J. W. Anderson, and J. C. Parker. 1975. An experimental oil spill: The distribution of aromatic hydrocarbons in the water, sediment and animal tissues within a shrimp pond. pp. 607-612 in: *Proceedings of 1975 Conference on Prevention and Control of Oil Pollution* (API, EPA, USCG). American Petroleum Institute, Wash., D.C.

Neff, J. M., and J. W. Anderson. 1975. Accumulation, release and distribution of benzo(a)pyrene-C^{14} in the clam *Rangia cuneata*. pp. 469-471 in: *Proceedings of 1975 Conference on Prevention and Control of Oil Pollution* (API, EPA, USCG). American Petroleum Institute Wash., D.C.

Anderson, J. W. 1976. Effects of petroleum hydrocarbons on the growth of marine organisms. pp. 157-165 in: *Petroleum Hydrocarbons in the Marine Environment* (A.D. McIntyre and K. Whittle, ed.). Rapp. P.-v. Reun. Cons. int. Explor. Mer, 171.

Anderson, J. W., and J. M. Neff. 1976. Accumulation and release of petroleum hydrocarbons by edible marine animals. pp. 1461-1469 in: *Proceedings International Symposium on Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Vol. III.* Commission European Communities, Luxembourg.

Anderson, R. D., and J. W. Anderson. 1976. Oil bioassays with the American oyster *Crassostrea virginica* (Gmelin). pp. 38-42 in: *Proceedings of the National Shellfisheries Association, Vol. 65.* Waverly Press, Easton, Md.

Neff, J. M., J. W. Anderson, B. A. Cox, R. B. Laughlin, Jr., S. S. Rossi and H. E. Tatem. 1976. Effects of petroleum on survival, respiration and growth of marine animals. pp. 515-539 in: *Sources, Effects & Sinks of Hydrocarbons in the Aquatic Environment.* American Institute of Biological Sciences, Arlington, Va.

Anderson, J. W. 1977. Responses to sublethal levels of petroleum hydrocarbons: Are they sensitive indicators and do they correlate with tissue contamination? pp. in: *Fate and Effects of Petroleum in Marine Ecosystems and Organisms* (D. Wolfe, ed.). Pergamon Press, New York. (In press)

Anderson, J. W., L. J. Moore, J. W. Blaylock, D. L. Woodruff, and S. L. Kiesser. 1977. Bioavailability of sediment-sorbed naphthalenes to the sipunculid worm, *Phascolosoma agassizii.* pp. in: *Fate and Effects of Petroleum in Marine Ecosystems and Organisms* (D. Wolfe, ed.). Pergamon Press, New York. (In press)

Anderson, J. W., D. B. Dixit, G. S. Ward and R. S. Foster. 1977. Effects of petroleum hydrocarbons on the rate of heart beat and hatching success of estuarine fish embryos. pp. 241-258 in: *Physiological Responses of Marine Biota to Pollutants* (F. J. and W. B. Vernberg, A. Calabrese and F. P. Thurberg, ed.). Academic Press, New York.

Dixit, D., and J. W. Anderson. 1977. Distribution of naphthalenes within exposed *Fundulus similus* and correlations with stress behavior. pp. 633-636 in: *Proceedings of 1977 Oil Spill Conference.* American Petroleum Institute, Wash., D.C.

Neff, J. M., and J. W. Anderson. 1977. The effects of copper (II) on molting and growth of juvenile and lesser blue crabs *Callinectes similis* Williams. pp. in: *Proceedings of NSF/IDOE Biological Effects Program Workshop* (Texas A&M University, May 16-19, 1976). In press.

Abstracts:

Petrocelli, S. R., and J. W. Anderson. 1971. The uptake of Dieldrin by *Rangia cuneata*. *Amer. Zool. 11*:694.

Bedford, W. B., and J. W. Anderson. 1972. Adaptive mechanisms of the estuarine bivalve, *Rangia cuneata*, to a salinity stressed environment. *Amer. Zool. 12*:721.

Roesijadi, G., S. R. Petrocelli, and J. W. Anderson. 1973. The effects of mercuric chloride on the survival and chloride ion regulation of *Petrolisthes armatus* (Crustacea: Porcellanidae). *Amer. Zool. 13*:1307.

Tatem, H. E., and J. W. Anderson. 1973. The toxicity of four oils to *Palaemonetes pugio* (Holthuis) in relation to uptake and retention of specific petroleum hydrocarbons. *Amer. Zool. 13*:1307.

Cox, B. A., and J. W. Anderson. 1973. Some effects of #2 Fuel oil on the brown shrimp *Penaeus aztecus*. *Amer. Zool. 13*:1308.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1973. Interactions of dieldrin with sediments and biota of an estuarine system. *Amer. Zool. 13*:1326.

Young, L., and J. W. Anderson. 1974. Influence of salinity and temperature on the O_2 consumption of *Neanthes arenaceodentata* Moore. *Amer. Zool. 14*:1260.

Anderson, R. D., and J. W. Anderson. 1974. Physiological responses of the American oyster, *Crassostrea virginica* Gmelin, to salinity changes. *Proc. Natl Shellfisheries Assn. 64*:1.

Anderson, R. D., and J. W. Anderson. 1974. Uptake and depuration of petroleum hydrocarbons by the American oyster, *Crassostrea virginica* Gmelin. *Proc. Natl Shellfisheries Assn. 64*:1.

Hopkins, S. H., J. W. Anderson, and K. Horvath. 1974. Biology of the clam *Rangia cuneata:* What we now know and what it means. *Proc. Natl Shellfisheries Assn. 64*:4.

Neff, J. M., and J. W. Anderson. 1974. Uptake and depuration of petroleum hydrocarbons by the estuarine clam *Rangia cuneata*. *Proc. Natl Shellfisheries Assn. 64*:6.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1974. Biological magnification of dieldrin in a two-part food chain. *Proc. Natl Shellfisheries Assn. 64*:7.

Young, L., and J. W. Anderson. 1976. Temperature, salinity and oil effects on the ingestion, egestion and growth of *Neanthes arenaceodentata* (Moore). *Amer. Zool. 16*:238.

Publications

Journal Articles:

Elliott, L. F., and J. W. Blaylock. 1971. A modified sand culture method for *Rhizobium* assay. *Proc. Soil Science Society of America 35*:158-159.

Elliott, L. F., and J. W. Blaylock. 1975. Effects of wheat straw and alfalfa amendments on solubilization of manganese and iron in soil. *Soil Science 120*: 205-211.

Technical Reports:

Yoss, J. K., J. W. Blaylock, M. J. Schneider, L. C. Schwendiman, C. J. Touhill, Jr., W. L. Templeton, R. E. Wildung, and D. B. Menzel. 1970. *Technical, Intelligence and Project Information System for the Environmental Health Service. Vol. IV. Pesticides Model Case Study*. Final Report to U.S. Dept. of Health, Education and Welfare. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Annual Reports:

Wildung, R. E., and J. W. Blaylock. 1971. Organic matter degradation in soil as influenced by soil type. pp. 1.38-1.39. In: *Pacific Northwest Laboratory Annual Report for 1970 to the USAEC Division of Biology and Medicine, Vol. 1, Part 2*. BNWL-1550. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Bean, R. M., and J. W. Blaylock. 1974. Determination of soluble aromatic hydrocarbons in suspensions of petroleum in sea water. pp. 35-37. In: *Pacific Northwest Laboratory Annual Report for 1973 to the USAEC Division of Biomedical and Environmental Research, Part 2*. BNWL-1850. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Blaylock, J. W., and R. M. Bean. 1975. Determination of methyl mercury in fish. pp. 43-49. In: *Pacific Northwest Laboratory Annual Report for 1974 to the USAEC Division of Biomedical and Environmental Research, Part 2*. BNWL-1950. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Bean, R. M., and J. W. Blaylock. 1976. Determination of hydrocarbons in sea water by helium equilibration gas chromatography. pp. 124-126. In: *Pacific Northwest Laboratory Annual Report for 1975 to the USERDA Division of Biomedical and Environmental Research, Part 2*. Battelle, Pacific Northwest Laboratories, Richland, Washington.

Symposium Proceedings:

Blaylock, J. W., P. W. O'Keefe, J. N. Roehm, and R. E. Wildung. 1973. Determination of n-alkane and methylnaphthalene compounds in shellfish. pp. 173-177. In: *Prevention and Control of Oil Spills;* Proceedings of Joint Conference sponsored by API, EPA and USCG. American Petroleum Institute, Wash., D.C.

Blaylock, J. W., R. M. Bean, and R. E. Wildung. 1974. Determination of extractable organic material and analysis of hydrocarbon types in lake and coastal sediments. pp. 217-219. In: *Marine Pollution Monitoring (Petroleum);* Proceedings of a Symposium sponsored by IOC-UNESCO, WMO and U.S. Dept. of Commerce. National Bureau of Standards Special Publication 409, Wash., D.C.

Bean, R. M., J. W. Blaylock, E. A. Sutton, R. E. Wildung, and F. M. Davidson. 1974. Characterization of sediments in the vicinity of offshore petroleum production. *Preprints (Symposia) of the Division of Petroleum Chemistry, Inc., American Chemical Society 19*:726-735.

Templeton, W. L., E. A. Sutton, R. M. Bean, R. C. Arnett, J. W. Blaylock, R. E. Wildung, and H. J. Moore. 1975. Oil pollution studies on Lake Maracaibo, Venezuela. pp. 489-497. In: *Proceedings of 1975 Conference on Prevention and Control of Oil Pollution,* sponsored by API, EPA and USCG. American Petroleum Institute, Wash., D.C.

Anderson, J. W., L. J. Moore, J. W. Blaylock, D. L. Woodruff, and S. L. Kiesser. 1977. Bioavailability of sediment-sorbed naphthalenes to the sipunculid worm, *Phascolosoma agassizii.* pp. In: *Fate and Effects of Petroleum in Marine Ecosystems and Organisms;* Proceedings of NOAA Symposium, Seattle, Nov. 10-12, 1976. Pergamon Press, N.Y. (In press).

Bean, R. M., and J. W. Blaylock. 1977. Characterization of volatile hydrocarbons in flowing seawater suspensions of No. 2 Fuel oil. pp. In: *Fate and Effects of Petroleum in Marine Ecosystems and Organisms;* Proceedings of NOAA Symposium, Seattle, Nov. 10-12, 1976. Pergamon Press, N.Y. (In press).

Vanderhorst, J. R., R. M. Bean, L. J. Moore, P. Wilkinson, C. I. Gibson, and J. W. Blaylock. 1977. Effects of a continuous low-level No. 2 Fuel dispersion on laboratory-held intertidal colonies. pp. In: *Proceedings of 1977 Oil Spill Conference (Prevention, Behavior, Control, Clean-up),* sponsored by API, EPA and USCG, New Orleans, March 8-10, 1977. American Petroleum Institute, Wash., D.C. (In press).

Abstracts:

Blaylock, J. W., and W. W. Chrudimsky. 1966. Induced antibiosis of *Aspergillus flavus* proliferation with *Arachis hypogoea.* p. 68. In: *Agron. Absts., ASA, SSSA, CSSA Annual Meeting,* Oklahoma State University, Stillwater, Okla.

Wildung, R. E., R. C. Routson, J. W. Blaylock, and A. R. Gahler. 1970. Seasonal distribution of P in total, inorganic, and organic P fractions of eutrophic lake sediments. p. 101. In: *Agron. Absts., ASA, SSSA and CSSA Annual Meeting,* Tucson, Arizona.

Publications

Journal Articles:

Brockheim, J. G., A. K. Schlicte, E. A. Crecelius, et al. 1969. Compositional variations of the Mazama ash as related to variation in the weathering environment. Northwest Sci. 43:162-173.

Crecelius, E. A. 1969. Molybdenum enrichment in the sediments of an anoxic fjord. Amer. Geophys. Union Trans. 50:208.

Crecelius, E. A., R. Carpenter and R. T. Merrill. 1972. Magnetism and magnetism and magnetic reversals in ferromanganese nodules. Amer. Geophys. Union Trans. 53:355.

Worsley, T. R. and E. A. Crecelius. 1972. Paleogene calcareous nannofossils from the Olympic Peninsula, Washington. Geol. Soc. Amer. Bull. 83:2859-2862.

Crecelius, E. A., R. Carpenter and R. T. Merrill. 1973. Magnetism and magnetic reversals in ferromanganese nodules. Earth and Plant Sci. Ltrs. 17:391-396.

Crecelius, E. A. and D. Z. Piper. 1973. Particulate lead contamination recorded in sedimentary cores from Lake Washington, Seattle. Environ. Sci. Technol. 7:1053-1055.

Crecelius, E. A., C. J. Johnson and G. C. Hofer. 1974. Contamination of soils near a copper smelter by arsenic, antimony and lead. Water, Air and Soil Pollution, 1975. 3:337-342.

Crecelius, E. A., M. H. Bothner and R. Carpenter. 1975. The geochemistries of arsenic, antimony, mercury and related elements in sediments of Puget Sound, Washington. Environ. Sci. Tech. 9:325-333.

Crecelius, E. A. 1975. The geochemical cycle of arsenic in Lake Washington and its relation to other elements. Limnol. Oceanogr. 20:441-451.

Crecelius, E. A. 1975. Analysis of total iodine in milk by X-ray fluorescence and iodide electrode. Anal. Chem. 47:2034.

Crecelius, E. A. 1977. Changes in the chemical speciation of arsenic following ingestion by man. Environmental Health Perspectives. (In press).

Smith, T. J., E. A. Crecelius and J. D. Reading. Airborne arsenic exposure and excretion of methylated arsenic compounds. Environ. Health Perspectives. (In press).

Robertson, D. E., E. A. Crecelius, J. S. Fruchter and J. D. Ludwick. Mercury emissions from geothermal power plants. Science. (In press).

Crecelius, E. A. Arsenite and arsenate levels in wine. Bull. of Environ. Contam. and Toxicol. (In press).

Publications (continued)

Annual Reports:

Crecelius, E. A. 1975. Feasibility of anodic stripping voltametry for trace element analysis of solutions, pp. 29. In: Pacific Northwest Laboratory Annual Report for 1974. BNWL-1950, Pt. 4. Battelle-Northwest, Richland, Washington.

Crecelius, E. A. 1975. High sensitivity X-ray fluorescence analysis by selective separations. p. 30. In: Pacific Northwest Laboratory Annual Report for 1974. BNWL-1950, Pt. 4. Battelle-Northwest, Richland, Washington.

Crecelius, E. A. 1975. Plasma excitation emission spectrometry applied to chemical speciation of trace metals in solutions, pp. 30-31. In: Pacific Northwest Laboratory Annual Report for 1974. BNWL-1950, Pt. 4. Battelle-Northwest, Richland, Washington.

Crecelius, E. A. 1975. Plasma excitation emission spectrometry applied to marine chemistry, p. 135. In: Pacific Northwest Laboratory Annual Report for 1974. BNWL-1950, Pt. 2. Battelle-Northwest, Richland, Washington.

Abel, K. H., D. E. Robertson and E. A. Crecelius. 1976. Physicochemical characterization of radionuclides and trace metals in reactor effluents at San Onofre nuclear power station, pp. 128-131. In: Pacific Northwest Laboratory Annual Report for 1975. BNWL-2000, Pt. 2. Battelle-Northwest, Richland, Washington.

Weimer, W. C., E. A. Crecelius and J. C. Langord. 1976. Age-dating recent lake and estuarine sediments by the direct counting of the ^{210}Pb 46.5 KeV gamma emission, pp.166-167. In: Pacific Northwest Laboratory Annual Report for 1975. BNWL-2000, Pt. 2. Battelle-Northwest, Richland, Washington.

Crecelius, E. A. 1976. Analysis of arsenic in solution by X-ray fluorescence of ferric hydroxide precipitate, p. 18. In: Pacific Northwest Laboratory Annual Report for 1975. BNWL-2000, Pt. 4. Battelle-Northwest, Richland, Washington.

Crecelius, E. A. 1976. Application of mercury speciation traps for geothermal gases, p. 22. In: Pacific Northwest Laboratory Annual Report for 1975. BNWL-2000, Pt. 4. Battelle-Northwest, Richland, Washington.

Crecelius, E. A. and J. C. Kutt. 1976. Analysis of trace elements in sea water by anodic stripping voltametry, p. 23. In: Pacific Northwest Laboratory Annual Report for 1975. BNWL-2000, Pt. 4. Battelle-Northwest, Richland, Washington.

Publications (continued)

Symposium Proceedings:

Crecelius, E. A. and R. Carpenter. 1974. Arsenic distribution in waters and sediment of the Puget Sound region. In: First Annual National Science Foundation Trace Contaminants Conf., Oak Ridge Nat'l. Lab., August 1973. 615-625.

Carpenter, R. and E. A. Crecelius. 1974. Geochemical cycles and budgets of arsenic in Puget Sound and Lake Washington. In: Second Annual NSF-RANN Trace Contaminants Conf., Asilomar, Calif., August 1974.

Crecelius, E. A. 1974. The geochemical cycle of arsenic in Lake Washington, Seattle. Presented at the 37th Annual Meeting of the Am. Soc. of Limn. and Oceanog., June 23-28, Seattle, Wash.

Crecelius, E. A. 1975. Chemical changes in arsenic following ingestion by man. Presented at the 15th Hanford Life Sci. Symp., September 29-October 1. Sponsored by ERDA., Richland, Washington

Crecelius, E. A., D. E. Robertson and L. A. Rancitelli. 1975. The development and characterization of marine standard reference materials (SRMs) for chemical speciation determinations. Presented at the Workshop on SRM for Marine Science, Catalina Island, October 8-9, Sponsored by National Bureau of Standards.

Crecelius, E. A., D. E. Robertson, J. S. Fruchter, and J. D. Ludwick. 1976. Chemical forms of mercury and arsenic emitted by a geothermal power plant. 10th Annual Conf. of Trace Substances in Environ. Health, Columbia, Missouri, June 8-10.

Crecelius, E. A. 1976. Changes in the chemical speciation of arsenic following ingestion by man. 8th Materials Res. Symp, Methods and Standards for Environ. Measurement, National Bureau of Standards, Gaithersburg, Maryland, September 20-24.

Smith, T. J., E. A. Crecelius and J. D. Reading. 1976. Airborne arsenic exposure and excretion of methylated arsenic compounds. Intl. Health Sci. and Dept. of Environ. Hygiene, Karolinska Inst., Fort Lauderdale, Florida, October 5-8.

Crecelius, E. A. 1976. Changes in the chemical speciation of arsenic following ingestion by man. Intl. Conf. on Environ. Arsenic, Cosponsored by Natl. Inst. Environ. Health Sci. and Dept of Environ. Hygiene, Karolinska Inst., Fort Lauderdale, Florida, October 5-8.

Crecelius, E. A. and M. L. Healy. 1977. Recommendations - Trace Elements. In: Recommendations for Baseline Research in Washington and Oregon Relative to Offshore Resource Development: Chemical Oceanography Workshop, pp. 175-179. Conference/Workshop Proceedings cosponsored by Bureau of Land Management Dept. of Interior. and Research Triangle Inst., December 15-17, 1976, Portland, Or.

PUBLICATIONS

JOURNAL ARTICLES:

Riley, Robert G. and P. E. Kolattukudy. 1976. Effect of treatment with calcium-ion containing formulations on the firmness of "golden delicious" apples. HortScience 11:249-251.

Riley, Robert G. and P. E. Kolattukudy. 1975. Biosynthesis of alkane-2,3-diols: chemical synthesis of 3-hydroxy [3-^{14}C] octadecane-2-one and its reduction to [3-^{14}C] octadecane-2,3-diol in the uropygial glands of ring-necked pheasants (Phasianus colchicus). Archives of Biochemistry and Biophysics. 171:276-281.

Riley, Robert G. and P. E. Kolattukudy. 1975. Evidence for covalently attached p-coumaric acid and ferulic acid in cutins and suberins. Plant Physiology. 56:650-654.

Riley, R. G., R. M. Silverstein and J. C. Moser. 1974. Biological responses of Atta texana to its alarm pheromone and the enantiomer of the pheromone. Science 183:760-762.

Riley, R. G. and R. M. Silverstein. 1974. Synthesis of S-(+)-4-methyl-3-heptanone, the principal alarm pheromone of Atta texana, and its enantiomer. Tetrahedron 30:1171-1174.

Riley, R. G., R. M. Silverstein, J. A. Katzenellenbogen and R. S. Lenox. 1974. Improved synthesis of 2-methyl-6-methylene-2,7-octadien-4-ol, a pheromone of Ips paraconfusus, and an alternative synthesis of the intermediate, 2-bromomethyl-1,3-butadiene. J. Org. Chem. 39: 1957-1958.

Riley, R. G., R. M. Silverstein, B. Carroll and R. Carroll. 1974. Methyl-4-methylpyrrole-2-carboxylate: A volatile trail pheromone from leaf-cutting ant, Atta cephalotes. J. Insect Physiol. 20:651-654.

Riley, R. G., R. M. Silverstein, and J. C. Moser. 1974. Isolation, identification, synthesis and biological activity of volatile compounds from the heads of Atta ants. J. Insect Physiol. 20:1629-1637.

Bozak, R. E., R. G. Riley, W. P. Fawns, and H. Javaheripour. 1974. The reaction of acylferrocenes with methylmagnesium halides. The intervention of carbonium-ion-like intermediates. Chemistry Letters, 167-170.

Bozak, R. E., H. M. Sorenson and R. G. Riley. 1969. An abnormal grignard product. The reaction of benzoylferrocene with methylmagnesium halides. Chemical Communications, 520.

REPORTS:

Technical Reports

Riley, R. G. 1976. Separation of polar shale oil compounds using high-speed liquid chromatography. BNWL-2128. Battelle-Northwest, Richland, Washington.

Publications

Journal Articles:

Roesijadi, G., S. R. Petrocelli, J. W. Anderson, B. J. Presley, and R. Sims. 1974. Survival and chloride ion regulation of the porcelain crab *Petrolisthes armatus* exposed to mercury. *Marine Biology 27:*213-217.

Roesijadi, G., J. W. Anderson, S. R. Petrocelli, and C. S. Giam. 1976. Osmoregulation of the grass shrimp *Palaemonetes pugio* exposed to polychlorinated biphenyls (PCBs). I. Effect on chloride and osmotic concentrations and chloride and water exchange kinetics. *Marine Biology 38:*343-355.

Roesijadi, G., J. W. Anderson, and C. S. Giam. 1976. Osmoregulation of the grass shrimp *Palaemonetes pugio* exposed to polychlorinated biphenyls (PCBs). II. Effect on free amino acids. *Marine Biology 38:*357-363.

Roesijadi, G., S. R. Petrocelli, J. W. Anderson, C. S. Giam, and G. E. Neff. 1976. Toxicity of polychlorinated biphenyls (Aroclor 1254) to adult, juvenile, and larval stages of the shrimp *Palaemonetes pugio*. *Bulletin of Environmental Contamination and Toxicology 15:*297-304.

Roesijadi, G. 1976. Description of the prezoeae of *Cancer magister* Dana and *Cancer productus* Randall and the larval stages of *Cancer antennarius* Stimpson (Decapoda: Brachyura). *Crustaceana 31*:275-295.

Lucu, C., G. Roesijadi, and J. W. Anderson. 1977. Sodium kinetics in the shrimp *Palaemonetes pugio*. I. Steady state and non-steady state experiments. *Journal of Comparative Physiology* (in press).

Roesijadi, G., D. L. Woodruff, and J. W. Anderson. 1977. Water turnover rates in the megalopa and crab stages I to V of *Pinnixa occidentalis*. *Comparative Biochemistry and Physiology*. (In press)

Roesijadi, C. 1977. Bioavailability of naphthalenes from marine sediments. *Environmental Pollution*. (In press)

Abstracts:

Roesijadi, G., S. R. Petrocelli, and J. W. Anderson. 1973. The effects of mercuric chloride on the survival and chloride ion regulation of *Petrolisthes armatus* (Crustacea: Porcellanidae). *American Zoologist 13:* 1307.

Presentations:

"Brown shrimp exposed to mercury in the field," presented at First Workshop for the Pathobiology and Toxicology of Penaeids, Galveston, Texas, 1975.

"Bioavailability of Petroleum Hydrocarbons from Marine Sediments Contaminated with Prudhoe Bay Crude Oil. presented at AAAS Annual Meeting, Pacific Divn., San Francisco, Calif., June 12-16, 1977.

AMENDMENT PROPOSAL TO NOAA FOR ADDITIONAL FUNDS ON

CONTRACT NO. 03-6-022-35204

for

Weathering of Prudhoe Bay Crude Oil

There is a phase of research programs on the effects and bioavailability of petroleum hydrocarbons in arctic and subarctic marine environments not covered by the OCSEAP program. The differences between freshly spilled oil and weathered oil are not being determined in any systematic manner. There are likely to be alterations in both the effects of these different substances and the uptake of specific hydrocarbons from them.

We have the facilities, personnel and expertise necessary to conduct a research project on the weathering of oil, but the present funding level is not sufficient to accomplish these additional objectives. With a supplement equivalent to approximately 12K, this phase of the research can be conducted. In the experiment we will be generating valuable information regarding alterations of oil during weathering, and the product may be used in small quantities by other investigators in effects studies on invertebrates, fish, birds, and mammals.

Objectives

The objectives of this supplemental proposal are to prepare weathered oils under three different conditions over a 64-day period and determine differences in composition of these products. Weathered oil will be prepared in quantities large enough (about 10 liters) to supply other investigators with samples. Replicate analytical samples will be available from several time intervals for verification by other laboratories (NOAA, Seattle) and follow-up studies on rates of change.

Experimental Approach

We have available 3 large volume tanks, measuring 1.6 M in diameter and 0.9 M deep (2M^2 area and 1,830 ℓ volume). A 2 cm thick layer of oil placed on the surface will require 40 ℓ of oil, of which about 25% (10 ℓ) should be available for sampling at later dates. The oil will be weathered in three ways:

Tank 1: To simulate weathering under calm conditions in the presence of sunlight, a slow flow of sea water will be injected below the oil slick and taken off from beneath.

Tank 2: To reduce the effects of sunlight (photo-oxidation of hydrocarbons), a system the same as Tank 1 will be prepared with a shade cover over the oil.

Tank 3: To simulate weathering under violent weather conditions, inflow water will be injected through a ring above the surface of the oil (without a sun shield).

At a time interval, which should be discussed with NOAA representatives, 10 ℓ of oil will be drained from each tank and placed in clean glass bottles. We plan to use one or more of these samples in our research, and other OCSEAP investigators have expressed an interest in utilizing such a "standardized" weathered oil. Analyses of these materials for percent hydrocarbon composition will be conducted for saturates between C_{11} and C_{26}, including pristane and phytane, and aromatics from naphthalene to dimethylphenanthrenes. These analyses will answer important questions regarding the nature of the weathering process, and also provide investigators with characterized substances for their studies.

The planned sampling schedule will be 200 ml quantities at 1, 2, 4, 8, 16, 32 and 64 days from each tank. These samples will be placed in 3 small vials

(15 ml) and one 200 ml bottle, sealed tightly with teflon lined caps. Before sealing, the air space above the bottle will be flushed with pure nitrogen gas. The bottles will be stored in a cool, dark location, and vials will be sent to Richland and other analytical facilities for hydrocarbon determinations. At termination of the weathering studies (64 days), the remaining oil (approximately 10 ℓ) will be skimmed from the tank surface and placed in amber glass gallon bottles. These will receive the nitrogen gas flush and be sealed. After removing 200 ml and treating as above, the remaining weathered oil will be available for shipment to investigators wishing to utilize these materials in their effects studies.

The water and weather conditions at the Marine Research Laboratory at Sequim Bay, Washington, during the weathering experiments (late spring and early summer) should be quite stable. Water temperature will vary from 9 to 11°C. There are more clear hours in this region than most northwest localities from San Francisco northward to Alaska. Therefore, an ample opportunity should be provided to observe differences between shaded and sun-exposed oil. Each day, readings of ambient light will be taken at 8:00 am, noon, and 4:00 pm to obtain a record of the extent of exposure to sunlight. We have the unique capability of treating a large volume of effluent from hydrocarbon exposures so dispersed or soluble materials will not enter the natural environment.

Comments on Anderson's weathered oil proposal from Killewich, 3/24/78

(1) The depth of Anderson's proposed slick, 2 cm, is much thicker than most oil slicks. As nearly as I can tell, these spread to 0.1-1 mm in thickness within 24 h (usually much less) of a spill. In the arrangement Anderson proposes, the oil will have no opportunity to spread, since its confined within a tank. This could affect the amount of photo-oxidation of petroleum components, due to the inability of light to penetrate the top layer of the slick. It could also affect the rate of evaporation of low molecular weight components. I don't know the degree to which these processes would be affected, but it should be discussed with Anderson.

(2) Agitation of water through turbulence, wave action, and mixing often leads to the formation of oil-water emulsions in the top 1-5 m of water. These emulsions have been termed "chocolate mousse." I wonder whether any of the conditions under which he is planning to weather the oil, even (3.), will induce formation of emulsions. I'm sure that oxidation, evaporation, and bacterial degradation are all facilitated by mousse formation, through increased surface area of oil. I would like to discuss this with Anderson also.

(3) We need more information about what part of the slick (surface, immediately under the surface, water column?) he's planning to sample for chemical analysis. In a real oil spill we would want to know the depth ot which petroleum components penetrated the water column as a function of environmental parameters such as temperature, salinity, light, wave action and currents, and wind. I suppose this is not possible in such an abbreviated study (particularly since the tank is only 0.9 m deep), but it does lead me to question the utility of this type of experimental approach.

(4) More information is needed on the kind of analysis he is proposing. Why is he not going to look at anything less than C_{11}? Is he assuming they'll all be evaporated in less than 24 h (the first sampling time)? I'd like to be sure of this; we have been putting a large amount of money into experiments designed to determine the toxicity of compounds such as benzene and toluene. What about components larger than dimethylphenanthrene, such as the infamous benzopyrene? Oxidation products of these components are much more water-soluble than the original compounds, and may therefore be available to water column organisms.

(5) I would suspect that 64 d may be much too long to continue the experiment; the major changes will probably take place much sooner than this (1-30d). This, however, will probably depend critically on the water and air temperatures, which also raises another difficulty in doing the experiment in Puget Sound. Although its possible weathering in Puget Sound will be similar to weathering in the subarctic, I doubt very much if it will at all resenble weathering under arctic conditions.

(6) Finally, it would be useful to know if bacterial populations, both numbers and types, in Puget Sound resemble Alaskan populations. If Puget Sound has any history of oil pollution, numbers of hydrocarbon degrading bacteria are undoubtedly higher than they would be in unpolluted Alaskan waters. This could clearly prejudice results.

Recommendation: Let me go talk to Anderson before we make a final decision on this.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P. O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

RFx41-454-300

Date: [illegible] 18 [illegible]

To : Wanda Power, Administrative Officer
Alaska Program Office, Boulder

Thru: Rudy Engelmann, Director
OCSEAP - Alaska Program Office, Boulder

RJE 4/24/78

From: Herbert E. Bruce, Manager
Juneau Project Office

Maurie J. Petto for

Subj: Supplemental Funding for RU 454

We approve Anderson's request for additional funds in the amount of $12,735, as decribed in the attached letter and amendment proposal. The following revisions in his proposal have been agreed upon by him, the Juneau Project Office, and Doug Wolfe:

(1.) the proposed oil slicks will be 1 cm thick initially, rather than 2 cm as proposed;

(2.) hydrocarbon analysis of the samples will be performed during the course of the weathering, rather than only at the end;

(3.) the experiment will be terminated at a time to be agreed upon by Anderson and the contract supervisor, Lois Killesich, and the duration will in all likelihood be no longer than 30 days.

Wanda: OK

Please initiate the appropriate paperwork and inform Anderson and Mr. Gary Counts at Battelle - Northwest, Richland, Washington.

Attachment

cc:
Lois Killewich
Doug Wolfe
Jack Anderson
Cary Counts
D.E. Olsen

Battelle
Pacific Northwest Laboratories
Battelle Boulevard
Richland, Washington 99352
Telephone (509)
Telex 32-6345

March 17, 1978

Dr. H. Bruce
National Oceanic and Atmospheric
Administration
Outer Continental Shelf
Environmental Assessment Program
Bering Sea/Gulf of Alaska Project Office
P. O. Box 1808
Juneau, AK 99802

SUBJECT: ACCUMULATION OF ORGANIC CONSTITUENTS AND HEAVY METALS FROM PETROLEUM-IMPACTED SEDIMENTS BY MARINE DETRITIVORES
BNW 2311102778, Amendment 2
NOAA Contract No. 03-6-022-35204

Dear Dr. Bruce:

Pursuant to discussions among you and Dr. Douglas Wolfe of the National Oceanic and Atmospheric Administration and Dr. J. W. Anderson of our laboratory, Battelle-Northwest proposes to amend the subject contract by increasing the authorized funding level to accommodate the increased scope of work described in Attacment A. We propose that the authorized funding be increased by $12,735 from the present level of $299,770 to a new level of $312,505. A breakdown based on our estimated cost increase is attached (Attachment B). No additional time will be necessary.

We feel there is a need for determining the fate of oil components in this seminatural system and for producing a characterized product that investigators on biological effects can utilize. Many of the conditions should be quite similar to the real-world, but this should only be considered a pilot study. Important data concerning breakdown products from oil can not be gathered at such a low funding level. The samples taken at various time intervals will be available for use in more comprehensive chemical studies on the qualitative and quantitative nature of breakdown products. In follow-up studies, a larger system (surface and depth) should be utilized, and the water column should be sampled. The 2 cm layer used in this study is not too far from reality, but a thinner layer would be expected under natural conditions. One problem which we will watch for is the disappearance of surface oil at later sampling intervals. It may be that 64 days will be too long, and the large sample will be taken sooner if loss rates suggest the need. In general, we feel this is a

Battelle

good beginning for evaluating the alterations in weathered oil and supplying a product to investigators. Hopefully, a larger scale project can be funded in the future which will more closely examine the production of breakdown products and their movement in the water column.

We believe this amendment is in the best interest of the overall project goals. All other terms and conditions of our existing agreement will remain unchanged.

If this proposed amendment is acceptable, please initiate the appropriate contract modification forms and forward them to Mr. C. A. Counts. If you have any questions about our proposal, please direct those of a technical nature to Dr. Anderson on (206) 683-4151. Contractual matters should be discussed with Mr. Counts on (509) 946-2642.

Very truly yours,

D. E. Olesen
Director, Research

DEO:nj

cc: Dr. Douglas Wolfe, Director
NOAA Environmental Research Laboratory
U. S. Department of Commerce
National Oceanic and
Atmospheric Administration
Environmental Research Laboratories
Boulder, CO 80302

Jane M. Ludka
Contract Specialist
U. S. Department of Commerce
National Oceanic and
Atmospheric Administration
Environmental Research Laboratories
Boulder, CO 80302

Sea-cliff Bird Surveys
Cape Thompson and Cape Lisburne, Alaska

Coprincipal Investigators

Alan M. Springer
David G. Roseneau

Research Unit 460

Total Cost of Proposal: $12,008.00

Organization: Renewable Resources Consulting Services Ltd.

Date of Proposal: 20 July 1977

Required Signatures:

Principal Investigators

Name Alan M. Springer Date 20 July 1977

Address RRCS, Ltd. 4 mi. College Rd. Fairbanks, AK 99701

Telephone Number (907) 479-2669

Name David G. Roseneau Date 20 July 1977

Address RRCS, Ltd. 4 mi. College Rd. Fairbanks, AK 99701

Telephone Number (907) 479-2669

Required Organization Approval and Financial Officer:

Name David G. Roseneau Date 20 July 1977

I. Title: Sea-cliff bird surveys, Cape Lisburne and Cape Thompson, Alaska.

Research Unit Number: 460/461

Contract Number: 03-6-022-35210

Proposed Dates of Contract: October 1977 - December 1978

II. Principal Investigators: Alan M. Springer
David G. Roseneau

III. Cost of Proposal:

Total $12,008.00

Distribution of effort by lease area: Hope Basin (100%)

IV. Background:

The seabird colonies at Cape Thompson and Cape Lisburne are the farthest north colonies in western North America and are by far the largest in the eastern Chukchi Sea. The birds which nest at the colonies feed at considerable distances from the cliffs, perhaps as far as 70 kilometers and convert tons of biomass daily. In tern they provide a major food source for several avian and mammalian species as well as local native villagers.

Approximately 50% fewer murres were counted at Cape Thompson in 1976 than were counted there in 1960 and 1961. The timing of the events in the breeding phenology of murres was later by about 10-14 days in 1976 than in the early 1960's. These two observations may be related, however, insufficient data exist to form any conclusions.

Black-legged Kittiwakes, which totaled about 24,000 in number and which nested with good success at Cape Thompson in 1960 and 1961, failed in their breeding effort during 1976. Reliable estimates of the population size of kittiwakes were not obtained. This breeding failure could be related to the relatively smaller number and late breeding of murres.

Among the factors which might have contributed to these phenomena are weather, sea ice and food availability. Analyses of stomach contents of both murres and kittiwakes suggest possibly low numbers of arctic cod, the principal food item taken by both murres and kittiwakes in 1960 and 1961. A "late" spring and persistent sea ice near the colonies may have also affected the timing, numbers and success of nesting birds at Cape Thompson.

The conditions which ultimately determine the timing of the breeding cycle and success of seabirds at Cape Thompson and at Cape Lisburne are different. Murre breeding schedules in 1976 began about 10 days earlier at Cape Lisburne than at Cape Thompson and the reproductive success of kittiwakes was demonstrably better. Satellite imagery of sea ice conditions in 1976 shows a substantially greater area of open water near the Cape Lisburne colony early in the summer than at Cape Thompson. No data exist on the relative availability of food items within the regions of the two colonies.

Field work at Cape Thompson and Cape Lisburne during the summer of 1977 is continuing to provide data describing differences and similarities between these two colonies. Integration of our results with those obtained by other investigators will help define the ecology of this area. However, two years' work will doubtfully provide sufficient information upon which to base firm conclusions about seabird ecology in the Chukchi Sea. Because of the importance of these two colonies to the surrounding ecosystem and because of the unique geographical position of these sites, we believe that continued low level investigations at Cape Thompson and Cape Lisburne could result in a much greater understanding of the biology of seabirds and of the ecology of the eastern Chukchi Sea.

V. Objectives

1. Provide an annual update on species composition, absolute numbers and reproductive success of seabirds nesting at Cape Thompson and Cape Lisburne.

2. Determine dietary components of Common Murres, Thick-billed Murres and Black-legged Kittiwakes.

3. Evaluate the phenology of breeding events and apparent reproductive success in relation to climatological and ice condition information and food habits data of 1976-1978; compare these data to similar data from other years at these colonies and with other major colonies in the Bering-Norton system.

Year to year changes in seabird populations of the Chukchi Sea are still poorly understood. That absolute numbers of major species and their reproductive success fluctuate over longer periods has been established. Data on the amplitude of yearly changes and long-term trends and the possible causes are necessary to any decisions made regarding leasing and development of the Alaskan Continental Shelf. The proposed study will compliment information on these aspects of coastal ecology gathered during past years.

VI. General Strategy and Approach:

Two weeks will be spent at each of the two sites, beginning with Cape Lisburne. Because nesting activities appear to start earlier at Cape Lisburne than at Cape Thompson, this schedule will allow work to be done during approximately the same times of the breeding seasons at the two colonies.

Colonies will be censused by counting selected plots representative of the different rock types and bird densities. Major changes in absolute numbers of birds colony-wide should be apparent from these samples when compared to 1976 and 1977 data. The plots selected for these population estimates will be established as monitoring sites for future studies.

Murres and kittiwakes will be collected at both sites. The specimens will provide additional food habits data and information on timing of breeding efforts of these species.

Estimates of the reproductive success of murres and kittiwakes will be made. Although the success of murres is extremely difficult to determine, it is somewhat easier for kittiwakes. Many fewer kittiwakes nest at these colonies than do murres in any year and a proportionately larger percentage of nests are able to be seen. Reproductive success per se will not be obtained from egg counts alone; however, the information will be important when compared to similar data from previous years.

Satellite inagery of sea ice conditions and climatological data in the Chukchi Sea will be obtained from other investigators. This information will be used with food habits data to help explain any trends which may be apparent in either the population size or reproductive success of murres and kittiwakes at Cape Thompson and Cape Lisburne. These data will also be compared to results of similar studies in the Bering Sea.

VII. Sampling Methods: NA

VIII. Analytical Methods: NA

IX. Anticipated Problems:

The only major problem which we might encounter is inclement weather. A severe storm would necessitate a schedule revision but would not seriously affect completion of the proposed work.

X. Deliverable Products:

A. Digital data - data to be recorded are listed in the attached data format sheets.

B. NA

C. Visual data to be submitted other than those included in reports will be one map showing colony locations, foraging flight directions and areas of critical habitat and approximately 200 plotographs of the study sites.

D. NA

E. Data collection - October 1977 to June 1978, acquisition of data from other investigators; July 1978 to September 1978, field data acquisition.

XI. Information Required from other Investigators

1. Remote sensing imagery of the Cape Thompson-Cape Lisburne coastline from 1 January 1977 to 1 October 1978.

2. Shipboard and aerial transect data on distribution and densities of seabirds in the Chukchi Sea which have been collected since 1976.

3. All current chemical, physical and biological oceanography data from the Chukchi Sea. Of particular interest are data on ocean and wind driven currents, results of plankton and fish trawls and benthic collections and bathymetry data.

XII. Quality Assurance Plans: NA

XIII. Special Sample and Voucher Archival Plans:

Voucher specimens of major food species of murres and kittiwakes will be preserved and archived at the University of Alaska, Fairbanks. Annual costs of this work will be insignificant.

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

Cape Lisburne - Room and board are available at the Cape Lisburne Air Force Base. There is no charge for room and board rates will be about $10.00/day/person. Two people will be quartered at the site for 15 days each.

Cape Thompson - We expect to again utilize the old Project Chariot buildings. The PI's will provide food at an estimated cost of $10.00/day/person. Two people will be at this site for 15 days each.

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

See above

3. What is your estimated per man day cost for this support at each location?

See above

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

XV. Management Plan:

The PI's will be responsible for both finantial and scientific management of this project. Maintenance of all finantial records and bookkeeping will be done by RRCS, Ltd., Edmonton.

XVI. Outlook

The results of this study should significantly broaden our understanding of seabird ecology. From this project we hope to describe recent trends in the populations of all species nesting at Cape Thompson and Cape Lisburne and to evaluate the degree of change which has occurred at Cape Thompson during the past 15 years. We also hope that major environmental factors which operate on these populations can be identified and assessed according to their relative effects.

Several interesting aspects of murre and kittiwake population structures at Cape Lisburne are emerging this summer. Murre collections reveal a substantial number of nonbreeding birds of both sexes and both species occur within the population. Most of the nonbreeders are lighter in weight and appear to be anatomically smaller than the breeding birds. It is possible that this group represents birds produced at this colony last year. This suggestion is based on a relatively very small percentage of birds but additional collections might permit population age structures to be established and might also even provide insighs into differential habitat utilization by age class.

Similar collections of kittiwakes indicate a large number of nonbreeding females are congregating along the coast near the colonies and along lagoons six to ten miles away. Birds collected from feeding groups near the cliffs or returning to the colonies from farther away have been predominantly adult birds in breeding condition. As with murres additional collections of kittiwakes might provide interesting information on characteristics of this population.

These observations will be elaborated upon with data collected through the 1978 field season. By that time we should understand many ofthe basic aspects of seabird populations nesting at these colonies. We believe that emphasis should then be placed on describing additional elements of murre and kittiwake population dynamics. We also believe that yearly updates on absolute numbers of birds at Cape Thompson and Cape Lisburne be maintained. Data on the amplitude and period of year to year changes of numbers and productivity of these seabirds will be central to to any decisions concerning impacts of resource development on the populations which nest at these sites.

We attach a high degree of importance to delineation of feeding areas of murres and kittiwakes, not only at our sites but at other major colonies to the south. Our data suggest that murres at Cape Thompson may feed as far away from the cliffs as 70 kilometers . We shall attempt to locate feeding areas at Cape Lisburne this summer by means of radio telemetry. In addition to providing information on areas critical to murres for food, telemetry studies of seabirds may produce valuable behavioral data. Should this technique prove reliable we anticipate expanding this program to other colonies in the Bering Sea and North Pacific Ocean. If principal foraging areas can be located within any of these waters, a collaborative study of physical, chemical and biological oceanography could perhaps elucidate many of the parameters important to maintaining the apparently high productivity of the region.

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the P.I. is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following standard acknowledgement is acceptable.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by P.I. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Seabird Colony	cards, tapes	as required	035	yes	10/77 to 9/78	12/78

MILESTONE CHART

RU #: 460/461 PI: Springer/Roseneau

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1976			1978													
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D		
First Quarterly Report				X													
Second Quarterly Report (ANNUAL)							X										
Third Quarterly Report										X							
Commencement of field activities										X							
Termination of Field activities											X						
Fourth Quarterly Report													X				
Data submission														X			
Final Report															X		

Publications and Reports

Swartz, L.G., W. Walker, D.G. Roseneau and A.M. Springer. 1973. Population status of Gyrfalcons in Alaska. Presented at the Conf. on Raptor Conservation Techniques, March 22-25, 1973, Ft. Collins, Colorado.

Springer, A.M. 1974. Effects of seasonal geographic and dietary changes on pollutant levels in Long-tailed Jaegers (*Stercorarius longicaudus*). Master's Thesis. Univ. of Alaska.

Springer, A.M. 1975. Observations on the summer diet of Rough-legged Hakws from Alaska. Condor 77: 338-339.

Swartz, L.G., W.Walker, D.G. Roseneau and Alan M. Springer. 1975. Populations of Gyrfalcons on the Seward Peninsula, Alaska, 1968-1972. In: J.R. Murphy, C.M. White and B.E. Harrell, eds., Population status of Raptors. Raptor ResearchFoundation, Inc., Report No. 3. Vermillion, S.Dakota.

Roseneau, D.G., A.M. Springer and L.G. Swartz. 1976. The status of Peregrine Falcons on the west coast of Alaska. In: Fyfe, R.S., S. Temple and T.J. Cade eds. The 1975 North American Peregrine Survey. Canadian Field-Naturalist 90:

Springer, A.M. and D.G. Roseneau. 1977. A comparative sea-cliff bird inventory of the Cape Thompson vicinity, Alaska. Annual Report NOAA/OCSEAP, Boulder, Colorado.

Springer, A.M. and K. Miller. Temperature regulation in feet of cold-stressed pigeons. In progress.

Springer, A.M. Lead and mercury accumulation in red-backed voles from Fairbanks, Alaska. In progress.

PUBLICATIONS AND REPORTS

1. Enderson, James H., David G. Roseneau and L. G. Swartz. 1968. Nesting performance and pesticide residues in Alaskan and Yukon peregrines in 1967. The Auk, Vol. 85: 4: p. 683-684.

2. Roseneau, D. G. 1969. Distribution, numbers and productivity in gyrfalcons on the Seward Peninsula, Alaska. In Alaska Department of Fish and Game Bird Segment Report Vol. X, April, 1969.

3. White, Clayton M. and David G. Roseneau. 1970. Observations of food, nesting and winter populations of large North American falcons. Condor 72: 1: p. 113-115.

4. Roseneau, D.G. 1970. Numbers and productivity of gyrfalcons on the Seward Peninsula, Alaska. In Alaska Department of Fish and Game Game Bird Segment Report Vol. XI, April, 1970.

5. Roseneau, D.G. 1971. Summer food habits of gyrfalcons on the Seward Peninsula, Alaska. In Alaska Department of Fish and Game Game Bird Report Vol. XII, April, 1971.

6. Cade, Tom J., Jeffrey L. Lincer, Clayton M. White, David G. Roseneau and L. G. Swartz. 1971. DDE Residues and eggshell changes in Alaskan hawks and falcons. Science 1971: Vol. 172 (No. 3986): 955-957. May 28, 1971.

7. Roseneau, D. G. 1972. Summer distribution, numbers and food habits of the gyrfalcons (Falco rusticolus L.) on the Seward Peninsula, Alaska. M. S. Thesis, College of Biological Sciences and Renewable Resources, University of Alaska, Fairbanks, Alaska.

8. Roseneau, D. G. 1973. Raptorial bird nesting sites along proposed pipeline routes in Alaska. Canadian Arctic Gas Study Limited Environmental Studies. Prepared for Northern Engineering Services, Ltd. by Renewable Resources Consulting Services, Ltd., June, 1973. 40 p.

9. Swartz, L. G., W. Walker, D. G. Roseneau and A. Springer, 1973. Population status of Gyrfalcons in Alaska. Presented at the Conf. on Raptor Conservation Techniques, March 22-25, 1973, Ft. Collins, Colorado.

10. Roseneau, D. G., and P.M. Stern. 1974.
Distribution of moose, muskox and sheep in northeastern Alaska. 1972. In: R. D. Jakimchuk (ed.) Distribution of Moose, Sheep, Muskox and Fur-bearing Mammals in Northeastern Alaska. CAGSL Biological Report Series Vol. 6, Chapt. 1, 61 p. + App.

11. Roseneau, D. G. and P. M. Stern. 1974.
Distribution and movements of the Porcupine caribou herd in northeastern Alaska, 1972. CAGSL Biological Report Series, Vol. 7, 209 p. + App.

12. Roseneau, D. G. 1974.
Caribou Fences located in northeastern Alaska, 1972. In: Millar, J. F. V. 1974. Proposal for Archaeological Salvage, Pipeline Corridor, Yukon and Northwest Territories. Archaeological Supplement to CAGSL Biological Report Series, Appendix A. 19 p.

13. Lenarz, Mark, Jon Klingel, Roland Quimby and D. G. Roseneau. 1974.
Moose. In: Mammal Studies in Northeastern Alaska with Emphasis Within The Canning River Drainage. CAGSL Biological Report Series, Vol. 24, Chapt. 1.

14. Roseneau, D. G. and C. Warbelow. 1974. Distribution and numbers of muskoxen in northeastern Alaska and the northern Yukon, 1973. In: K.H. McCourt and L.P. Horstman (eds.), Studies of large mammal populations in northern Alaska, Yukon and Northwest Territories, 1973. CAGSL Biological Report Series, Vol. 22, Chapt. 5, 30 p.

15. Roseneau, D. G. 1974.
A continuation of studies of raptorial bird nesting sites along proposed pipeline routes in Alaska. Report prepared for Northern Engineering Services, Ltd. 69 p.

16. Roseneau, D. G., P. Stern and C. Warbelow. 1974.
Distribution and movements of the Porcupine caribou herd in northeastern Alaska. In: K.H. McCourt and L.P. Horstman (eds.), Studies of large mammal populations in northern Alaska, Yukon and Northwest Territories, 1973. CAGSL Biological Report Series, Vol. 22, Chapt. 1, 56 p.

17. Roseneau, D. G., J.A. Curatolo and G. Moore. 1975.
Distribution and movements of the Porcupine caribou herd in northeastern Alaska and the Yukon Territory, 1974. CAGSL Biological Report Series, Vol. 32, Chapt. 3. 104 p.

18. Roseneau, D. G. and J.A. Curatolo. 1975.
A comparison of the movements and distribution of the Porcupine caribou herd 1971 - 1974. Address presented at the Annual Conference of the Northwest Section of the Wildlife Society, April 1-4, 1975, Anchorage, Alaska.

19. Warbelow, C., D.G. Roseneau and P. Stern. 1975.
The Kutchin caribou fences of northeastern Alaska and the northern Yukon Territory. CAGSL Biological Report Series, Vol. 32, Chapt. 4, 129 p.

20. Swartz, L.G., Wayman Walker II, D.G. Roseneau and A.M. Springer. 1975.
Populations of gyrfalcons on the Seward Peninsula, Alaska, 1968-1972. In: J. R. Murphy, C. M. White and B. E. Harrell (eds.), Population Status of Raptors. Raptor Research Report No. 3. Raptor Research Foundation, Inc. Vermillion, South Dakota.

21. Roseneau, D. G., Alan M. Springer and L. G. Swartz. 1976.
West coast of Alaska. In: Fyfe, R., S. Temple and T. J. Cade. 1976. The 1975 North American Peregrine Survey. Canadian Field-Naturalist Vol. 90.

22. Roseneau, D. G., H. Reynolds III and C. M. White. 1976.
Northeastern Alaska. In: (see 21 above).

23. White, C. M., D. G. Roseneau and M. Hehnke. 1976.
Gulf Coast of Alaska. In: (see 21 above).

24. D. G. Roseneau and J. A. Curatolo. 1977.
Distribution and movements of the Porcupine caribou herd in northeastern Alaska and the Yukon Territory, 1975. CAGSL Biological Report Series, Vol. 36.

25. Springer, A. M. and D. G. Roseneau. 1977.
A comparative sea-cliff bird inventory of the Cape Thompson vicinity, Alaska. Annual Report, NOAA-OCSEAP, Boulder, Colorado. 51p.

26. Curatolo, J. A. and D. G. Roseneau.
Distribution and movements of the Porcupine caribou herd in northeastern Alaska and the Yukon Territory, 1976. (in press).

PUBLICATIONS AND REPORTS

1. Craig, P. 1968.
The activity pattern and food habits of the limpet, (Acmaea pelta). Veliger III (Suppl.) 13-19.

2. Craig, P. 1970.
The distribution and behaviour of the intertidal sand beetle, (Thinopinus pictus) (Staphylinidae). Ecology 51: 1012-1017.

3. Craig, P. 1971.
An analysis of the concept of lunar orientation in (Orchestoidea corniculata) (Amphipoda). Animal Behavior 19 (1).

4. McCart, P. and P. Craig. 1971.
Meristic differences between anadromous and freshwater-resident Arctic char (Salvelinus alpinus) in the Sagavanirktok River drainage, Alaska. J. Fish. Res. Board Can. 28: 115-118.

5. Craig, P. 1972.
Orientation of the sand-beach amphopod (Orchestoidea corniculata). Animal Behavior, 21: 699-706.

6. McCart, P. and P. Craig and H. Bain. 1972.
Report on fisheries investigations in the Sagavanirktok River and neighboring drainages. Report to Alyeska Pipeline Service Company. 150p.

7. Craig, P. 1973.
The behavior and distribution of a sand-beach amphipod (Orchestoidea corniculata). Marine Biology (In press).

8. Craig, P. and G. J. Mann. 1974.
Life history and distribution of the Arctic cisco (Coregonus autumnalis) along the Beaufort Sea coastline in Alaska and the Yukon Territory. In: P.J. McCart (ed.), Life Histories of Anadromous and Freshwater Fishes in the Western Arctic. Canadian Arctic Gas Study Limited, Biological Report Series Vol. 20 (4). 32p.

9. Craig, P.C. and G.J. Mann. 1974.
Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska and the MacKenzie Delta. In: P.J. McCart (ed.), Classification of Streams in Beaufort Sea Drainages and Distribution of Fish in Arctic and Subarctic Drainages. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 17 (1). 47p.

10. Craig, P.C. and P. McCart. 1974.
Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the MacKenzie Delta 1972-1973. In: P.J. McCart (ed.), Fisheries Research Associated with Proposed Gas Pipeline Routes in Alaska, Yukon and Northwest Territories. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 15(3). 36p.

PUBLICATIONS AND REPORTS

1. Dzus, R. and G. McGonigal. 1971.
The Turkey Creek Drainage Basin: An Analysis of Phosphate Yield Variation Through Time and Space. Report submitted to C.A.H.E. of Toronto and Pollution Probe of Windsor.

2. Welch, R., A. Rahman and G. McGonigal. 1973.
User's Manual for Computer Mapping: "Symap", Version VII.

3. McGonigal, G. 1974.
Time Series Analysis: A Review of the Power Spectral Approach. An unpublished study of the Great Lakes for use by geography students in advanced quantitative analysis.

BEAUFORT SEA BARRIER ISLAND -- LAGOON

ECOLOGICAL PROCESS STUDIES, 1978

OCS Research Unit No. 467

LGL Limited Project No. US-18

Joe Truett, Ph.D.	Project Director
Peter Craig, Ph.D.	Aquatic Ecology
Stephen Johnson, Ph.D.	Ornithology
Richard Robarts, Ph.D.	Primary Productivity and Nutrient Dynamics

Total Cost: $570,617.41

15 August 1977

LGL Limited-US, Inc.
103-A Pleasant Street
Bryan, Texas 77801

Approved By:

Joe C. Truett

Joe C. Truett
LGL Limited
P.O. Box 80725
Fairbanks, Alaska
(907) 479-6519

TECHNICAL PROPOSAL

I. BEAUFORT SEA BARRIER ISLAND - LAGOON ECOLOGICAL PROCESS STUDIES

Research Unit No. 467

Contract No. 03-6-022-35193

Proposed Dates of Contract: 1 October 1977 to 1 March 1979

II. PRINCIPAL INVESTIGATORS

Joe C. Truett: Project Director
Peter Craig: PI, Aquatic Ecology
Stephen Johnson: PI, Ornithology
Richard Robarts: PI, Primary Productivity and Nutrient Dynamics

III. COST OF PROPOSAL (see Appendix II for cost breakdown)

A. Science

$570,617.41

B. PI - Provided Logistics

-0-

C. Total

$570,617.41

D. Distribution of Effort By Lease Area

Beaufort Sea, 100%

IV. BACKGROUND

This program (Research Unit No. 467) commenced in May 1976. Its general objective was to design and implement a scientifically integrated ecological process study of a barrier island - lagoon ecosystem on Alaska's Beaufort Sea coast. The focus of such a study was to (1) identify and analyze those ecosystem components and processes contributing importantly to the structure and productivity of nearshore ecosystems, (2) to determine the feasibility of detecting and quantifying temporal change in those ecosystem components and processes and (3) to evolve mechanisms by which those components and processes could be routinely evaluated for their reaction to man-caused change and, therefore, to determine their value as development impact indicators.

The study was foreseen as a two-phase effort -- a research planning phase (Phase I) followed by an implementation phase (Phase II). Phase I was, naturally, almost complete before the detailed objectives of Phase II were determined. Successive editions of the research plan, step by step embraced increasing amounts of detail. The basic plan initially tried to thoroughly describe the hypothetical ecosystem interactions. Then by simulation and deductive reasoning those ecological elements likely to be most affected by OCS development were exposed. Throughout the planning process, the design emphasis was to create a comprehensive program which was totally interdisciplinary.

The use of modelling during the course of project workshops created a common rhetorical base for PI's, project managers, and NOAA and BLM coordinators. Computer simulation models attempted to accumulate current data of the key ecological processes applicable to the study area. They were prepared and refined during the course of these workshops and investigators regularly were forced to critically evaluate each task statement in light of new insights: those gained through interdisciplinary discussions, and from results of varied simulations of key process interactions as portrayed by the models.

This project is basically different from other Research Units of the Alaskan OCS program in three ways:

(1) The Research Unit requires several Principal Investigators, each with a distinct and very different task objective.

(2) There is intense interdisciplinary cooperation and research integration, both in the planning and implementation phases of the program.

(3) Research implementation was preceded by a relatively lengthy planning period during which, it was found, modifications in research tasks had to be made. Striving to preserve the integrity of the program's goal, we identified continuing flexibility as a primary need. That is, research planning had to encompass a capacity for altering specific task objectives as the need for that alteration in emphasis became evident.

As a consequence of the unique characteristics of this Research Unit, key features of this renewal proposal are:

(1) A recommendation and request for flexibility in the way that proposed tasks are eventually implemented. This is critical because we expect that information from the 1977 field program will importantly direct task resolution for field research in 1978. Proposed objectives and methodology are, perhaps, not as specific as they might be if the planned tasks were expected to change relatively little during the course of the next several months.

(2) A presentation of each major disciplinary effort within this Research Unit as a separate task. In Appendix I, each task is reviewed as required by the "Request for Proposal Guidelines": Background, Objectives, General Strategy and Approach, Sampling and Analytical Methods, etc. Background and Objectives and General Strategy and Approach are also presented for the entire Research Unit.

V. OBJECTIVES

The broad objective of the proposed work is to study selected ecosystem processes operative in a barrier island - lagoon system on the Alaskan Beaufort Sea coast as a basis from which to predict impacts of OCS development upon ecosystem elements of concern to society.

To accomplish this major directive, tasks were developed, each with a set of more specific research objectives. These objectives are stated within the proposal for accomplishing each task (Appendix I): they are, briefly:

(1) To assess production and standing crops of primary producers (ice algae, phytoplankton, benthic algae).
(2) To assess the nature and extent of detritus inputs from terrestrial and aquatic sources.
(3) To analyze nutrient dynamics as they relate to aquatic productivity.
(4) To determine food habits of zooplankton and epibenthos.
(5) To determine habitat utilization and habitat dependencies of particular life cycle stages of fishes and principal species of invertebrates.
(6) To assess food sources and feeding dependencies of fishes and invertebrates in lagoon and nearshore marine waters.
(7) To document movements and residency times of fish and invertebrates in the lagoon habitat.
(8) To contribute to development of the population age-structure picture emerging from studies of nearshore fish species in adjacent regions.
(9) To analyze invertebrate collections and fish stomach samples (portions of samples gathered in 1977 as well as samples collected in 1978), to the new degree of detail required by refinements of the ecosystem model.
(10) To characterize the manner in which selected bird species utilize the barrier island - lagoon system for feeding, nesting, resting and/or molting.
(11) To describe the feeding and habitat dependencies of the bird species studied as these dependencies may be disrupted by OCS-related development.
(12) To evaluate the relative abilities among the various bird species to successfully cope with disturbance either by altering their feeding habits, non-feeding behavior, or habitat usage.
(13) To attempt to gather information on nesting/feeding/resting site-tenacities of selected bird species (contingent upon the success of bird marking efforts in 1977).
(14) To evaluate habitat use in the area by large mammals.
(15) To integrate results or the above research objectives with products of Research Units No. 526, 529, 530, and 531, which will be carried out in the same area.

VI. GENERAL STRATEGY AND APPROACH

The general strategy for implementing the overall program objective is to continually re-evaluate and refine specific objectives and tasks in light of new information produced by ongoing field research, data analysis, and systems analysis. Interdisciplinary workshops and impromptu meetings among PI's are critical to continued program integration. Specific strategies for accomplishing each objective will be modified as specific objectives are changed to more effectively meet project needs.

The specific approaches for accomplishing the proposed tasks as they are now envisaged are detailed in Appendix I (Tasks 1 through 6)

VII. SAMPLING METHODS

Sampling schemes for accomplishing task objectives are described under each task in Appendix I.

VIII. ANALYTICAL METHODS

Analytical methods contemplated for each task are discussed in Appendix I. Systems analysis, or modelling, will be used for simulating processes, for hypothesis generation, and for testing the probable impacts of development through sensitivity analysis.

We propose to hold workshops in the spring preceding the field season (April 1978), and again in late fall or winter (November-December) following the analysis of the major portion of the field research data.

IX. ANTICIPATED PROBLEMS

The major problems anticipated at this point are those associated with continued program integration. Recommended solutions are (1) increased efforts at communication among disciplines through discussion at the field camp, (2) periodic distribution of key research findings to each PI, and (3) periodic interdisciplinary workshops as proposed. (See "TASK 4: PROJECT INTEGRATION" for more detail about proposed integration plans for 1978).

X. DELIVERABLE PRODUCTS

A. Digital Data

Parameters to be recorded during the course of the proposed program are, in part, as follows:

(1) Distributional standing crops of ice algae, phytoplankton and benthic algae.
(2) Deposition rates of detritus to nearshore benthic environments.
(3) Seasonal plankton biomass and nutrient levels by habitat type within the lagoon and nearshore marine area.
(4) Seasonal abundance by species and distribution by microhabitat of fish and benthic invertebrates in the lagoon and nearshore marine habitats.
(5) Seasonal food consumption patterns by fish and benthos as related to distribution and abundance of food items.
(6) Population age structures of fish populations in the area.
(7) Water quality parameters (salinity, dissolved oxygen, temperature, etc.) and water currents in relation to fish and benthos presence and apparent movements.
(8) Seasonal distribution and abundance of birds in the barrier island - lagoon system related to habitat features.
(9) Seasonal habitat use and feeding dependencies of birds in the system.
(10) Distribution and abundance of foods utilized by birds.
(11) Temporal movement patterns of and habitat use by migrating birds in the nearshore environment.
(12) Seasonal distribution of marine mammals in the nearshore marine and lagoon area.

B. Narrative Reports

These include periodic progress and result reporting as required of all NOAA-OCSEAP projects. Specifically, this project will continually update the assessment of ecological processes subject to development effects; narrative models of interrelated processes and cause-effect relationships will be important.

C. Visual Data

Maps, charts, graphs, figures and diagrammatic descriptions of biota distribution, habitats, and processes will be provided as necessary.

D. Other Non-Digital Data

Not applicable.

E. Data Submission Schedules (see Data Products Schedule on next page)

Because of the proposed flexible nature of this program, and the probability that the schedule of data product submission envisaged now is likely to change prior to the beginning of the proposed program, we request that this schedule be viewed as tentative.

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

Mechanisms for a considerable amount of data exchange have been made a part of the design of this program. Specifically, Principal Investigators for Research Units No. 526, 529, 530, and 531 have been an integral part of this program to date, and will continue to closely integrate their work with the proposed efforts of this program. We will therefore be acquiring oceanographic, sedimentological, and geomorphological information from those PI's to complement the work proposed herein. The proposal for Research Unit No. 537 has been closely integrated with this proposal.

XII. QUALITY ASSURANCE PLANS

For those analytical procedures normally requiring quality assurance, we propose to use standardized and appropriately calibrated equipment both in the field and in the laboratory. Most laboratory analyses requiring sophisticated equipment (chlorophyll-a analysis, etc.) will probably be done at laboratories at the University of Alaska, which routinely calibrates and tests its equipment.

Quality assurance during performance of field research tasks is provided by the routine inclusion of at least two workers/observers for the accomplishment of most measurements (aerial bird surveys, migration watches, aquatic sampling procedures, etc.); these co-workers continually check their performance by comparing observations and research decisions.

Quality assurance plans for data assimilation and analysis include (1) one person's data coding checked by a second individual, (2) redundancy on data collection forms (two ways of representing animal species: by number and name), and (3) computer validation programs which search for impossible or improbable situations.

X. DELIVERABLE PRODUCTS

E. Data Products Schedule

Data Type	Media	Estimated Volume	OCSEAP Format	Processing & Formatting Done By PI?	Collection Period	Submission Date
Water current	magnetic tape	1,000 cards	File type 015	Yes	June-Sept. 1978	31 October 1978
Salinity, Temp., Depth (STD)	"	1,000 cards	File type 022	"	June-Sept. 1978	15 November 1978
Nutrients	"	1,000 cards	To be determined	"	Periodically: Oct 1977-Oct 1978	31 December 1978
Detritus	"	500 cards	To be determined	"	1 June-30 Sept. 1978	31 October 1978
Phytoplankton	"	1,000 cards	File type 028 or 029	"	Periodically: Oct 1977-Oct 1978	31 December 1978
Benthic Organisms	"	3,000 cards	File type 032	"	1 June-30 Sept. 1978	15 December 1978
Fish	"	10,000 cards	File type 023	"	1 June-30 Sept. 1978	31 December 1978
Birds: Aircraft Census	"	2,000 cards	File type 033	"	15 May-15 Sept. 1978	15 October 1978
Birds: Migration Watch	"	5,000 cards	File type 038	"	15 May-15 Sept. 1978	15 October 1978
Birds: Other	"	3,000 cards	To be determined	"	15 May-15 Sept. 1978	15 November 1978
Marine Mammals	"	500 cards	File type 026,027	"	15 May-15 Sept. 1978	30 October 1978

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLANS

Samples proposed to be taken during the course of this study are largely biological in nature (fish, fish larvae, invertebrates, fish otoliths, stomach samples, etc.). Voucher specimens can be easily retained and stored if requested by NOAA-OCSEAP, but in many cases preservation of entire samples would be costly (fish, epibenthos) and is not recommended. Also in many cases the samples are destroyed by analytical procedures and would not be suitable as vouchers. We propose to routinely save those samples which may be preserved indefinitely at room temperature in small vials or which are unusual or unique, but to discard those samples difficult to preserve and/or if identification of specimens is not normally open to question. We will maintain vouchers at the offices of LGL Limited in Edmonton, Alberta, unless otherwise requested by NOAA/BLM.

XIV. LOGISTICS REQUIREMENTS (see Appendix IV and Appendix II)

It is understood that logistics support costs are to be paid by the OCS Project Office. Please refer to Logistics Requirements form and to the attachment thereto for projected logistics support needed from NOAA-OCSEAP.

XV. MANAGEMENT PLAN

General Project Management: Overall sponsorship and supervision of this project is under the directorship of NOAA's OCSEAP program. Drs. Gunter Weller and David Norton of the OCS Arctic Project Office in Fairbanks, Alaska, function within OCSEAP for the execution, coordination, review, and assistance in logistics support of project research. LGL must respond primarily to the Arctic Project Office as appropriate during the execution of the project.

Dr. J.C. Truett will function as Project Director for the proposed study. He is responsible for the proper coordination and execution of the project by LGL. The Project Director will be responsible within LGL to a scientific and managerial advisory board composed of Drs. W.W.H. Gunn, J. Richardson, R. Davis, and A. Birdsall. The Project Director will direct the field research and general project operation. It is planned that Dr. Turett be based in Fairbanks during the performance of the research.

OCSEAP supervisory personnel will be able to exert their project coordination and review responsibility through the Project Director; he in turn will keep OCSEAP personnel informed of project development. Principal Investigators will coordinate their research planning and field effort with the Project Director to assure that the efforts of each discipline will complement, where appropriate, the efforts of each other discipline, and that timely and appropriate submission of data to OCSEAP is accomplished. Principal Investigators of related projects (Research Units No. 526, 529, 530, and 531) will also be requested to coordinate project planning and data collecting with LGL's Project Director.

Research Management: Field research management will be the responsibility of each Principal Investigator within his discipline; he will consult frequently with the Project Director to assure that his activities and data products are sufficiently coordinated with those of other disciplines and that they address overall project objectives. Dr. Peter Craig will be the fisheries Principal Investigator. Dr. Steve Johnson will be Principal Investigator for bird and terrestrial studies. Craig and Johnson will co-direct the entire field effort under the general supervision of the Project Director, who will visit the field periodically during the summer to maintain as awareness of the needs and research progress of investigators.

Craig and Johnson will have responsibility for assuring that a minimum of environmental disturbance accompanies field research effort. They will periodically review with the Project Director the nature and extent of environmental consequences of field research implementation, and propose plans for mitigative efforts if disturbance appears excessive.

Dr. Carl Walters, consultant for modelling tasks, will communicate directly with the Principal Investigators during workshop sessions so that investigators may respond to modelling needs as they collect and analyze data. Dr. Walters will communicate with Principal Investigators through the Project Director at other times, and the Project Director will assure that field data collections remain appropriate for use in modelling.

Milestone Data Chart: Please refer to chart on page 12.

XVI. OUTLOOK

It is anticipated that research objectives outlined for this program in 1979 and subsequent years will be adherent to these four general categories:

(1) Adding data and defining tasks - Topics requiring additional information and precision in aquatic ecology may include:

nutrients (seasonal variation, under-ice conditions)
primary production (dynamics of ice algae, phytoplankton, benthic algae)
detritus (sources, timing, distribution)
zooplankton (factors affecting distribution and life history)
invertebrates (critical life-history stages, habitat dependencies)
fish (population numbers, movement patterns, stock identification, critical habitats, distribution under ice, feeding dependencies)

We anticipate that important aspects of ornithological investigations will include quantification of precisely defined key energy-transfer mechanisms (feeding dependencies of arriving spring migrants and post-nesting waterfowl, etc.), as well as analyses of special habitat requirements (lagoons as molting habitat for ducks, etc.). Understanding the natural variability of birds responding to annually changing environmental factors is a consequence of annually repeated surveys; surveys designed to detect such variation, therefore, should be continued.

(2) Possible need for microbial investigation - As the ecosystem model develops it may indicate that estimates of microbial acticity (bacterial breakdown of organic detritus in cold water, nitrification, etc.) are essential. Studies of other processes as yet undefined may also prove to be desirable.

(3) Re-definition of the study area - Because we are dealing with highly transient populations, it may be logical to extend the physical boundaries of the study area to encompass a greater area. For example, offshore influences on the barrier island - lagoon ecosystem may warrant further study. It may also be desirable to test hypotheses developed in Simpson Lagoon studies by examining other Beaufort Sea lagoons as well as non-lagoon systems.

(4) Evaluating perturbations to the ecosystem - After a sophisticated ecosystem model has been developed, purposeful perturbations to the system may be used as a means of testing the model and evaluating its predictive capabilities. Such testing could be accomplished by either experimental manipulation or site-of-opportunity studies of actual environmental disturbances (dredging, fuel spills, etc) associated with OCS development.

Projected cost estimates for research efforts in the Barrier Island - Lagoon program for 1979 and 1980 reflect a decreased emphasis on new field research and a relatively higher level of integrative and interpretive effort. Estimates by task are as follows: (actual budgets and proposed budgets for 1977 and 1978, respectively, are given for comparison)

TASK	1977	1978	1979	1980
Task 1A. Trophic Ecology of Fish and Invertebrates	200 k	200 k	150 k[5]	75 k[5]
Task 1B. Primary Production and Nutrient Dynamics	12 k[1]	82 k	100 k[5]	60 k[5]
Task 2. Terrestrial Biology (Ornithology)	120 k	69 k	50 k[5]	40 k[5]
Task 3. Project Management and Data Management	142 k[2]	78 k	50 k	40 k
Task 4. Project Integration	40 k[3]	112 k	120 k	145 k
Task 5. Project Research Support and Review	-0-[4]	59 k	50 k	40 k
Total	514 k	600 k	520 k	400 k

[1] Estimate; not budgeted separately from Task 1A in 1977.
[2] A substantial portion of this amount was actually used for project integration in 1977.
[3] A considerably greater amount than this was actually used for 1977 project integration, but was funded during 1976.
[4] Paid for from 1977 Task 3 budget.
[5] A lesser portion of this is expected to be used for <u>new</u> research during each succeeding year, leaving a greater percentage for assembly and interpretation of other on-going research.

XVII. STANDARD STATEMENTS OF PROJECT PROCEDURE

A. Updated Activity / Milestone / Data Management charts will be submitted quarterly.

B. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October. Annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract..

C. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (larvae, juveniles, adults) when they are used, and sexes where these are morphologically distinguishable.

D. At the option of the Project Office, the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

E. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

F. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see para. B).

G. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

H. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

I. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release. The release of such material within a period of less that sixty (60) days shall be made only prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

J. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following standard acknowledgement is acceptable:

> This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office.

COST PROPOSAL (per Guideline requirements)

A categorical summary of projected costs for this proposed research program can be found on the next page.

A detailed breakdown of costs can be found in Appendix II, Cost Proposal Details.

MILESTONE CHART

RU #: 467　　　　P I: Truett et al.

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops, etc.

MAJOR MILESTONES	1977			1978														
	Oc	No	De	Ja	Fe	Ma	Ap	Ma	Ju	Ju	Au	Se	Oc	No	De	Ja	Fe	M
Primary Production and Nutrients																		
Field Research																		
Laboratory Analysis																		
Data Submission																		
Reporting																		
Fish and Invertebrate Ecology																		
Field Research																		
Laboratory Analysis																		
Data Submission																		
Reporting																		

MILESTONE CHART

RU #: 467 P I: J Truett et al.

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops, etc.

MAJOR MILESTONES	1977			1978														
	Oc	No	De	Ja	Fe	Ma	Ap	Ma	Ju	Ju	Au	Se	Oc	No	De	Ja	Fe	M
Ornithology																		
Field Research								←			→	Δ						
Laboratory Analysis												←	→	Δ				
Data Submission													Δ	Δ				
Reporting													←			→	Δ	
Modelling and Ingegration Workshops				Δ			Δ								Δ			
Quarterly Reports			Δ			Δ			Δ			Δ			Δ			
Final Report																		Δ

APPENDIX I

TASK STATEMENTS

TASK 1. AQUATIC ECOLOGY

1A: Trophic Ecology of Fish and Invertebrates
1B: Aquatic Primary Production and Nutrient Dynamics

TASK 2. TERRESTRIAL BIOLOGY (Ornithology)

TASK 3. PROJECT MANAGEMENT AND DATA MANAGEMENT

TASK 4. PROJECT INTEGRATION

TASK 5. PROJECT SUPPORT AND REVIEW

TASK 6. ENVIRONMENTAL ASSESSMENT OF RESEARCH ACTIVITIES

TASK 1. AQUATIC ECOLOGY

This task encompasses integrated studies of fish, benthos, plankton, aquatic productivity and nutrient dynamics in the Simpson Lagoon study area. Descriptions of studies within the aquatic program are based on anticipated results from the 1977 program, and an emphasis is placed on project objectives which were deferred until the second year of research. Research objectives also take into account the information needs identified at the NOAA/BLM-OCSEAP Synthesis Meeting held in Barrow (February 1977).

The 1978 aquatic program is divided into TASK 1A: Trophic Ecology of Fish and Invertebrates, and TASK 1B: Aquatic Primary Production and Nutrient Dynamics. Allocation of funds between TASKS 1A and 1B is provisional, depending largely on research needs to be identified as a result of this year's research and at the subsequent workshop and modelling session to be held in December 1977.

* * * * * *

TASK 1A: TROPHIC ECOLOGY OF FISH AND INVERTEBRATES

Principal Investigator: Dr. Peter Craig, LGL Limited

Cost of Proposal: $199,742.61 (Please refer to Appendix II for details)

Background: Task 1A is a continuation of fish and invertebrate research initiated in June 1977. These studies form an integral part of LGL's research plan involving important biotic processes in the barrier island - lagoon ecosystem.

A variety of other research efforts along the Beaufort Sea coastline will contribute useful information to Task 1A. With respect to fishes, Bendock (RU 233) surveyed fish resources in nearshore habitats between Harrison Bay and Flaxman Island, and Frost (RU 248/249) will be studying distributions and life-histories of Arctic cod and other offshore fishes collected during the Glacier cruise in 1977. These studies will aid in refining the descriptive picture now emerging (Craig and McCart 1976) of fish utilization of Beaufort Sea coastal regions. Doxey's (1977) study of fish passage around the ARCO causeway at Prudhoe Bay, and past Alaska Department of Fish and Game (ADF & G) studies in the vicinity are also pertinent in that these reports provide general information on fish movements in the vicinity of Simpson Lagoon. Other fisheries reports of particular significance to Task 1A are previous baseline studies conducted by our own personnel (Griffith et al. 1975 and 1977) which describe fish and benthos in two other Beaufort Sea nearshore systems, Kaktovik Lagoon (Barter Island) and Nunaluk Lagoon (Yukon Territory). These latter investigations will be valuable for comparative purposes since they describe nearshore environments which are both distant from and physically dissimilar to the Simpson Lagoon study area.

Benthic invertebrates have also received considerable attention in recent years. Crane (1975) gathered useful data on benthos within the Simpson Lagoon study area, and this information has been used by LGL to design the proposed sampling program.

Other benthos investigations in Beaufort Sea areas include both surveys and site-specific studies. Broad (RU 356) and Carey (RU 7) have surveyed benthic invertebrates between Barrow and Demarcation Bay in both littoral and offshore zones. Recent studies of zooplankton (RU 359), offshore invertebrates (RU 248/249) and Prudhoe Bay benthos (Feder 1976) may provide distribution and life history data for some species common to Simpson Lagoon.

Summarizing the relationship and relevance of LGL's proposed research to past and present scientific efforts makes it evident that the other investigations will provide useful information to supplement our Simpson Lagoon program but will not duplicate or replace any of the process-oriented research contained in this proposal. Specifically, data derived from the other studies will (1) provide life-history and other background data helpful for elucidating ecological processes in Simpson Lagoon and, (2) enable LGL to make a more realistic geographical extrapolation of the barrier island-- lagoon ecosystem model.

Objectives: Objectives of the aquatic program are to evaluate the various impacts of OCS development on a barrier island - lagoon system on the Beaufort Sea coast by studying selected processes and organisms within this system which are particularly vulnerable to impact. Specifically, we propose to:

(1) Determine habitat utilization and dependencies of particular life cycle stages of fishes and principal species of invertebrates.

(2) Assess food sources and feeding dependencies of fishes and invertebrates in lagoon and nearshore marine waters; determine feeding rates of fishes.

(3) Document movements and residency times of fish and invertebrates in the lagoon habitat.

(4) Contribute to development of the population/age structure picture emerging from studies of nearshore fish species in adjacent regions.

(5) Analyze invertebrate collections and fish stomach samples (portions of samples gathered in 1977 as well as samples gathered in 1978) to the new degree of detail required by refinements of ecosystem model.

Essential components of the objectives listed above can be summarized as studies of:

- habitat partitioning
- trophic interactions and feeding dependencies
- rates of immigration to and emigration from the lagoon system
- important life-history characteristics of key species.

All four of these components are essential if we are to construct a realistic model of key biotic processes in the barrier island - lagoon ecosystem.

Implicit in these research objectives is a test for a fundamental point of inquiry in the ecosystem model being developed: The special importance or "biological integrity" of the lagoon system in contrast to other nearshore environments. An understanding of the relative contribution of the lagoon system to aquatic productivity, when viewed in the broader context of Beaufort Sea coastal processes, would be of immediate significance to BLM for decision-making during OCS leasing and development.

Strategy and Approach: The aquatic program has been shaped by data needs of the following users:

(1) BLM/NOAA - Impacts of OCS development on aquatic organisms and habitats.

(2) OCS and other scientists - A review of the current status of fisheries research in arctic waters.

(3) Ecosystem Model - Research needs regarding energy pathways in the barrier island - lagoon ecosystem model (identified in preliminary workshops).

(4) Cooperating disciplines - Aquatic data requirements for other disciplines within RU 467 (densities of fish and invertebrates in bird-feeding areas, for example).

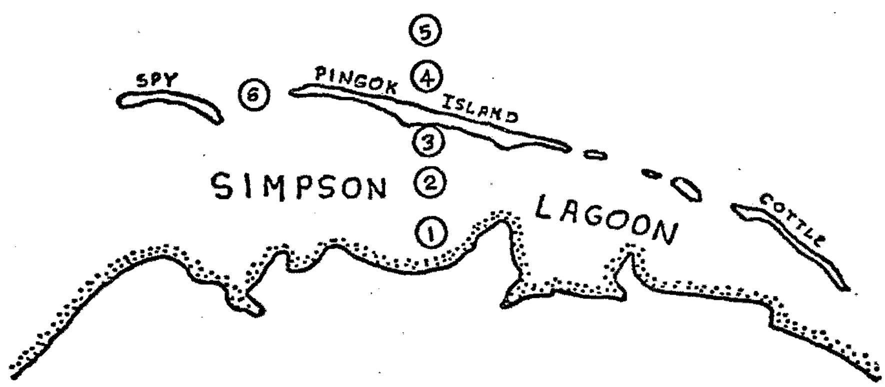
Our general strategy during 1978 will be to concentrate research efforts during the open-water season when biological activity is greatest, but to devote a significant portion of the program to under-ice investigations Sampling during the open-water period will consist of (1) a program of regularly-spaced collections in a variety of nearshore habitats, (2) non-routine samples to compare naturally occurring phenomena (breakup, storms, etc.) to the distribution and abundance of organisms, and (3) experiments to satisfy specific model needs such as feeding and colonization rates. Sampling emphasis will again be placed on key organisms in the aquatic ecosystem. For fish, these include the major anadromous species (Arctic char, Arctic and least cisco, broad and humpback whitefishes) and marine species (Arctic cod, fourhorn sculpin). Key invertebrates are generally the epibenthic amphipods, isopods and mysids which are widely distributed, abundant and overwhelmingly the main source of food for nearshore fishes.

Under-ice studies are scheduled for early and late winter since these periods have received little fisheries attention to date. Unfrozen nearshore areas may be vital to certain species at these times. For example, after surface waters freeze in early winter, there is a 1 - 2 month period when water levels below the ice in shallow coastal lagoons are still adequate for the passage of fish migrating to overwintering areas. It is also important to investigate nearshore habitats later in winter when they might be utilized by overwintering fish. During these winter sampling periods, LGL will rely on a diving program (which has proven successful in other LGL arctic projects) as well as standard sampling techniques.

Although Simpson Lagoon should remain the principal area of study, at this stage in the aquatic program there is a definite need to view the lagoon ecosystem in a broader context. Is the lagoon environment, in fact, an area of special ecological significance to fish and invertebrate populations? In terms of OCS development, this question seems fundamental, and therefore, we recommend that the 1978 sampling program extend beyond the physical boundaries of Simpson Lagoon and nearby marine habitats. A comparison would be made between the lagoon ecosystem and selected non-lagoon habitats, particularly exposed coasts and "offshore" locations (the relatively shallow waters seaward of the barrier islands which are receiving minimal attention in 1977). Our approach would be to determine, for example, whether densities of important fish and invertebrate species are lower in non-lagoon habitats than they are near coasts which have barrier islands or spits.

<u>Sampling Methods</u>: A variety of nearshore habitats will be sampled in the Simpson Lagoon study area. Six representative habitat types were established as sampling stations in 1977 (see below); the same general scheme will prevail in 1978, although the sites may be relocated to suit 1978 objectives.

Spatial Pattern



Additions to this spatial scheme include non-lagoon stations, the locations of which are as yet undetermined.

The temporal pattern of these ecosystems will be evaluated seasonally. Under-ice studies are proposed for early winter (October/November 1977 or 1978) and late winter (April 1978) periods. Overwintering fish, principally arctic cod and sculpins, will be observed and collected by divers in conjunction with studies of aquatic primary production and nutrient dynamics (TASK 1B). Determinations will be made of fish and invertebrate densities, habitat utilization, life-history status, and feeding habits. Samples of food organisms will be taken using (1) a 0.25 m zooplankton net, (2) a Ponar grab or diver-operated core sampler for benthic infauna (the need for this will be evaluated on the basis of 1977 field studies), and (3) a diver-operated core sampler for ice-bottom invertebrates.

During the open-water season, at approximately 10-day intervals, the distribution and abundance of fishes (including icthyoplankton) and important invertebrates will be monitored at locations previously indicated.

Fish sampling methods will include fyke nets, variable mesh gill nets, seines, and an otter trawl. Field analysis of specimens will involve standard life-history data; length, weight, sex, and reproductive condition. Stomach samples and otoliths (for age determination) will be retained for laboratory analysis. Live fish will be marked (Floy dart tags, opercular tags) and released for movement studies.

Sampling methods for invertebrates will include an otter trawl (equipped with a small mesh liner) and zooplankton nets of several kinds (0.25 m zooplankton net, Faber trawl, surface 14 cm net). An increased examination of infauna may be warranted pending results of the 1977 program. Collections will be preserved in formalin and returned to the laboratory for analysis of numbers, weights and gross taxonomic groupings. Basic life-history analysis (length frequency, sex, reproductive condition, diet) will be determined for selected species. Colonization rates of epibenthic invertebrates will be estimated in field tests.

Underwater transects by divers will provide quantitative information on habitat partitioning by fish and invertebrates. Transect methodology will follow Werner et al. (1977). Where possible, divers will also make behavioral observations on fish (feeding behavior, response to turbidity, etc.) and invertebrates (mobility, predator avoidance, etc.).

In order to determine trophic relationships between fish and epibenthic invertebrates in the lagoon ecosystem, estimates will be made of the following: (1) fish densities, based on fyke net, diving and fish tagging data, (2) invertebrate densities, based on trawl data, (3) fish feeding rates, based on field determinations of the daily food consumption per fish (Bajkov, 1935).

Use of the Alumiak or other research vessel, if it is available in 1978, is again desirable for sampling fish at locations seaward of Pingok Island.

Considerable laboratory analysis time is needed to:
(1) sort and identify invertebrate collections
(2) record lengths, weights, diets, etc. of important invertebrate species
(3) sort and identify stomach contents of fishes
(4) read otoliths for age determination of fishes.
Note also that analysis of some 1977 benthic invertebrate samples and stomach samples were deferred until 1978.

A pilot examination of gross parasite loading in nearshore fishes is also recommended since some fish appear heavily infested. Analyses would be conducted on a small, seasonal sample of fishes collected in 1977 in order to evaluate whether this topic (importance of fish parasites in terms of trophic energy pathways) was worth pursuing during the 1978 field season.

Analytical Methods: For the most part, standard analytical methods of fisheries science (catch per unit effort) will be used in this study. In the feeding rate experiment, estimates of a fish's daily food ration will be determined by Bajkov's (1935) simplified field test. Data analysis in diet studies (fish stomach contents) will include, (1) an estimate of stomach fullness, (2) numbers and damp weight for major taxa, (3) dry weight conversion factors obtained from subsamples, (4) Hynes' Point Method (Hynes, 1950) for direct comparison with diet data obtained at Barter Island by Griffiths et al.(1977), (5) estimates of statistical overlap in diets of major species (Horn, 1966), and (6) estimates of food dependencies or "Electivity Index" as described by Davis and Warren (1971).

Anticipated Problems: We do not anticipate major problems with field research other than the normal uncertainties and inconveniences periodically caused by the vagaries of weather. It is likely that significant problems, should they occur, will be associated with program integration. We recommend continued regular interdisciplinary conferences and workshops to help circumvent such difficulties with interdisciplinary cooperation.

* * * * * * *

Literature Cited

Bajkov, A.D. 1935. How to estimate the daily food consumption of fish under natural conditions. Trans. Amer. Fish Soc. 65: 299-9.

Craig, P.C. and P. McCart. 1976. Fish use of nearshore coastal waters in the western arctic: emphasis on anadromous species. In: Hood, D.W. and D.C. Burrell (eds.), Assessment of the arctic marine environment: Selected topics. Occas. Publ. No. 4, Inst. Mar. Sci., Univ. Alaska, Fairbanks. chapt. 23: 361-388.

Crane, J.J. 1975. Ecological studies of the benthic fauna in an arctic estuary. M.S. thesis, Univ. Alaska, Fairbanks. 105 pp.

Davis, G.E., and C. Warren. 1968. Estimation of food consumption rates. In: W.E. Ricker (ed.) Fish Production in Fresh Waters. IBP Handbook No. 3, Blackwell Scientific Pub., Oxford. Chapt. 10: 204-225.

Doxey, M. 1977. Fishery impact survey of the ARCO causeway. Alaska Dept. Fish and Game, Unpublished report to Atlantic Richfield Co., 38 pp.

Feder, H., A. Naidu, D. Schamel, D. Shaw, E. Smith and G. Smith. 1976. The arctic coastal environment of Alaska. Vol. III. The nearshore marine environment in Prudhoe Bay, Alaska. Inst. Mar. Sci., Univ. Alaska, IMS Report R76-7. 155 pp.

Griffiths, W., P.C. Craig, G. Walder and G.Mann. 1975. Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Y.T.). Canadian Arctic Gas Study Ltd., Calgary, Alberta. Biol. Rept. Series 34(2): 219 pp.

Griffiths, W., J. DenBeste and P. Craig. 1977. Fisheries investigations in a coastal region of the Beaufort Sea (Kaktovik Lagoon, Barter Island, Alaska). Canadian Arctic Gas Study Ltd., Calgary, Alberta. Biol. Rept. Series 40(2).

Horn, H.S. 1966. Measurements of "overlap" in comparative ecological studies. Am. Nat. 100: 419-429.

Hynes. H. 1950. The food of freshwater sticklebacks (Gasterosteus aculeatus and Pygasteus pungitius), with a review of methods used in studies of the food of fishes. J. Anim. Ecol. 19: 36-58.

Werner, E., D. Hall, D. Laughlin, D. Wagner, L. Wilsmann and F. Funk. 1977. Habitat partitioning in a freshwater fish community. J. Fish. Res. Board Can. 34: 360-370.

TASK 1B: AQUATIC PRIMARY PRODUCTION AND NUTRIENT DYNAMICS

This task outlines proposed investigations for the analysis of aquatic productivity in relation to physical and chemical changes in the barrier island - lagoon system. Emphasis will be placed on studies of primary production, detritus input from terrestrial sources, and nutrient dynamics.

The study will be jointly carried out by Dr. Richard Robarts (LGL Limited) and Dr. Donald Schell (University of Alaska). It is proposed that Dr. Schell be funded under separate contract to NOAA-OCSEAP. Task responsibilities, however, will be shared by Drs. Robarts and Schell to promote complete integration of the research. (A preliminary work plan for the allocation of responsibilities has already been produced.) It will be Dr. Robarts additional responsibility to accomplish the complete integration of the task with other disciplines within this program.

Principal Investigators: Dr. Richard Robarts, LGL Limited.

Cost of Proposal: $ 53,038,97

Background: The lagoon food chain is based on two principal types of primary production (ice algae and phytoplankton) and on detritus input from terrestrial sources (local runoff, major river sources). Primary production and detritus are processed by zooplankton and benthos which, in turn, generate food available for fish, birds and marine mammals.

The relative contributions of primary production and detritus as principal energy sources to the lagoon ecosystem are not understood. Preliminary results from LGL's barrier island - lagoon ecosystem model predict a rapid development and collapse of ice algae and plankton shortly after breakup, and consequently, inputs from aquatic primary production into the benthic system may be so short-lived as to constitute no real support for the benthic community. On the other hand, previous studies have suggested the importance of ice algae and phytoplankton production in arctic waters (Alexander et al. 1975, Horner et al. 1974, English RU 359). Ice-algae communities lengthen the season of aquatic productivity, and these algae are known to support organisms used as food by important fish species (principally Arctic cod) during the season of ice cover.

Nutrient chemistry in nearshore waters has received limited attention to date. Schell's (1975) earlier studies in Simpson Lagoon and other nearshore habitats provide a useful base for TASK 1B studies.

Objectives: Objectives of the aquatic program are to determine the various impacts of OCS development on a barrier island - lagoon system on the Beaufort Sea coast and to study selected processes and biota within this system which are particularly vulnerable to impact. Specifically, we propose to -

(1) Assess production and standing crops of primary producers (ice algae and phytoplankton.
(2) Assess the volume and nature of detritus inputs from terrestrial (and phytoplankton sinking) sources.
(3) Investigate the dynamics of nutrient cycling as they relate to aquatic productivity.
(4) Determine food habits of zooplankton and epibenthos, and assess the nature of lagoon detritus.

The individual roles of detritus input, primary production and nutrient dynamics are not fully understood, but their net contribution is the driving force in the lagoon food chain. All may be directly affected by OCS development activities, for example, (1) a decrease in light penetration (caused by turbidity from dredging, shading by spilled oil, changes in depth of snow cover) may reduce productivity, (2) contaminants (drilling muds, brine, sewage, petroleum products) may cause serious adverse impacts locally, and (3) physical alterations such as changes in water currents (resulting from causeways or dredging) may affect sedimentation or nutrient transport patterns in nearshore habitats.

Strategy and Approach: As a result of the latest LGL workshop (6 - 8 April 1977) it was decided that a precursory program to TASK 1B should be initiated in 1977. Purposes of the first year's sampling program were to obtain preliminary estimates for several fundamental assumptions underlying LGL's evolving barrier island - lagoon ecosystem model. These assumptions involved (a) principal sources of energy driving the system, and (b) the physical and chemical integrity of the lagoon environment. The following parameters are being investigated in the 1977 program:

(1) Detritus input to the lagoon system. Since a majority of invertebrates in the lagoon are deposit feeders or scavengers rather than herbivores (Feder 1976), the detritus budget to the system is a vital aspect of the ecosystem model. Thus, the 1977 program included estimates of the seasonal amount of detritus (organic carbon:nitrogen ratio) available to the benthic community and the sedimentation rate at which organic carbon is deposited on the substrate.

(2) Plankton dynamics. The dynamics of plankton communities in Simpson Lagoon are a product of plankton movements into and out of the lagoon system and of conditions inside the lagoon itself. Because of the rapid flushing of water masses which apparently occurs in Simpson Lagoon, it is difficult to predict at this stage whether plankton levels in the lagoon merely reflect the lagoon's boundary conditions. Thus, the 1977 program was designed to include a seasonal comparison of plankton (chlorophyll-a, zooplankton biomass) and nutrients (nitrate, ammonia) at stations inside and outside Simpson Lagoon.

A more detailed approach to these topics is needed and an analysis of the preliminary tests described above will significantly aid in determining the research direction of TASK 1B in 1978. If 1977 data suggest that lagoon productivity differs significantly from that occurring in waters outside the lagoon, then a detailed sampling program in both space and time is scheduled for the study area. If 1977 reveals no biological or physical "integrity" to the barrier island - lagoon ecosystem, the sampling program of TASK 1B will be spatially broadened to evaluate levels of primary production and detritus in adjacent habitats.

TASK 1B, which includes both summer and winter studies, will be coordinated with TASK 1A. Sampling times and locations will be similar for both tasks where possible, and fisheries personnel will aid personnel of TASK 1B to prevent duplication of field effort. Time requirements for fisheries personnel (Craig and Griffiths) to integrate TASKS 1A and 1B are accounted for in the budget for TASK 1A.

Sampling Methods: TASK 1B will include selected sampling stations (spatial pattern) which are illustrated in TASK 1A. Additional stations farther east and west in Simpson Lagoon will be selected because we expect that any parcel of lagoon water will be carried several kilometers per day by longshore currents, and therefore, samples taken at a fixed station would represent cross-sections through blooms initiated at various times and places "upstream" which might be completely uninterpretable.

To determine the temporal pattern, during late winter (April) concentrations of organic carbon in substrates, nutrient transport in water under ice, and the distribution and density of ice algae will be examined in nearshore habitats without bottomfast ice. Replicate ice cores will be taken in the deepest part of Simpson Lagoon and outside the barrier islands at approximately the 2.5 and 6 m isobaths. Additional cores will be drilled in randomly selected areas with bottomfast ice. At each sample site, profiles of water temperature, salinity and dissolved oxygen will be measured as well as snow and ice thickness. Ice cores will be analyzed for phytoplankton, chlorophyll-a and nutrient content. Additional nutrient and salinity samples will be taken in the water column (Schell 1975).

During the open-water season, water samples for chlorophyll-a and nutrients (ammonia, nitrate, phosphate, silica) will be taken every 10 days at lagoon stations. Phytoplankton productivity will be estimated using the ^{14}C light and dark bottle technique. Special attention will be directed towards determining how lagoon productivity reflects naturally-occurring phenomena such as storms and calm weather periods. Food habits and food sources of important zooplankton and epibenthic species will be evaluated by comparing stomach contents with available detrital material. TASK 1A will supply density data for invertebrate grazers.

Analytical Methods: Ice core samples will be analyzed for particulate N_2, and chlorophyll-a nutrient content following the techniques of Horner et al. (1974). Water samples taken during summer will be analyzed for chlorophyll-a and nutrients. Phytoplankton productivity will be estimated by ^{14}C incorporation.

Anticipated Problems: No critical problems are anticipated except for the normal inconveniences caused by inclement weather.

* * * * * * *

Literature Cited

Alexander, V., D.C. Barrell, J. Chang, R.T. Cooney, C. Coulon, J.J. Crane, J.A. Dygas, G.E. Hall, P.J. Kinney, D. Kogl, T.C. Mowatt, A.S. Naidu, T.E. Osterkamp, D.M. Schell, R.D. Seifert, and R.W. Tucker. 1974. Environmental studies of an arctic estuarine system - final report.

Feder, H., A. Naidu, D. Schamel, D. Shaw, E. Smith and G. Smith. 1976. The arctic coastal environment of Alaska. Vol. III. The nearshore marine environment in Prudhoe Bay, Alaska. Inst. Mar. Sci., Univ Alaska, IMS Report R76-7. 155 pp.

Horner, R.A., K.O. Coyle, and D.R. Redburn. 1974. Ecology of the plankton of Prudhoe Bay, Alaska. Univ. Alaska. IMS Report R74-2. 78 p.

Schell, D.M. 1974. Seasonal variation in the nutrient chemistry and conservative constituents in coastal Alaskan Beaufort Sea waters. In: V. Alexander et al. Environmental studies of an arctic estuarine system - final report. Univ. Alaska. IMS Report R-74-1, p. 217-282.

TASK 2. TERRESTRIAL BIOLOGY (Ornithology)

Principal Investigator: Dr. Stephen Johnson, LGL Limited

Cost of Proposal: $ 69,172.47

Background: This task primarily is a process-oriented study of birds using lagoons and nearshore marine waters.

It is also a continuing assessment of the presence and postulated importance of large mammals (polar bears, seals, and terrestrial mammals) in natural processes occurring in the area. It is, with some modifications, a continuation of research being conducted in 1977 in the Simpson Lagoon area under the same Research Unit.

A number of studies relevant to the proposed research have been made in the Beaufort Sea and elsewhere. Johnson et al. (1975) present a review of literature on birds of the Beaufort Sea. Schamel (1974) reports on the utilization of a barrier island in the Jones Island chain by birds. Flock (1973) has made radar-assisted observations of bird migration near the study area, as have Richardson et al. (1975) in the Yukon Territory along the coast. Other bird studies in the southeastern Beaufort Sea (Canada) include Gollop and Davis (1974), Koski (1975), Patterson (1974), Searing et al. (1975), Ward and Sharp (1974), and Wisely (1974).

Ongoing and recently completed OCS-funded research on birds in the Beaufort Sea includes (1) studies of shorebird dependence on arctic littoral habitats (Connors, RU 172); (2) distribution, abundance and feeding ecology of birds associated with the Beaufort ice pack (Divoky, RU 196); (3) identification, documentation, and delineation of coastal migratory bird habitat in Alaska (Divoky, RU 3/4); and (4) avifaunal utilization of an offshore island near Prudhoe Bay (Mueller, RU 215).

Arctic fox studies near the Beaufort Coast include recent investigations by the Los Alamos Scientific Laboratory and by Underwood (1975) in the Prudhoe Bay area. The distributional status and natural history of seals (Burns and others, RU's 230, 232, and 248/249) are currently under investigation, as are the distribution and habitat use of polar bears in the Beaufort (Lentfer, U.S. Fish and Wildlife Service, Anchorage).

These and other investigations will complement but not duplicate the efforts of this proposed work. As a process-oriented study, this program will utilize habitat and feeding-dependency information from many sources, in addition to the results of its own effort, to define the ecological support mechanisms of birds and mammals.

Objectives: Objectives of these investigations are:
(1) To characterize the manner in which important bird species use the barrier island - lagoon system for feeding, nesting, resting and/or molting.
(2) To describe feeding- and habitat-dependencies of the bird species studied as these dependencies may be disrupted by OCS-related development, and evaluate the relative abilities among the various species to successfully cope with disturbance by changing feeding habits, behavior and habitat usage.

(3) To evaluate the seasonal distribution of bird species among the major coastal habitat types.
(4) To evaluate the importance of micro-habitat features (micro-relief, physiognomy and distribution of vegetative growth, presence/absence of driftwood and other debris, depth of lagoons, characteristics of eroding shorelines and of islands,etc.), and the occurrence of seasonal phenomena (over-ice flooding, etc.) and study their effect on the nesting and feeding habits of those bird species studied, particularly if those features are likely to be altered by development.
(5) To evaluate the status of marine and nearshore terrestrial mammals by observation during the course of other studies.

These objectives are similar to those addressed in the 1977 program except that less attention will be given to analysis of bird migration. We propose not to repeat the radar observation program at the Oliktok DEW station because data from here and elsewhere (Richardson et al. 1975) indicate that migration is largely traditional and not likely to vary much annually. Another year's study would, therefore, probably not contribute significant information of use to this program.

We propose to place more emphasis in 1978 on the feeding- and nesting-dependent use of the barrier island and surrounding habitats, which is likely to vary considerably from year to year. Preliminary observations made early in this year's program indicate that island nesting-bird populations may be considerably different than has been reported by other workers on nearby barrier islands (Schamel 1974; Gavin 1976; Mueller, RU 215). Causes for these apparent differences are unknown, and need to be investigated.

Also, at this preliminary stage, it appears that more emphasis should be directed at investigating the importance of seasonal phenomena; over-ice flooding and resultant availability of resources supporting bird populations, for example.

Similar to the objectives of aquatic ecological research, more emphasis should be placed upon evaluating whether there is a special biological importance to the barrier island - lagoon system as such, or if exposed nearshore areas without islands and lagoons suffice equally well as habitat for birds.

Strategy and Approach: The basic methodologies for accomplishing the above objectives are similar in most respects to those of the 1977 program, except that we are recommending deletion of the radar migration study for reasons discussed above. Observers on the mainland and on the offshore islands will document by observation the use of the area by birds during migration. The distribution and behavior of birds in the area will be monitored by aerial survey. Use of islands by nesting-birds will be investigated, and use of island and mainland shorelines by post-nesting shorebirds will continue to be a part of the program.

Emphasis on feeding dependencies may suggest that collections of birds for food habits analysis equal or exceed those made in 1977. Pending the success of marking/banding scheduled for 1977, emphasis on netting and/or otherwise looking for marked birds may be an integral part of studying site tenacities among birds.

Tactics for elucidating the ecological roles of mammals in the area will be restricted to literature searches and observations incidental to other parts of this program.

Sampling Methods:

(1) Analysis of Bird Migration

Observers will document, from positions on mainland beaches and on barrier islands, the use of the Jones Islands - Simpson Lagoon area by migrating and staging birds during spring and late summer. These observers will maintain migration watch for several hours of each day during the peak of spring migration. During late summer, observers will maintain daily migration watches to be conducted simultaneously with systematic observations of use of the lagoon by molting, feeding and staging birds. Because migration is spread over a longer time period in late summer than in spring, and because field personnel will be involved with several other tasks in summer, it will not be possible to maintain watch for as many hours each day as in spring, but incidental observations of migrations during the course of other duties will be recorded. During migration watches, observers will record numbers, behavior, and habitat use by all birds observed migrating or in the area. A computer data form developed by LGL for recording observations of migrating birds will be used so that data may be readily analyzed with the aid of existing computer programs.

(2) Aerial Surveys

Approximately 6-8 aerial surveys will be made during the course of the spring and summer to characterize the aerial distribution of and habitat use by each species of large bird (duck, goose, whistling swan, loon, gull, arctic tern, jaeger) and by shorebirds as a group. Because of the great annual variability to be expected in bird population densities, distribution, habitat use, and breeding behavior, this proposed survey effort should complement (rather than duplicate)coastal bird surveys made in 1976 by George Divoky.

Surveys will be made from a helicopter transecting the area at an altitude of about 25 m . The first survey should be made when ice-free leads have formed offshore, but before lake, lagoon, and nearshore waters are open (probably about mid-June). This survey should be a reconnaissance to document the use of offshore leads and over-ice flood waters from mainland streams by early-arriving migrants (oldsquaw, eiders, etc.). Later surveys will parallel the coastline from the west end of Simpson Lagoon to the west end of Gwydyr Bay (a distance of about 30 km). Final decisions about overall design of coastal aerial survey sampling should be made after the results of 1977 surveys are analyzed.

(3) Nesting-Bird Surveys on Islands

Investigators will search for nesting birds on barrier islands by regular transect survey or complete count in June and July. Several islands, each with different physical features important to nesting birds, should be searched for nests by the ornithologists. Physical features characterizing nest sites (island size, distance from mainland and distance from other islands, relationships of nest and colony sites to spring break-up and snow-melt patterns, distance of nests from shore of islands, height above sea level, proximity to driftwood or vegetation, substrate material, nearness of nests located to nest of same or other species, etc.) will be described; descriptions will emphasize those parameters likely to be modified by development activity. Sites and islands where birds are not apt to nest will be described in the same manner, where applicable.

(4) Ground Surveys

In addition to the nesting-bird survey on selected islands, surveys of post-nesting shorebirds along beaches are proposed for use on the mainland. The purpose of these surveys is to characterize the feeding patterns of shorebirds, relate these to food use as determined by bird collections, and evaluate potential effects on shorebirds of such impacts as oil coverage of lagoons and beaches.

An investigator walking a transect along the water's edge will record information on (a) number of each species, and age and sex, if possible, (b) bird activity (feeding, flying, etc.), (c) specific feeding actions of birds (picking food from surf or debris, probing in the sand, etc.), and (d) comments on apparent migratory movements, other behavioral activities, and other types of birds (such as waterfowl using lagoons or the sea). Transects will be arranged so that beach type comparisons may be made at regular intervals (point vs. sheltered cove; narrow vs. broad beach; mainland vs. island; seaward vs. landward side of island).

(5) Bird Collections for Food Habits Analysis

Numbers of birds collected for food habits analysis should be adequate to generally compare to collections made in other Beaufort Sea coastal localities by OCS workers (P. Connors' shorebird work near Barrow; G. Divoky's oldsquaw collections near Cooper's Islands), and to collections made in 1977 during the course of this study. Collections should be adequate enough to equate bird diet to food availability, determined by sampling lagoon and shoreline invertebrates. Specific collection sites will be identified by the principal investigator on the basis of ground and aerial surveys, after the study begins. Collected birds will be identified, sexed, aged, and categorized by body fat index and reproductive condition. Stomachs will be collected, preserved, and labeled by date, collection location, and general activity at time of collection (feeding, in molting flock, in migration, etc.). When possible, samples for investigating bird prey abundance and composition should be taken at the same time and place as each bird collection.

Analytical Methods: Proposed methods of analysis are several. Most analyses of bird distribution, abundance, and behavior as observed during the various types of surveys are routinely keyed into computer programs developed by LGL, paralleled by basic laboratory procedures for preserving and analyzing bird stomach contents. Portions of this project's aquatic collections will be preserved for reference and to assist in identifying stomach contents. Standard statistical methods will be used where applicable to test the precision of sample results. Analysis of bird migration by simultaneous use of radar photography and visual observation will follow the procudures of Richardson et al. (1975)

Anticipated Problems: This year's field research season has not yet been long enough to determine by comparison what difficulties may be encountered next year. However, based on the success of past field experiences in similar environments, we do not anticipate any major problems in 1978.

It is likely that any obstacle to be overcome will be associated with program integration. Researchers are accustomed to dealing with specific problems in their respective fields but the interdisciplinary cooperation we propose for this study is new to most scientists. We recommend continued regular interdisciplinary conferences to alleviate task-integration problems likely to be encountered.

* * * * * * * *

Literature Cited

Flock, W.R. 1973. Radar observations of bird movements along the arctic coast of Alaska. Wilson Bull. 85(3): 259-275.

Gavin, A. 1976. Wildlife of the North Slope: the islands offshore Prudhoe Bay; the snow geese off Howe Island -- the seventh year of study. Atlantic Richfield Company, 71 pp.

Gollop, M.A., and R.A. Davis. 1974. Studies of bird populations and productivity on the Yukon North Slope, July 1972. In: W.W.H. Gunn and J.A. Livingston (eds.), Bird distribution and populations ascertained through ground survey techniques. Arctic Gas Biol. Rept. Ser. 12(1): 1-35.

Johnson, S.R., W.J. Adams, and M.R. Morrell. 1975. Waterbirds of the Beaufort Sea: a literature review. Rept. by LGL Limited to Canadian Wildlife Service.

Koski, W. 1975. A study of the distribution and movements of snow geese, other geese, and whistling swans on the Mackenzie Delta, Yukon North Slope, and Alaskan North Slope in August and September, 1974, including a comparison with similar data from 1973. In: W.W.H. Gunn, R.E. Schweinsburg, C.E. Tull and T.D. Wright (eds.), Ornithological studies conducted in the area of the proposed gas pipeline route: Northwest Territories, Yukon, and Alaska, 1974. Arctic Gas Biol. Rept. Ser. 30(1): 1-58.

Patterson, L.A. 1974. An assessment of the energetic importance of the North Slope to staging snow geese (Chen caerulescens hyperborea). In: W.W.H. Gunn, W.J. Richardson, R.E. Schweinsburg and T.D. Wright (eds.), Studies of snow geese and waterfowl in the Northwest Territories, Yukon Territory and Alaska, 1973. Arctic Gas Biol. Rept. Ser. 27(4): 1-67.

Richardson, W.J., M.R. Morrell, and S.R. Johnson. 1975. Bird migration along the Beaufort Sea coast: radar and visual observations in 1975. Beaufort Sea Technical Report No. 3c, Dept. of the Environment, Canada. 137 pp.

Searing, G.J., E.Kuyt, W.J. Richardson, and T.W. Barry. 1975. Seabirds of the southeastern Beaufort Sea:aircraft and ground observations in 1972 and 1974. Beaufort Sea Tech. Rep. No. 3b, Dept. of the Environment, Canada. 257 pp.

Schamel, D.L. 1974. The breeding biology of the Pacific Eider (Somateria mollissima v-nigra Bonapart) on a barrier island in the Beaufort Sea, Alaska. M.S. Thesis, Univ. Alaska. 95 pp.

Underwood, L.S. 1975. Notes on the arctic fox (Alopex lagopus) in the Prudhoe Bay area of Alaska. Pages 145-149 In: J. Brown (ed.) Ecological investigations of the tundra biome in the Prudhoe Bay region of Alaska. Biol. Papers, Univ. Alaska, Spec. Rep. No. 2.

Ward, J., and P.L. Sharp. 1974. Effects of aircraft disturbance on moulting sea ducks at Herschel Island, Yukon Territory, August, 1973. In: W.W.H. Gunn, W.J. Richardson, R.E. Schweinsburg, and T.D. Wright (eds.), Studies on terrestrial bird populations, moulting sea ducks and bird productivity in the western Arctic, 1973. Arctic Gas Biol. Rept. Ser. 29(2): 1-54

Wisely, A.N. 1974. Disturbance to snow geese and other large waterfowl species by gas compressor sound simulation, Komakuk, Yukon Territory, on snow geese and waterfowl in the Northwest Territories, Yukon Territories and Alaska, 1973. Arctic Gas Biol Rept. Ser. 27(3): 1-37.

TASK 3. PROJECT MANAGEMENT AND DATA MANAGEMENT

Cost: $ 77,425.81

General Project management is discussed under Section XV of Technical Proposal.

Data management is to be the responsibility of Mr. Tom Wetmore, computer specialist with LGL. The Data Manager is responsible for over-seeing project data collection for the needs of LGL, and for transmitting this data to the Environmental Data Service (EDS) in the form and format specified by OCSEAP. Data is to be submitted to the EDS within 90 days after collection. For those data which require extensive laboratory or computer analysis, the 90-day interval should begin at the completion of any specialized analysis.

TASK 4. PROJECT INTEGRATION

Cost: $112,256.49

Modelling and integration workshops will continue to be the key feature in integrating the various facets of this program, including Research Units No. 526, 529, 530, and 531. Dr. Carl Walters and his systems analysts from the University of British Columbia (UBC) Institute of Animal Resource Ecology in Vancouver, British Columbia, will continue to be investigators for this portion of the program. It is proposed that modelling workshops continue to be held at UBC because of the ease with which programs are conducted at the computer facility there.

Having recognized that effective project integration as a key objective of this program is also one of the most difficult tasks to carry out, we propose that integration efforts increase in intensity in 1978 and command a larger portion of the budget. Integration will be promoted in several ways, as follows:

(1) Provide strong encouragement to PI's to assemble in the field camp periodically during the summer to discuss research findings, problems encountered and research needs currently envisaged but not previously identified or anticipated. As an example of the potential usefulness of this approach: During the early phases of the 1977 field research effort biologists were able to more precisely identify (based upon the on-going field research effort) the kinds of information they would like to have had from the oceanographers. Unfortunately, by that time the oceanography field research plan had already become relatively inflexible and could not be changed to accommodate these newly envisaged needs.

(2) Promote periodic distribution of key research findings among PI's. A key integrative necessity is the meaningful exchange of the most currently available findings of Barrier Island - Lagoon program investigators. We propose periodic structured non-workshop seminars or research review sessions to be held either immediately prior to planned modelling workshop sessions, or at an entirely different time and location. Only the PI's of relevant research efforts (RU's No. 467, 526, 529, 530, and 531) would need to be involved in these seminars, although it would be desirable to include appropriate "outside" scientists if such is convenient.

(3) Arrange for impromptu seminars and discussion sessions among PI's to be held at times when investigators may conveniently assemble. For example, it would be desirable to have the PI's convene in Fairbanks at or near the end of the 1978 field research program. At this time general impressions gained from the PI's field research effort should be exchanged and proposed methods for assembling each PI's data into a coherent and integrated final report should be discussed.

(4) Hold interdisciplinary/modelling workshops during 1977-1978 (as well as in succeeding years, should the program be continued). The most appropriate and convenient strategy for accomplishing project integration is to hold a (a) December 1977 Workshop immediately following analysis of data collected during the preceding (1977) field season. During the course of this Workshop new information will be used to refine the model, and sensitivity analysis will be used to help define processes which should be studied in greater depth during the course of 1978 research. (b) Hold an April 1978 Workshop to enable researchers to plan a highly-integrated research program for summer, 1978, shortly prior to the beginning of the major field research effort.

A proposed partial time schedule of events to promote project integration:

DATE	EVENT	PARTICIPANTS
December 1977	Pre-workshop seminar.	Project PI's.
December 1977	Modelling workshop to integrate research findings to date.	PI's, modellers, NOAA/BLM coordinators.
April 1978	Workshop to refine and integrate 1978 field research plans.	Project Director, PI's, modellers? , NOAA/BLM coordinators.
September 1978	Post field season seminar to discuss general findings.	PI's, Project Director, NOAA-OCS project coordinators.
December 1978	Pre-workshop seminar and modelling workshop to analyze and integrate new data from 1978 research.	PI's, modellers, NOAA/BLM coordinators.

EXAMPLE: Agenda for a Beaufort Sea Barrier Island - Lagoon Workshop:

SESSION I: Program Overview (Day One, 9:00 AM - 11:00 AM)

1. Overview of research carried out to date in relation to BLM needs and NOAA objectives. (LGL Project Director, NOAA and/or BLM coordinator)

2. Brief review of results from first field season: systems properties and disciplinary interrelations elucidated that were found to be important processes. General changes in program emphasis since the last workshop and implications of these changes to the model. (Modellers, with input from LGL Project Director)

SESSION II: Model Critique and Refinement (Day One, 11:00 AM - 3:00 PM)

1. Brief presentation of submodels (oceanography, geophysical processes, aquatic ecology, and terrestrial biology) by appropriate modellers. Identification of changes in submodels which appear appropriate in light of general research findings since the last workshop.

2. Workshop participants separate into disciplinary subgroups to modify and refine submodels by soliciting input from PI's. At this time PI's will provide any newly-acquired quantitative data that are available as a consequence of new research (such as feeding rates, shoreline erosion rates, sediment deposition rates, rates of movement of animals in and out of the system, etc.).

SESSION III: Research Proposal for Next Year (Day One, late afternoon-evening).

1. During this time modellers will not attend general session but will work on the refinement of the model, using the information provided earlier in the day.

2. PI's and other workshop participants will reconvene in general session. Each PI will present to the group his general study proposal with emphasis on the following questions:

-What will be measured?
-How will the data be analyzed in light of program objectives and expected inputs from other investigators (if the data were now in hand, what would be done with it)?
-Which results does the investigator expect to be of special importance to other investigators (how does he view the total system implications of his results)?

Field research plans for the next research period will be presented in the following sequence:

(1) Naidu	- Sedimentology (RU No. 524)
(2) Cannon	- Geomorphology (RU No. 530)
(3) Matthews	- Oceanography (RU No. 526)
(4) Mungall	- Oceanography (RU No. 531)
(5) Craig	- Aquatic Ecology (RU No. 467)
(6) Johnson	- Terrestrial Ecology-Birds (RU No. 467)

SESSION IV: Evaluation and Revision of Next Season's Research Proposals (Day Two, morning and afternoon)

1. Evaluation of linkages between studies. Each investigator will be asked to review in a general discussion session all other studies of this program pertinent to his own area, and to discuss recommended revisions of these studies.

2. Modellers will be asked to compare model outputs based on the previous day's revisions to those of the last workshop and to recommend revisions of disciplinary programs based on model outputs.

3. After the linkage evaluation, there will be a brief (two-hour) meeting of subgroups with similar disciplinary interests, with the objective of modifying research plans, (a) to meet needs of other disciplines and (b) in response to any new areas suggested to be important by the modelling exercise. (Recommended changes, however, must fall within the capability range of presently-identified Principal Investigators, and their budgets,in order to be incorporated as changes in the 1978 field program)

4. The day will end with a general discussion session aimed at detecting and correcting major flaws in the program:

   (a) Have any major ecosystem components, processes, or linkages been neglected both in the field plans for last season, and as research priorities for next field season?

   (b) Are any of the field studies going to be essentially meaningless due to inability of other investigators to provide critical inputs?

   (c) Will the study results, when interrelated, provide NOAA and BLM with an improved basis for predicting impacts on those system components that they see as most important?

SESSION V: Future Research Coordination (Day Two, evening; Day Three, morning and early afternoon)

1. Each investigator will outline to the group his revised research program in terms of sampling dates, equipment needs, use of technical staff, and other tactical requirements.

2. The group will develop a simple analysis to determine an optimum schedule for sharing field research resources.

3. Areas of uncertainty about sampling times, etc., will be clearly delimited and alternative contingency plans will be developed.

TASK 5. PROJECT SUPPORT AND REVIEW

Cost: $ 58,982.57

This task includes expenses necessary for the effective implementation of the Barrier Island - Lagoon Program, but which are not specifically related to any of the other tasks. Personnel costs included are for in-house review (W.J. Richardson and W.W.H. Gunn), program logistics and editorial assistance (M. Spies), secretarial and accounting support, and a technician to replace vacationing field personnel and serve as field camp cook. Travel and per diem for the above persons are also part of the budget.

TASK 6. ENVIRONMENTAL ASSESSMENT OF RESEARCH ACTIVITIES

This task will be routinely accomplished during the course of other parts of the program and will not be assigned a separate budget. Stephen Johnson and Peter Craig will assume responsibility to continue to monitor the field program in 1978, as in 1977, and will:

1. Identify field activities likely to importantly affect ecosystem processes.

2. Conduct the field research program so that adverse impacts will be avoided to the greatest extent possible within the limits of effective accomplishment of objectives.

3. Document the nature and extent of study-caused impacts.

The accomplishment of this task will be primarily through day-to-day observations of human activity in and near the Pingok field camp, including activity associated with sampling routine. Subjective evaluations of impacts will, in most cases, form the basis for this task product.

LOGISTICS REQUIREMENTS FORM

Area of Operation ______

Please fill in all spaces or indicate not applicable (N/A). Use additional sheets as necessary. Budget line items concerning logistics should be keyed to the relevant item described on these forms.

INSTITUTION LGL Limited- US, Inc. PRINCIPAL INVESTIGATOR Truett et al.

A. SHIP SUPPORT

1. Delineate proposed tracks and/or sampling grids, by leg, on a chart of the area. Include a list of proposed station geographic positions.
   Offshore of Simpson's Lagoon, Beaufort Sea Coast.
2. Describe types of observations to be made on tracks and/or at each grid station. Include a description of shipboard sampling operations. Be as specific and comprehensive as possible.
   Fish and epibenthos sampling with nets and trawls.
3. What is the optimum time chronology of observations on a leg and seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification.)
   Optimum sampling times are as soon as possible after ice move-out in midsummer and again in late August-early September.
4. How many sea days are required for each leg? (Assume vessel cruising speed of 14 knots for NOAA vessels. Do not include running time from port to beginning point and from end point to port and do not include a weather factor.)
   About 4 - 5 days optimum at each of the two sampling times above.
5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback?
   Could piggyback.
   Approximately how many vessel hours per day will be required for your observations and must these hours be during daylight? Include an estimate of sampling-time on station and sample processing time between stations.
   Vessel hours per day = 8 or less. Do not have to be in daylight.
6. What equipment and personnel would you expect the ship to provide?
   Would be helpful if ship could provide: 1.A technician 2.Winch for handling trawls and nets 3.Food and bunk space.
7. What is the approximate weight and volume of equipment you will bring?
   Max. wt. of equipment = 500 lbs. Max. volume of equipment = 2 m^3
8. Will your data or equipment require special handling? No If yes, please describe:
9. Will you require any gasses and/or chemicals? Yes if yes, they should be on board the ship prior to departure from Seattle or time allowed for shipment by barge. **Will need formalin as preservative; can provide our own if ship does not have.**
10. Do you have a ship preference, either NOAA or non-NOAA? If "yes" please name the vessel and give the reason for so specifying.
    Ship preference: Alumiak or similar vessel.
11. If you recommend the use of a non-NOAA vessel, what is the per sea day charter cost and have you verified its availability
    N/A
12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals.
    Must have two persons on board, or one if ship can supply a technician.
    Potential participants: Peter Craig (American) and William Griffiths (Canadian).

Delineate proposed flight lines on a chart of the area. Indicate desired flight altitude on each line. (Note: If flights are for transportation only, chart submission is not necessary but origin and destination points should be listed)
Flights for transportation to and from Oliktok DEW station, Beaufort Coast, either from NARL, Barrow, or from Prudhoe Bay.

2. Describe types of observations to be made.
Transport flights only.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification)
Key transportation times are late May-early June, and late September, when several tons of equipment and 4-6 persons must be moved to and from Pingok Island.

4. How many days of flight operation are required and how many flight hours per day?
Flight schedule erratic; dependent on plane size. Estimate 3-4 flights with Twin Otter at each time (early summer and late summer), and more frequent flights with Cessna 180
Total flight hours? Approximately - 20 hours (Twin Otter); 40 hours (Cessna 180)

5. Do you consider your investigation to the principal one for the flight thus precluding other activities or requiring other activities to piggyback or could you piggyback?
The nature of transport requirements indicates we should have primary control of the flights.

6. What types of special equipment are required for the aircraft (non carry-on)?
N/A
What are the weights, dimensions, power requirements, and installation problems unique to the specific equipment.

7. What are the weights, dimensions and power requirements of carry-on equipment?
See #3 above.

8. What type of aircraft is best suited for the purpose?
Twin Otter or larger transport plane.

9. Do you recommend a source for the aircraft? No
If "yes" please name the source and the reason for your recommendation.

10. What is the per hour charter cost of the aircraft?
Dependent on type used.

11. How many people are required on board for each flight (exclusive of flight crew)?
See #3 above.

12. Where do you recommend that flights be staged from?
Would be most convenient if equipment could be carried directly from Fairbanks to Oliktok DEW station; failing that, either Barrow or Deadhorse (preferably the latter) would serve as staging point.

AIRCRAFT SUPPORT - HELICOPTER

Delineate proposed transects and/or station scheme on a chart of the area. (Note: If flights are for transport of personnel or equipment only from base camps to field camps and visa versa, chart submission is not necessary but origin and destination points should be listed)

Approximately 2 hours flight per two week period in vicinity of Simpson's Lagoon. Freight and personell transport, Oliktok to Pingok Island in early June and late September. Miscellaneous personnel transport at other times.

2. Describe types of observations to be made.
Bird census; freight and personnel transport.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?
Maximum time chronology: Bird census - biweekly, late May through mid-September.
Allowable departure: A few days from each scheduled flight. (June 1, Sept. 20 = freight

4. How many days of helicopter operations are required and how many flight hours per day?
Estimated 12-14 days helicopter operation; 3-4 hours per day.

Total flight hours? About 40 flight hours.

5. How many people are required on board for each flight (exclusive of the pilot)?
Bird surveys require two persons + pilot. Other flights variable.

What are the weights and dimensions of equipment or supplies to be transported?
Several tons of equipment transported, Oliktok to Pingok Island in early June and late September. Equipment transport at other times, little or none.

7. What type of helicopter do you recommend for your operations and why?
Bell 205 is optimum because of precision of its navigation equipment.
Bell 206 is second choice; has less desirable navigation system.

8. Do you recommend a particular source for the helicopter? If "yes" please name the source and the reason for your recommendation.
No.

9. What is the per hour charter cost of the helicopter?
Approximately $500

10. Where do you recommend that flights be staged from?
Deadhorse Airport

11. Will special navigation and communications be required?
Radar altimeter and precice compass orientation desirable.

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

We anticipate using the field camp on Pingok Island again in 1978, 1 June-late Sept. Number of people at the field camp would be a minimum of 6, to a maximum of 10-12 during late summer. Other quarters and subsistence requirements would be periodic needs at as yet undetermined times to overnight at Deadhorse or NARL. Estimated maximum of 10 man-days total at each place.

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

Yes, we would like to use NARL again in 1978 for food, fuel, and other camp maintenance support. Reason: convenience and reasonably priced.

3. What is your estimated per man day cost for this support at each location?

Estimated cost of support per man/day = about $20.
(estimate based on approximate cost for support in 1977)

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

[illegible]CIAL LOGISTICS PROBLEMS

[illegible]hat special logistics problems do you anticipate under your proposal and how do you propose that the problems be solved? (Provide cost estimates and indicate whether you propose handling the problems yourself or whether you must depend on NOAA to solve them for you?

The principal concern is that LGL be able to sample offshore from the Aluniak or similar vessel, twice during the summer for several days each time. The availability of the Aluniak depends upon the needs of other investigators, which will determine its cruise pattern.

PROGRAM INTEGRATION

FOR THE NOAA OCS ENVIRONMENTAL

ASSESSMENT PROGRAM

Statement of Work

SAI 1-022-71-781-24R1

Research Unit #468

Total Cost: $475,000

Submitted by:

Science Applications, Inc.
1200 Prospect Street
La Jolla, California 92038

STATEMENT OF WORK

Since May 1976, SAI staff have assisted the NOAA/OCSEAP Program Office by performing a multitude of tasks, ranging from summarizing, integrating, and synthesizing data and results from OCSEAP studies to preparing graphics, briefing documents and management plans. SAI's varied contributions to the program and interaction with the Program Office, Project Offices, PIs, and related state and federal agency personnel has afforded us an opportunity to realize the complexities and goals of a program of this magnitude. This understanding offers a unique capability to OCSEAP, and assures that future contributions will continue to be relevant to the overall objectives and requirements of the program.

SAI proposes to continue providing program support to OCSEAP, working in close collaboration and coordination with the Program Office, Project Offices, and principal investigators as required. This support will include providing specialized technical consultation and support services as needed, and assisting in any activities associated with the Outer Continental Environmental Assessment Program as needed. Following are examples of specific tasks and support functions where SAI could assist OCSEAP:

Synthesis and Subject-Specific Workshops: A major SAI contribution will be synthesis reports, documents resulting from our participation in lease area synthesis meetings. The intent of the reports is to synthesize relevant data from all available sources to produce a comprehensive, interdisciplinary view of each lease area which will aid in the decision-making process. Four synthesis meetings are currently scheduled for FY 78. SAI will work with the Program and Project Offices on the design of the scientific format and the organization and coordination of the meetings, in addition to participating at the meetings. Following the meetings, SAI staff will prepare appropriate synthesis reports, the content and format of which will be decided by NOAA staff.

In addition to lease area synthesis meetings, program reviews and disciplinary workshops (e.g., Trophic Dynamics Workshop, Geology Workshop, Effects Workshop) may be conducted to further contribute to the understanding of physical processes in the lease areas and any impact oil and gas development may exert upon the systems. SAI can provide any, or all, support required for these meetings ranging from structuring the scientific format and objectives of the meetings to logistical organization to writing a summary document of the meeting(s) in a manner which would be useful to meeting participants, OCSEAP staff, and decision makers.

Data Management: Developing the methodology and scientific implementation systems necessary to enable the synthesis of data and information products resulting from the Alaskan Outer Continental Shelf Assessment Program requires a data management system oriented towards statistical analysis and capable of handling data of different disciplines and formats. To facilitate useful and comprehensive synthesis, computer capabilities can be developed to produce plots of data and statistical analysis. In addition, available data sets, utilized in the preparation of a series of maps, could provide a readily usable, synthesized picture of Alaskan OCS resources that might be affected by oil development activities. Graphic display of OCSEAP data could be used to check for features indicative of environmental sensitivities or possible data errors. X-Y plots and other graphics could be used for cross correlation of disciplinary data sets generated in different seasons or at different localities, and interdisciplinary data sets collected at the same locality in the same season. The maps could be used in constructing synoptic pictures of multidisciplinary data sets gathered on the most sensitive portions of the lease areas. SAI has highly sophisticated data management capabilities to meet the above needs. Data management activities and the resulting products will form an integral part of the lease area Synthesis Reports and therefore further meet BLM assessment needs.

OCSEAP Draft Annual Technical Summary Reports: Draft annual technical summary reports will be written by SAI personnel. Annual and quarterly reports will be thoroughly reviewed and summaries of the principal findings will be prepared by lease area. Significant program achievements and technical progress will be documented.

Research Needs Identification: There appears to be a need for projects to test available data and models, and to determine their adequacy for assessing environmental effects from hypothesized contamination and perturbations. SAI has the capability to perform such analyses which include sensitivity tests to determine the weakest links in the source-transport-receptor-effects relationships and contaminant pathways. Such efforts could aid the Program Office to adjust the priorities and direction of future research projects to supply BLM and other decision makers with relevant, up-to-date information.

Environmental Processes Studies: A critical component of synthesis is to identify and study environmental processes, species, and their interaction in relation to oil and gas development; and concentrate on understanding these relationships within a particular environment. Such studies depend on the integration of data from all relevant scientific disciplines and the close linkage between laboratory and field studies. Ideally, a series of questions would have to be formulated and incorporated into the technical development plans to avoid communication gaps which may obscure the definition and understanding of synthesized end products. The Bering Sea Environmental Processes Study management and technical plans, prepared by SAI personnel in cooperation with John Kelley, were intended to address these objectives. SAI could continue its effort in assisting OCSEAP with design and implementation of environmental processes studies for other lease areas; at all times working closely with the Program and Project Offices.

Compendium of Graphics: SAI possesses the capability to design charts, graphs, and overlays which would display, in a comprehensible form, data developed in OCSEAP and elsewhere. This effort would be in addition to the synthesis documents and is viewed as a special tool to further achieve synthesis of data on an area-by-area basis. Selection of the material to be presented, the format in which it will be presented, and the layout to be utilized would be coordinated with the OCSEA Program and Project Offices.

Other: SAI staff will be available to assist the Program Office in any additional OCS related tasks that are requested. Examples include: assisting in TDP preparation; briefings; gathering and presenting data for federal permits; writing of informational documents; technical review of programs; identifying key future issues; data management; preparation, testing and use of selected computer software packages; hiring consultants to assist with special projects or to provide a particular expertise to OCSEAP. The diversity and experience of SAI staff allows us to provide a variety of services in program integration and management. Such tasks would be identified by the OCSEA Program Office and could be of a long-term, short-term, special, and/or one-time nature.

However, SAI reserves the right to decline certain requests for assistance on the grounds that it may prevent future bidding on competitive RFPs.

1-024-71-791-02R1

21 March 1978

CD 2074

Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Research Laboratories
Boulder, CO 80302

Attention: Ms. Jane M. Ludka

Subject: Contract 03-7-022-35213,
Proposal for Program Support Services

Reference: SAI Letter CD 2047 dated 3 March 1978

Enclosure: (1) Statement of Work dated 20 March 1978 (3 copies)
(2) Optional Form 60 dated 20 March 1978 (3 copies)
(3) Assumptions and Conditions dated 20 March 1978 (3 copies)

Dear Ms. Ludka:

In response to your request of 20 March 1978, reference proposal for relocating Dr. Jawed Hameedi to Juneau, Alaska has been revised and is resubmitted herewith.

It is trusted that this proposal adequately reflects your desires. I am available at your convenience to discuss this matter and may be contacted at extension 228.

Very truly yours,

SCIENCE APPLICATIONS, Inc.

A. I. Dow
Manager of Contracts

AID/an

cc (w/encl.): NOAA/OCS Program Office
Boulder, CO 80302
Attn: Mr. David Friis

NOAA/OCS Program Office
P.O. Box 1808
Juneau, Alaska 99802
Attn: Dr. Herb Bruce

Science Applications, Inc. 1200 Prospe). Box 2351, La Jolla, Ca. 92038, 714/459-0211

Other SAI Offices: Albuquerque, Ann Arbor, Arlington, Atlanta, Boston, Chicago, Huntsville, Los Angeles, McLean, Palo Alto, San Diego, Sunnyvale, and Tucson.

STATEMENT OF WORK

SAI proposes to provide management support to OCSEAP Project Office in Juneau in the planning and conduct of research activities in the Kodiak and Aleution lease areas. SAI support shall include, but not be limited to, providing specialized technical consultation and recommendation and support services as needed and assisting in any activities associated with the Outer Continental Shelf Environmental Assessment Program (OCSEAP) as needed. Major areas of support outlined in this proposal include: research coordination, preparation of Technical Development Plan (TDP) and synthesis of scientific information through meetings and workshops. These functions and assignments are similar to those of Lease Area Coordinators, currently members of Project Office staff for eastern Bering Sea and Lower Cook Inlet.

Research Coordination

Concentrated OCSEAP studies in the Kodiak and Aleutian lease areas were initiated in FY 76 and FY 77, respectively. These studies are focused on the assessment of environmental impact of the proposed oil and gas development over the continental shelf which would involve highly complex, extensive and, at times, innovative use of technology in areas where industrial development has been only modest. The overall objectives of OCSEAP is to acquire the necessary information for the Bureau of Land Management (BLM) which will:

- Enable an assessment of potential impact of oil and gas exploration and development on the marine environment of the Alaskan continental shelf.
- Provide pertinent information and data to influence leasing regulations, operating procedures, inshore facility design and location, and design of monitoring programs to permit resource development and also maintain the quality of the natural environment.

These studies follow the OCSEAP Program Development Plan in developing and managing scientific studies and providing scientific products and deliverables. Research program for each lease area has evolved around OCS Planning Schedule, information needs and objectives of BLM, and specific regional environmental characteristics. These studies are being supplemented by extensive literature search and compilation and review of available scientific data and results as they pertain to the description of the environment and possible effects of OCS development.

Planning changes in OCS development and leasing schedule necessitate a shift in emphasis and direction of OCSEAP research from one lease area to another and timing of data collection and completion of certain PDP tasks within a particular lease area. Proposed date of Kodiak lease sale (Sale #46) has changed from December 1976 (June 1975 schedule) to November 1977 (November 1976 schedule) to October 1980 (August 1977 schedule). These changes influence BLM requirements for environmental assessment information, especially concerning the level of spatial and temporal resolution in the collected data. Therefore, a close supervision and coordination of ongoing and proposed research activities and information exchange with BLM are required to insure that research projects are mission-oriented within the context of OCSEAP's objective. In this regard, responsibilities of Lease Area Coordinator (LAC) include the following:

- Coordinate existing research projects.
- Define and update information requirements for future research.
- Prioritize or restructure individual projects to meet changing needs of BLM. Provide recommendations and consultations relative to program restructuring decisions, as required.
- Act as Project Coordinator for interdisciplinary and multi-institutional research units involving joint collection of data and exchange of information among various investigators, for example in case of Integrated Trophics Studies over the Kodiak Shelf. Such a role in the Project Office would establish vital communication links, enhance project integrity and maintain it's relevance to OCSEAP objectives.

Technical Development Plan

Lease Area Coordinator for Kodiak and Aleutian areas will be responsible for the preparation of Technical Development Plans (TDPs) for these areas. TDPs are developed annually and when approved by BLM are the major implementation mechanisms for the PDP. These TDPs follow the Technical Approach described in the PDP and provide: a more detailed description of the specific work to be undertaken each fiscal year; a description of how the work in the individual TDP addresses the overall objectives of the program; a planned schedule; required funding; and, finally, how that year's work fits into the long-term study for the area. Primarily, each TDP includes the following:

- The relationship of the individual TDP to the PDP. Specifically, the relation of the TDP objectives and milestones to those in the PDP and the relative responsibilities for each TDP's management and logistics.
- The scope, objectives and applicability of the subtasks to be undertaken for that area.
- Rationale for selection and level of effort of the subtasks and research units (RU) to be undertaken during the year.
- Intra-and inter-area relationships of RU, subtasks, tasks, and interdependencies, where appropriate.
- Funding levels required by subtask or RU.
- Detailed description of the objectives, sampling and analytical methods, and expected products from each selected research unit.
- Data products and deliverables, and a schedule for that year's delivery, the relationship or interdependence of those deliverables to one another and to BLM's needs.
- The logistics support to be provided by the Government to the subtask level if known.

Meetings and Workshops

Communication and coordination among principal investigators, OCSEAP personnel and BLM representatives is an important element of OCSEAP. Periodic meetings, by discipline and lease area are scheduled to review and update status of knowledge, identify research needs and priorities, and point out operational or communication problems within OCSEAP. Synthesis Meetings are planned to seek a comprehensive understanding of the structural and functional aspects of the environment of each lease area and identify the impacts and effects that are related to oil and gas development. It is accomplished by organizing and reviewing information by lease area; involving principal investigators, OCSEAP personnel and other scientists in synthesizing all available information into a cohesive whole and highlighting potential problems and deficiencies for consideration by OCSEAP and BLM.

In addition, smaller meetings and workshops are encouraged where specific problems require strong interpersonal scientific contact. In all cases, meeting or workshop structure is oriented toward the overall research objectives with an agenda which ensures that benefits accrue to both the particiapnts and to OCSEAP.

Lease Area Coordinator will plan, organize and conduct lease area Synthesis Meeting, research coordination meeting, and also design synthesis and integration methodology, as required. He will also act as Chairman of these meetings in the absence of or on behalf of the Project Office Manager.

1978 Proposal
R.U. 473

TITLE: Shoreline history of the Beaufort and Chukchi Seas as an aid to predicting offshore permafrost conditions - R.U. 473

PRINCIPAL INVESTIGATOR: David M. Hopkins

TOTAL COST OF PROPOSAL: OCSEAP $30,050

INSTITUTION AND DEPARTMENT: U.S. Geological Survey, Branch of Alaskan Geology

DATE OF PROPOSAL: June 28, 1977

REQUIRED SIGNATURES:

Principal Investigator David M Hopkins

Name D. M. Hopkins Date June 28, 1977

Address 345 Middlefield Road, Menlo Park, CA 94025

Telephone FTS 8-467-2659

Required Organization Approval

Name A. Thomas Ovenshine

Address 345 Middlefield Road, Menlo Park, CA 94025

Telephone FTS 8-467-2231

Organization Financial Officer

Name for Elwood H. Like Sandra K Wendell

Address Office of Mineral Resources, U.S. Geological Survey, National Center, Mail Stop 913, 12201 Sunrise Valley Drive, Reston, VA 22092

Telephone FTS 8-928-6572

TECHNICAL PROPOSAL

I. Title: Shoreline history of the Chukchi and Beaufort Seas as an aid to predicting offshore permafrost conditions.
Research Unit 473
Proposed dates: October 1, 1977-September 30, 1978

II. Principal Investigator: D. M. Hopkins

III. Cost of Proposal

Total	30,050

Distribution of Effort by Lease Areas

Chukchi Sea	75%
Beaufort Sea	25%

IV. Background

This study was originally conceived to provide supporting data for development of an understanding of the distribution of offshore permafrost (R.U. 105, 204, 253, 271, 456). Discussions at the Barrow Synthesis Meeting, February, 1977, showed that the study also provides information needed to assess the biologic and geological impact of gravel-mining of beaches and barrier islands and of construction of causeways and jetties. It supplements process-oriented studies of the modern beaches and barrier islands (R.U. 59) and of rates of coastal change over the last few decades (R.U. 407) by providing information on coastal changes over millenia-long time spans.

V. Objectives

1. Survey lithology, stratigraphy, geochronology, paleoecology, and ice content of rocks and sediments exposed in selected sections of the coastal bluffs.

   Relevance: Provides data needed for prediction of horizontal and vertical distribution of bonded permafrost on the continental shelf and potential for thermokarst subsidence in adjoining offshore areas.

2. Collect information bearing on climatic history (summer, winter temperatures, thickness and continuity of snow cover) during last 30,000 years, in coastal northwestern Alaska.

   Relevance: Thermal history is a parameter needed for development of predictive models for offshore permafrost.

V. Objectives (Cont.)

3. Identify gravel sources and gravel sinks along Beaufort and Chukchi Sea coasts.

   Relevance: Permits recognition of sites in which gravel can be removed with relatively little ecological effect as well as areas in which gravel mining will have drastic consequences.

4. In particular, identify sources of gravel composing individual or groups of Beaufort Sea barrier islands and estimate their net migration over millenia-long time base.

   Relevance: Permits assessment of geological and ecological consequences of removal of barrier islands for construction of artificial islands.

VI. General Strategy and Approach

Airphoto interpretation, supplemented by overflights to identify geomorphic features providing information on long-term coastal changes and information on ancient sediments beneath the adjoining sea bed.

Visit selected segments of mainland coast in order to identify and date major geomorphic-lithologic units such as alluvial fans and ancient marine terraces. Excavate selected sections of bluffs in order to examine stratigraphy and to collect samples for geochronological, petrological, and paleoecological analysis.

Brief visits to barrier islands between Point Barrow and Flaxman Island to collect pebble samples for lithologic study and to obtain overall impression of trends of change in gravel size.

Radiocarbon- and amino-acid-dating of selected samples; petrological study of gravel samples; paleontological analysis of selected samples.

VII. Sampling Methods

Samples selected by eye to obtain those providing maximum geochronological or paleoecological information.

VIII. Analytical Methods

Radiocarbon dating. Amino-acid-racemization analyses for purposes of correlation and age estimates. Some thin-section microscopy to identify distinctive pebble types that can be related to specific sources. Paleontological studies (pollen, mollusks, and vertebrates).

IX. Anticipated Problems

Some barrier islands may have originated from sources that have subsequently been eroded to sea level and then drowned by rising sea level. If this emerges as a realistic possibility, then sources must be sought by use of bottom sampling coupled with high-resolution profiling.

X. Deliverable Products

A. Digital data - none

B. Narrative Reports

Report on genesis and migration of Beaufort Sea Barrier Islands.

Report on thermal history of Prudhoe Bay region during the past 30,000 years (this will be joint report of R.U. 204 and 473).

C. Visual Data

Maps showing erodibility of mainland coast, long-term erosion rates of different segments of the coast, and vertical position of highest driftwood line for segments of the coasts of Beaufort and Chukchi Seas.

D. Other Non-Digital Data - none

E. Data Submission Schedule

First new data will be collected 7/15/77-9/1/77. Data collection will be finished 9/1/78. Data will be submitted in or as appendices to Annual and Quarterly Reports.

XI. Information Required from Other Investigators - none

XII. Not applicable.

XIII. Special Sample and Voucher Specimen Archival Plans

Samples archived in Principal Investigator's office until no longer needed and then to be discarded.

Important paleontological specimens will be retained in collections of Paleontology and Stratigraphy Branch of U.S. Geological Survey as long as needed. Types, illustrated specimens, and other significant material will ultimately be deposited in the U.S. National Museum.

XIV. Logistics Requirements

Billeting at Naval Arctic Research Laboratory during late July and early August, 1978: 2 men for 6 days each.

Helicopter or Twin Otter support to move field party to field area: 3 R.T. to points between Barrow and Harrison Bay during late July and early August, 1978.

XV. Management Plan

Management of the project is the responsibility of the Principal Investigator and the administrators of the Geological Survey. The Principal Investigator will lead and supervise the proposed work.

See page 7.

XVI. Outlook

The last fieldwork will take place during the summer of 1978. Following that fieldwork, samples will be analyzed, and in November, 1978, work will begin on the final report, which will consist of maps showing the erodibility, long-term erosion rates, and vertical position of the highest driftwood line for segments of the Beaufort and Chukchi Sea coasts between Point Lay and Flaxman Island.

Costs for terminal phases of the project during FY 1979 will be about $30,000.

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labeled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the P.I. is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

XVII. 5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following standard acknowledgement is acceptable.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

MILESTONE CHART

RU #: 473 PI: D. M. Hopkins

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	FY 1977			FY 1978												FY 1979					
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Prepare for field season	--																				
Fieldwork, Flaxman Island to Harrison Bay	--	--																			
Analyze 1977 field data			--	--	--	--	--	--	--	--	--	--									
Prepare preliminary report on coast between Pt. Lay and Pt. Barrow	--		--	--	--	--															
Prepare preliminary report on Beaufort Barrier Islands							--	--	--	--	--										
Prepare preliminary report on mainland coast, Flaxman to Colville River							--	--	--	--	--										
Prepare for 1978 fieldwork										--	--	--	--								
Fieldwork, Barrow to Harrison Bay														--							
Analysis of 1978 field data															--	--	--	--	--	--	--
Prepare final report																	--	--	--	--	--
Quarterly Reports						▲						▲									
Annual Report									▲												

Renewal Proposal to U.S. Department of Commerce
National Oceanic and Atmospheric Administration, Environmental Research Laboratories for "Characterization of Organic Matter in Sediments from Gulf of Alaska, Bering and Beaufort Seas"

Contract 03-6-022-35250
Research Unit #480

I.R. Kaplan, Principal Investigator
Institute of Geophysics & Planetary Physics, UCLA
Telephone Number213/825-1805
Social Security Number: 546-56-6808

W.E. Reed, Co-Principal Investigator
Department of Earth & Space Sciences
UCLA
Telephone Number: 213/825-2819
Social Security Number: 460-46-1931

C.F. Kennel, Acting Assoc. Dir., IGPP
Telephone Number: 213/825-1580

C.A. Hall, Chairman, Earth & Space Sci.
Telephone Number: 213/825-1475

Jerry R. Fabian, Contract & Grant Officer
Telephone Number: 213/825-0759

October 1, 1977 to September 30, 1978
Amount Requested: $100,744
Date Submitted: June 14, 1977

The Regents of the University of California
Institute of Geophysics and Planetary Physics
University of California, Los Angeles, California 90024

3. TECHNICAL PROPOSAL

I. Title: "Characterization of Organic Matter in Sediments from Gulf of Alaska, Bering and Beaufort Seas"

Contract: 03-6-022-35250

Dates: October 1, 1977 to September 30, 1978

II. Principal Investigators: I.R. Kaplan and W.E. Reed

III. Cost of Proposal:

Total: $100,744

Lease areas and percentage of total effort:

-Lower Cook Inlet (50%)

-Norton Sound (25%)

-Kodiak (25%)

IV. Background and Current Research:

The studies to be undertaken in this project will be the analyses of total carbon, nitrogen, and sulfur, high molecular weight hydrocarbons, carbon isotope ratios and low molecular weight hydrocarbons in sediment. Samples for these studies were collected in the summer of 1976 using the U.S. Geological Survey ship the SEA SOUNDER. Studies on these samples are continuing, and some results were provided in the Annual Report.

Current Research

Elemental Analysis of Sediments. Sediment samples were collected during July-September 1976 in Lower Cook Inlet, Kodiak Shelf, N. Bering Sea, and Beaufort Sea and have been analyzed for total carbon and organic carbon. Nitrogen and sulfur analysis of the sediments is in progress.

The methods used in the carbon analysis involve the use of a Leco combustion furnace and acid-base carbon determinator and are described in a previous report (Annual Report, 1976, RU #275, subcontract). A modification of the sample preparation procedure was included in this year's analysis to decrease the sample preparation time. Instead of removing carbonates with acid while the sample is in the crucible, the sediment sample was placed on glass fiber filters, the carbonates removed with acid, followed by a rinse with distilled water. The filter and carbonate-free sediment are subsequently placed in the Leco crucible and dried prior to analysis.

High Molecular Weight Hydrocarbon Analysis (HMWHC). In our effort to characterize the distribution and concentration of HMWHC in surficial sediments, we are trying to improve and test our procedures of extraction and analysis of hydrocarbons. During the analysis of sediment samples collected from the E. Bering Sea and W. Gulf of Alaska we found that the saponification procedure did not sufficient remove fatty acid methyl esters, which subsequently eluted in the benzene fraction of the column chromatographic separation. The methyl esters were present in much greater concentrations than aromatic compounds, thus interfering with gas chromatographic analysis of these important compounds. Consequently, we developed thin layer chromatographic procedures to eliminate the saponification step (see Methodology).

Low Molecular Weight Hydrocarbon Analysis (LMWHC). We also have a program to characterize the distribution and concentration of LMWHC (C_1-C_8) in surficial sediments from the Alaskan continental shelf. These measurements are necessary to determine background concentration of these hydrocarbons, which may be derived from biogenic or abiogenic processes affecting recently deposited organic material. Alternatively, these LMWHC may be derived from natural oil and gas seeps. The analysis of LMWHC in the sediments is a necessary complement to other research efforts, such as the determination of HMWHC in sediments, LMWHC in sea water, and microbiota in sediments, which in total allow an assessment of the dynamics of petroleum hydrocarbons in the shelf environments to be made.

Accurate determination of LMWHC in sediments is difficult because of the low concentration of these compounds and their inherent volatility. During our survey of LMWHC in surficial sediments from the E. Bering Sea and W. Gulf of Alaska we placed the collected sediments in sealed cans, a method that minimizes loss of volatile components. However, the method of static headspace sampling of the cans for gas chromatographic analysis was not sensitive enough to detect significant concentrations of LMWHC. Consequently, we have been developing a method that would concentrate LMWHC and thus provide increased sensitivity. In addition, methane is separated from selected samples for $^{13}C/^{12}C$ isotope measurements.

Background

To the best of our knowledge, no previous studies on C, N, S, or HMWHC have been conducted on the sediment in the detail described. By contrast, LMWHC analyses are being conducted in the Bering Sea by Dr. Joel Cline, Pacific Marine Environmental Labs., NOAA, Seattle, and Dr. Keith Kvenvolden, Marine Geology Branch, USGS, Menlo Park. In particular, the former has suggested that natural seeps may exist in Norton Sound, based on shipboard LMWHC analyses.

This summer samples will be obtained from Norton Sound aboard the USGS R/V SEA SOUNDER which will be operating in the northern Bering Sea and in particular in the gas-seep area. During 1978, it is hoped to obtain samples from Kodiak Island and the northwest shore of Lower Cook Inlet. Maps of locations sampled already are included in this report. Areas tentatively identified as those to be sampled at a future date are marked as ---- on the maps (Figures 1 and 2).

Sample exchange will be made with Dr. Keith Abel (RU 506), who will measure physical parameters of the sediment. If possible, sampling co-ordination will also be made with Drs. J. Cline (RU 153), D. Burrell (RU 162), and D. Shaw (RU 275).

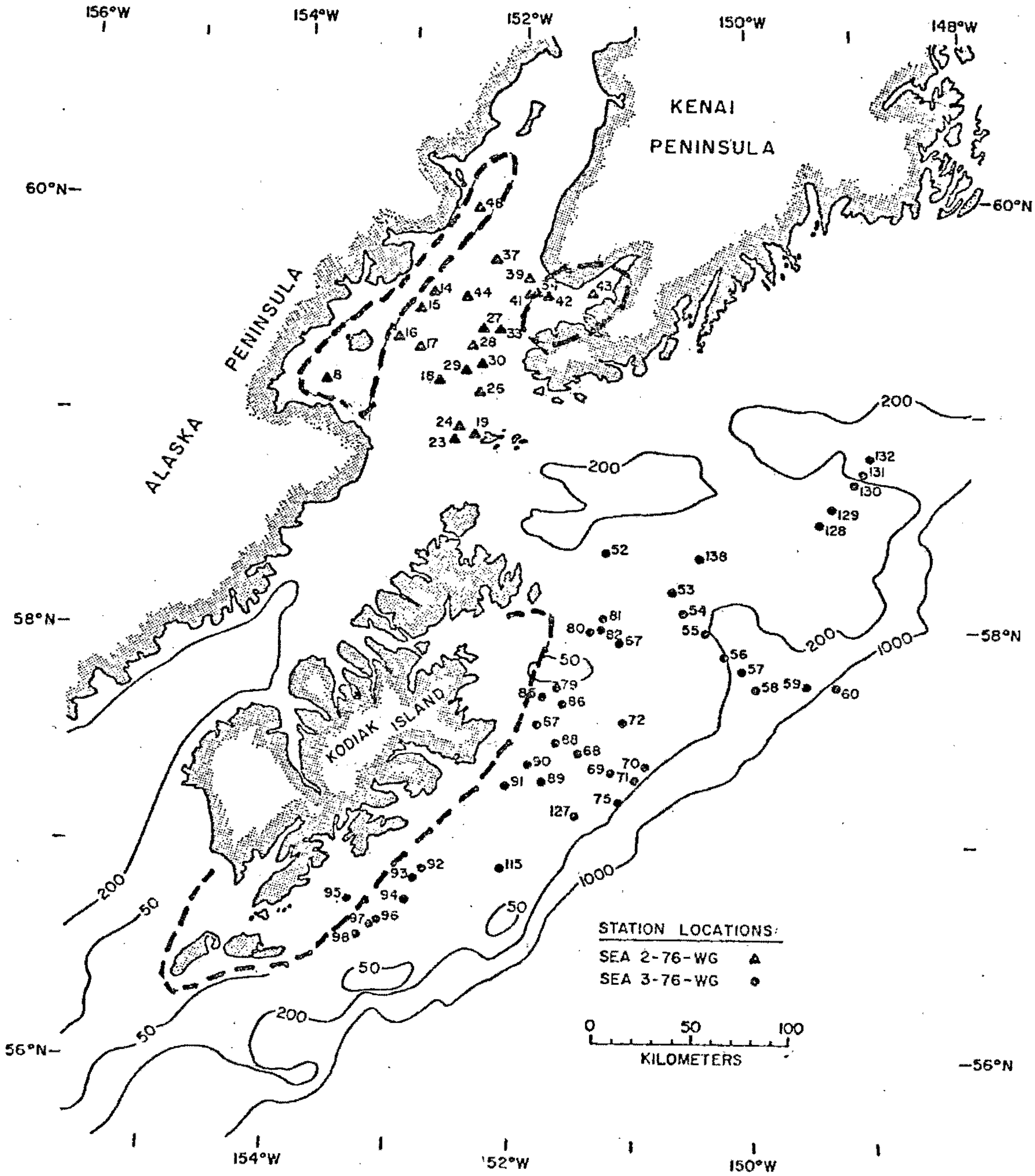


Figure 1. Locations of samples collected during 1976 in Lower Cook Inlet and Kodiak Shelf and proposed sample locations for 1977-1978 (----).

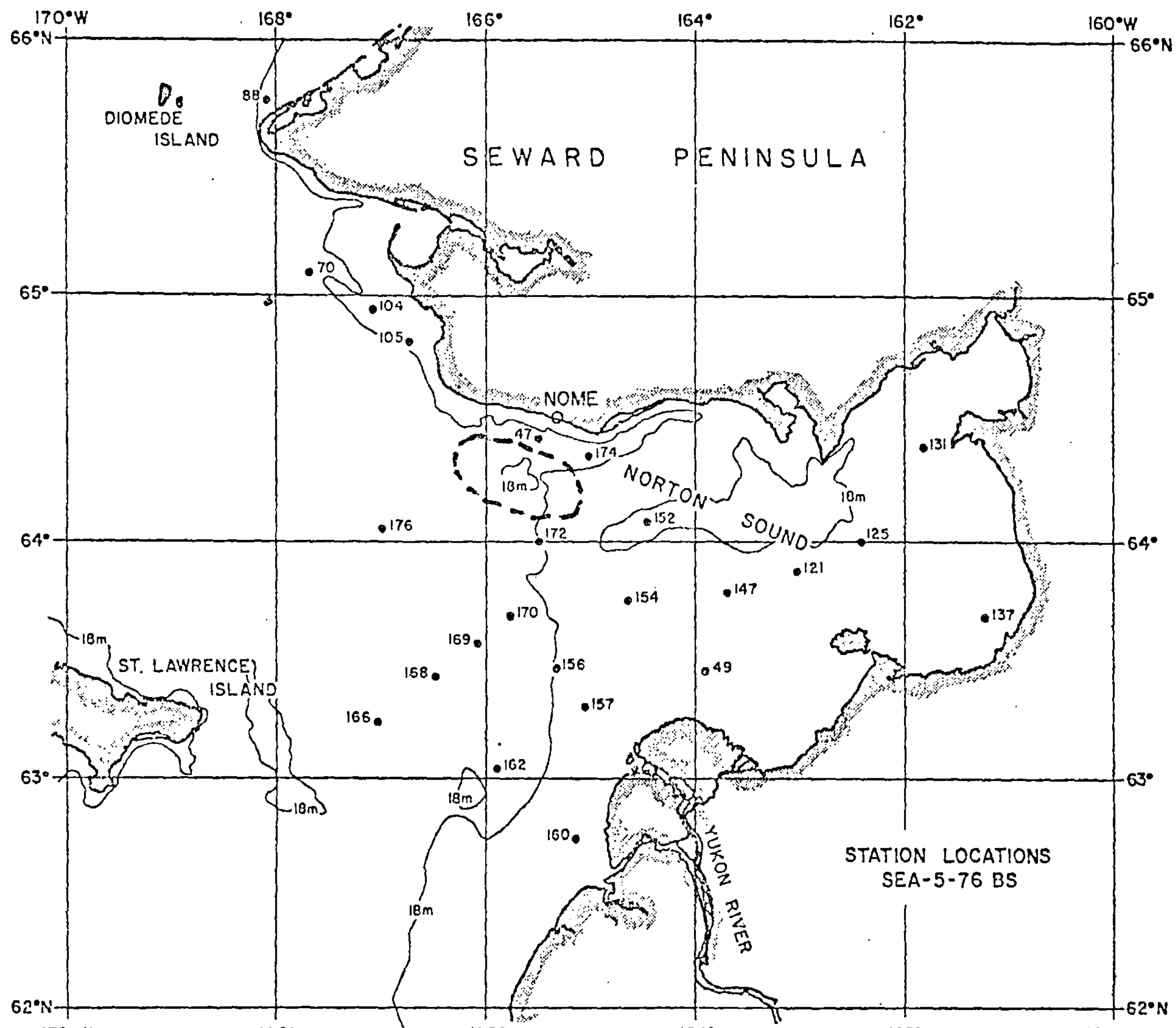


Figure 2. Locations of samples collected during 1976 and proposed sample location for FY 1977-1978 (----).

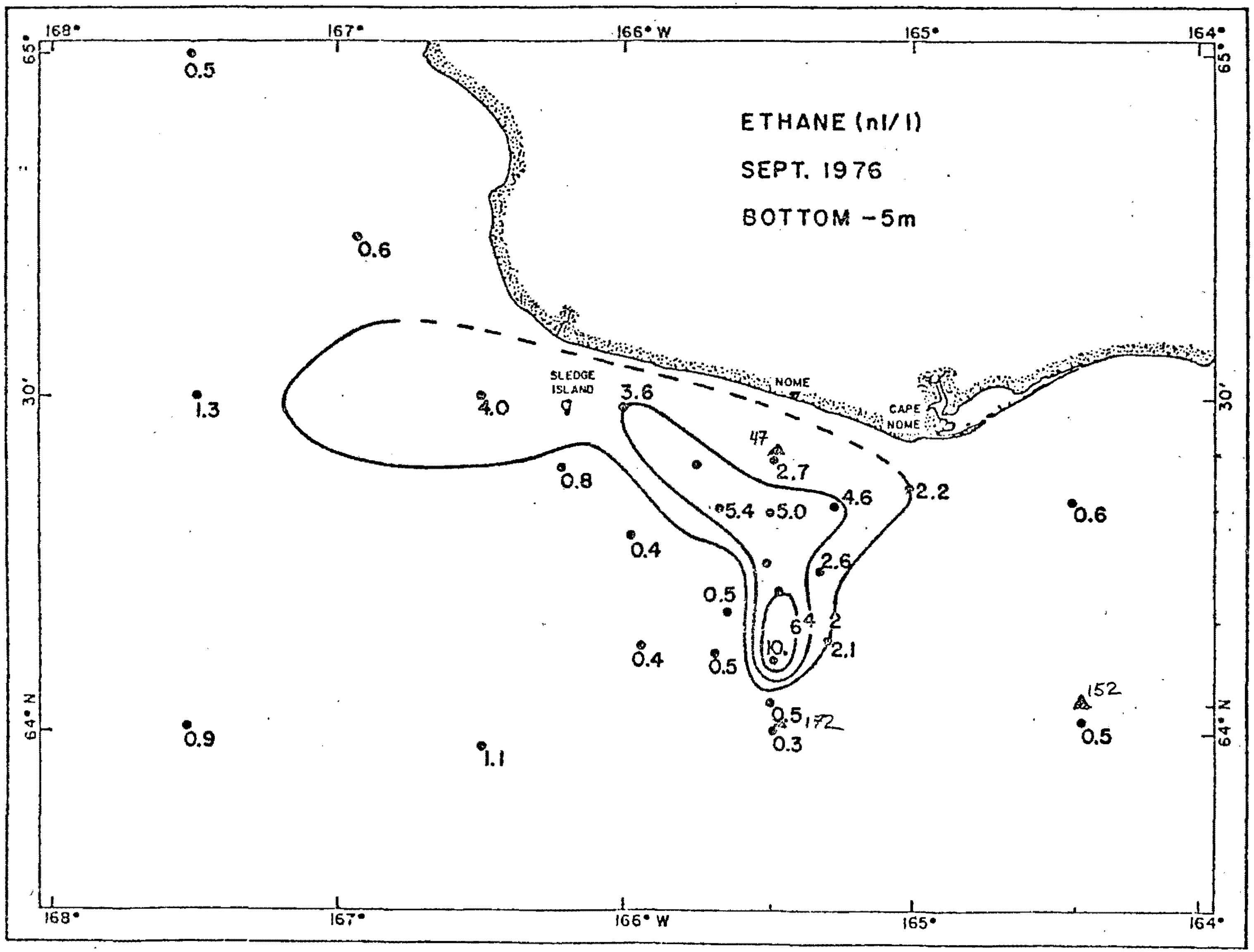
V. Objectives:

The major objective of the investigation will be the analysis of both light and high molecular weight hydrocarbons in surface sediment from Lower Cook Inlet, Norton Sound and around Kodiak Island. Particular emphasis will be placed on analysis of sediments that may already contain significant concentrations of petroleum hydrocarbons, either as a result of natural seepage or anthropogenic activities.

In Lower Cook Inlet a sample grid will be established to include sediment from both the eastern and western sides of Cook Inlet in areas where petroleum hydrocarbons may accumulate. Crude oil has been produced in upper Cook Inlet and in Kachemak Bay and oil spills have occurred periodically. An effort will be made to determine whether any oil still persists in the sediment. In the west, natural seeps have been documented onshore. It is not known whether the offshore sediments are petroleum free or not. These studies will determine whether hydrocarbons accumulate or degrade rapidly in the Lower Cook Inlet environment.

During a recent survey of petroleum-related hydrocarbons in Norton Sound by J. Cline, Pacific Marine Environmental Labs., NOAA, Seattle, an unusual accumulation of dissolved C_2-C_4 hydrocarbons was observed in a localized area approximately 40 km south of Nome (Figure 3). Concentrations of ethane and propane reached maximum values of 9.6 and 3.3 nl/l (STP) at the locus of the seep or more than a factor of 10 above ambient levels observed toward the east and south. Closer scrutiny of the dissolved LMWHC showed significant increases in the C_4 alkanes as well as a "show" of C_5 or C_6 hydrocarbons.

The most striking diagnostic features of the hydrocarbon plume are the high concentrations of ethane and the corresponding low abundance of the



Stat...
147
152
121

Fig. 3 Dispersion plume of ethane within 5 m of the bottom in Sept. 1976. Concentrations are expressed in nl/l (STP).

C_2 and C_3 olefins. The localized source and characteristic plume structure strongly suggest a natural gas seep, possibly associated with petroleum.

Preliminary examination of the subsurface geology of Norton Basin reveals several lines of evidence suggesting gas/oil seep probability in this region of Norton Sound. This evidence includes basinward dipping strata truncated by an unconformity, velocity pulldowns, and numerous steeply dipping faults in the immediate vicinity of the seep.

In summary, the dissolved LMWHC data indicate that the seep gases are of thermal origin rather than of recent microbial processes. Whether liquid petroleum is associated with the LMWHC remains to be determined by analysis of HMWHC in the sediments in the area of the seep plume.

Analyses have been performed on hydrocarbons in sediment south of Kodiak Island. This is an area of coarse sediment, high energy and generally low carbon content (see Annual Report, 1977). This coming year we believe that collection of sediments should be made in the fjords around Kodiak Island which acts as traps for fine-grained sediments and hydrocarbons. Here, hydrocarbons may be least affected and may persist for a longer time. At the same time, sediment samples will be collected in regions that preliminary geophysical evidence indicates seepage of gases from the sediments. Gases emanating from the sediments can in some cases be correlated with geologic structure, for example surface faults, while in other cases are related to thick accumulations of sediments. Analysis of both LMWHC and HMWHC in the sediments may indicate whether these gases are of petrogenic or biogenic origin. Exact locations of these gas seeps will be obtained from the U.S. Geological Survey (Anchorage).

In addition to the above areas, samples have previously been collected from the Beaufort Sea and Outer Bristol Basin. Analyses are presently being conducted on about 100 samples collected from the above areas in the summer of 1976. These will be largely completed by the end of this year.

VI. General Strategy and Approach:

The procedures to be followed on the new samples will be two-fold: (1) light hydrocarbons (methane, ethane, etc.) will be removed from the head space in cans filled with sediment. A known volume will be injected into a calibrated gas chromatograph. Where sufficient quantity of sample is present, samples of gas will be flushed out with helium from the total sediment sample in a vacuum line and combusted to CO_2. This gas will then be used for $^{13}C/^{12}C$ measurement. The C_1/C_2+ ratio combined with the $^{13}C/^{12}C$ ratio should be an important indicator of the source of the light hydrocarbon, i.e., biogenic vs. petroliferous. (2) High molecular weight hydrocarbons will be extracted by the procedures described in the Methodology Section). In addition to the procedure described for extraction and thin layer chromatographic separation of the hydrocarbons, ten percent of all extracts will be analyzed by computerized GC-mass spectrometer to confirm the compound composition.

Where possible, the following information will be obtained:

1. Total weight of extractable hydrocarbons
2. Total weight of saturated hydrocarbons
3. Total weight of aromatic hydrocarbons
4. Pristane/$\underline{n}$-C_{17} ratio
5. Phytane/$\underline{n}$-C_{18} ratio
6. Odd/even carbon ratio
7. Identification of homologous $\underline{n}$-alkane series
8. Identification of individual aromatic compounds.

In addition to the above, the organic content will be further characterized by analysis of organic carbon, carbonate carbon, total nitrogen and total sulfur in the sediment.

VII. Sampling Method

During the past sampling season, we have used a sampling device and procedure which we feel is a vast improvement over our previous sample collection effort. Furthermore, since this sampling device recovered a sample large enough for sampling for trace metals, grain size, sediment texture, and microbiology, we would like to recommend its use in subsequent (NOAA/OCSEP) sediment sample collection cruises.

In the characterization and determination of baseline concentrations of hydrocarbons in recent sediments, it is critical that the surface layer be quantitatively collected because changes in the distribution of hydrocarbons in sediments as a result of petroleum development will initially be detected in the surface layer. Furthermore, it is essential that the samples are not contaminated with hydrocarbons during the collection procedure, for example, from paint or grease on the sample collection device.

With these requirements in mind, a modified aluminum Van Veem grab sampler, constructed of non-contaminating materials and capable of quantitatively collecting the sediment surface was purchased by UCLA in order to collect samples during the 1976 summer sample collection period.

This sampling device was developed by A. Soutar for the Southern California BLM baseline study, and we were able to successfully use it in Alaskan OCS environments. The main features of this sampler, which is illustrated in Figure 4, are (1) the incorporation of a frame which orients the grab normal to the sediment surface, a competely vented top which not only prevents blowing away of the fine surface layer but allows easy access to the sample after recovery, (2) the use of aluminum, stainless steel and teflon in construction, which precludes any contamination from hydrocarbons or trace metals, and (3) ability to collect sand and gravel sediments.

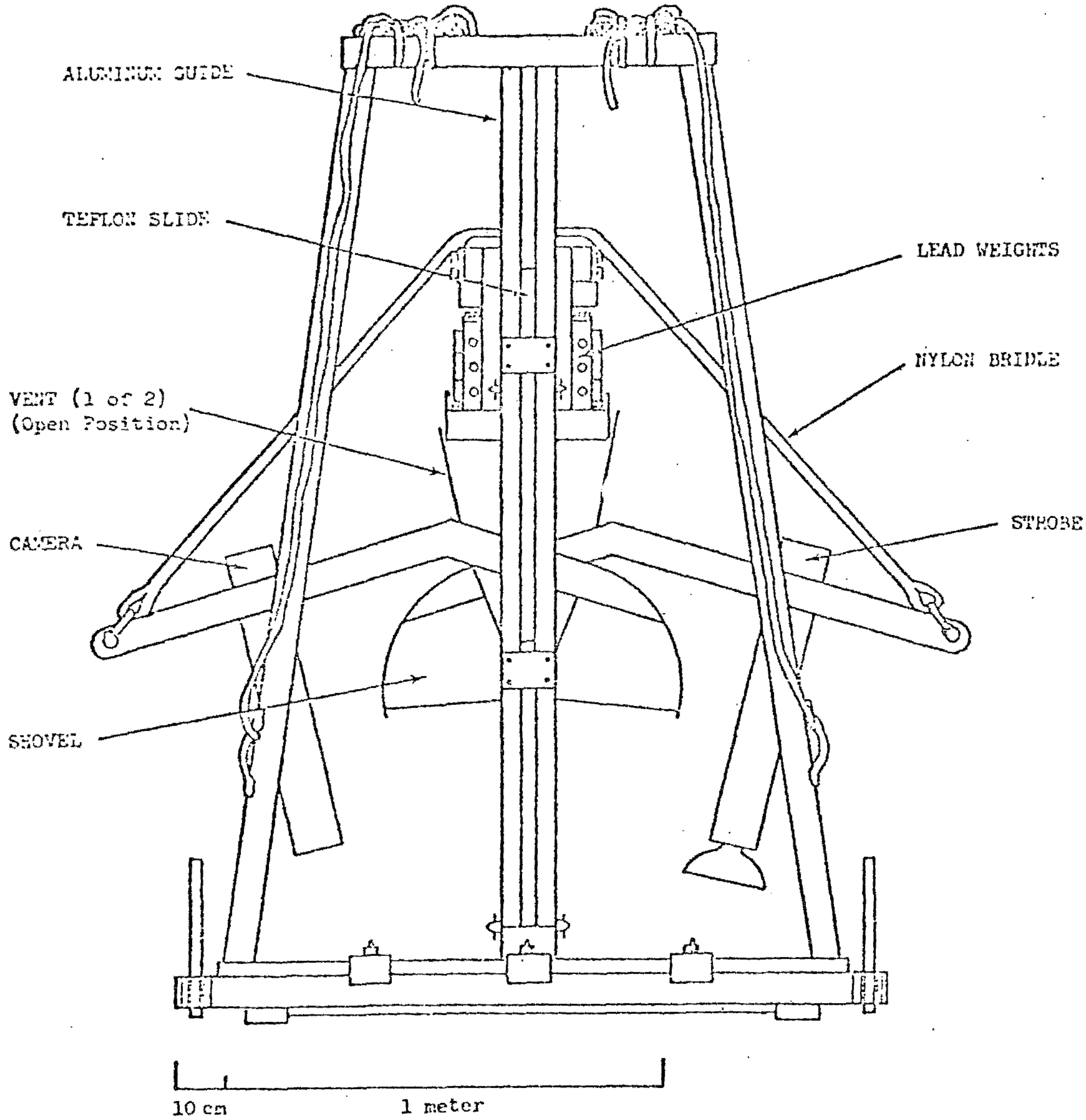


Fig. 4. Frame Supported Van Veem Grab Sampler

The volume of sediment recovered is usually sufficiently large so that replicate HMWHC and LMWHC samples can be collected. Moreover, there was sufficient sediment for other investigators to collect samples for trace metals, Pb-210, foraminiferal, microbiological or textural analyses.

In addition to this improved sampling device, a procedure for subsampling that is accurate, reproducible and non-contaminating was used. This procedure has been developed for use in the BLM Southern California Baseline Analysis Program, and involves the use of a template and scoop which allow sampling from 0-2 to 2-4 cm depths on the undisturbed surface layer of sediment recovered in the grab sampler.

When the grab sampler was brought on deck, a plastic bag was placed beneath the weight stand to prevent water from the hydrowire or weights from dripping into the sample. The top-loading doors were opened, and any supernatant water was siphoned off. Pre-cleaned templates for HMWHC samples and stainless steel core tubes for LMWHC subsamples were pushed into the sediments. HMWHC subsamples were taken with a stainless steel scoop by sliding the scoop along the top of the template. Thus, accurate, repetitive samples of 0-2 and 2-4 cm depths could be taken. If it appeared that the surface layer had been disturbed during the sample collection, the template was not used and bulk or surface and subsurface samples were collected with a stainless steel spoon.

Upon recovery, the sample was inspected and graded on a subjective scale of 1 (poor) to 5 (excellent). For example, an excellent sample had an essentially flat surface, the supernatant water was clear, and fine particulate material was present. In some cases, intact polychaete tubes protruded from the surface or mollusks, arthropods, etc. were recovered, indicating little disturbance at the sediment-water interface of the recovered sample.

On the other hand, a poor sample would be one in which extensive erosion and loss of the surface 1 cm of sediment had occurred as a result of drainage of the supernatant water through partially-closed grab sampler jaws.

The results from analysis of sediments collected using this sampling device and procedure are shown in Figure 5 and illustrate why we feel it is important to quantitatively collect the sediment surface. Figure 5 shows a series of gas chromatograms of the hexane fractions of surface sediments from different depths at BLM station 579 near the edge of the continental shelf. The samples from 1-2 and 2-4 cm depths are similar to many surface samples collected in the So. California outer basins and banks in that they indicate a mixture of hydrocarbons derived from recent biogenic sources and from weathered petroleum sources. However, the surface sample, 0-1 cm, is noticeably different and may indicate (1) a recent change in contribution sources and/or depositional environment, or (2) a recent introduction of relatively fresh, unweathered petroleum.

Nevertheless, the important point is that sample collection devices and procedures which "blow away" the surface layer before collection, or homogenization of the upper few cm of the sediment may lose possibly important information.

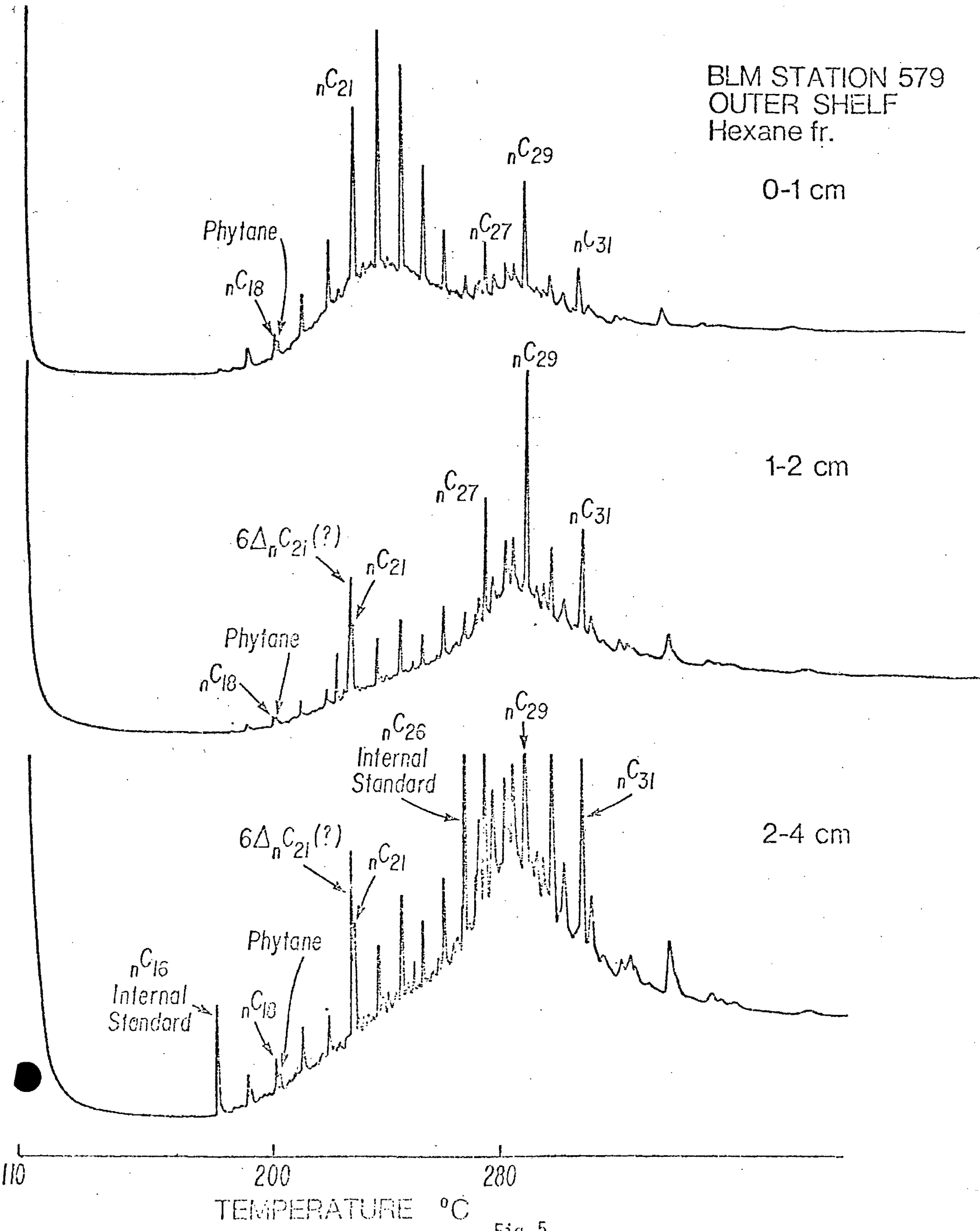

BLM STATION 579
OUTER SHELF
Hexane fr.
0-1 cm
1-2 cm
2-4 cm
nC21
nC29
nC27
nC31
nC18
Phytane
6ΔnC21(?)
nC26
Internal
Standard
nC16
Internal
Standard
110
200
280
TEMPERATURE °C

Fig. 5

VIII. Analytical Methods:

Samples will continue to be analyzed according to methods outlined in our Annual Report, 1976. However, in the HMWHC analysis, we have incorporated a modification in the procedure for separating the hydrocarbon fractions. The method involves the use of two successive thin layer chromatography (TLC) steps, replacing the saponification and column chromatography steps in the former procedure.

The frozen sediment samples are rinsed with distilled water, freeze-dried, and Soxhlet extracted as before. After sulfur removal, the first chromatographic step, which separates the total hydrocarbons from non-hydrocarbons, utilizes a pre-coated Absorbsil 5 TLC plate (20 cm × 20 cm, 250 μm, Applied Science). The plates are pre-cleaned by overnight elution with ethyl acetate, then activated at 130°C for 30 min. An aliquot of the total extract (80-100 mg) is spotted onto the plate and eluted with 100% dichlormethane (CH_2Cl_2). A narrow strip at each side of the plate is sprayed with a saturated solution of Rhodamine 6G in acetone and visualized in UV light (long wavelength) for identification of the different bands. An example of the separation of the different bands is illustrated in Figure 6. The top band, corresponding to the hydrocarbons is scraped and extracted with CH_2Cl_2. Under these conditions aliphatic as well as substituted and unsubstituted aromatic hydrocarbons elute together and are well separated from esters.

The extract of the hydrocarbon band is rechromatographed under different conditions to separate saturated hydrocarbons from aromatics. The total hydrocarbon extract from the first TLC step is spotted onto another Absorbosil-5 TLC plate, this time eluted with _n_-pentane. Saturated hydrocarbons elute as the most rapidly moving band while aromatics move

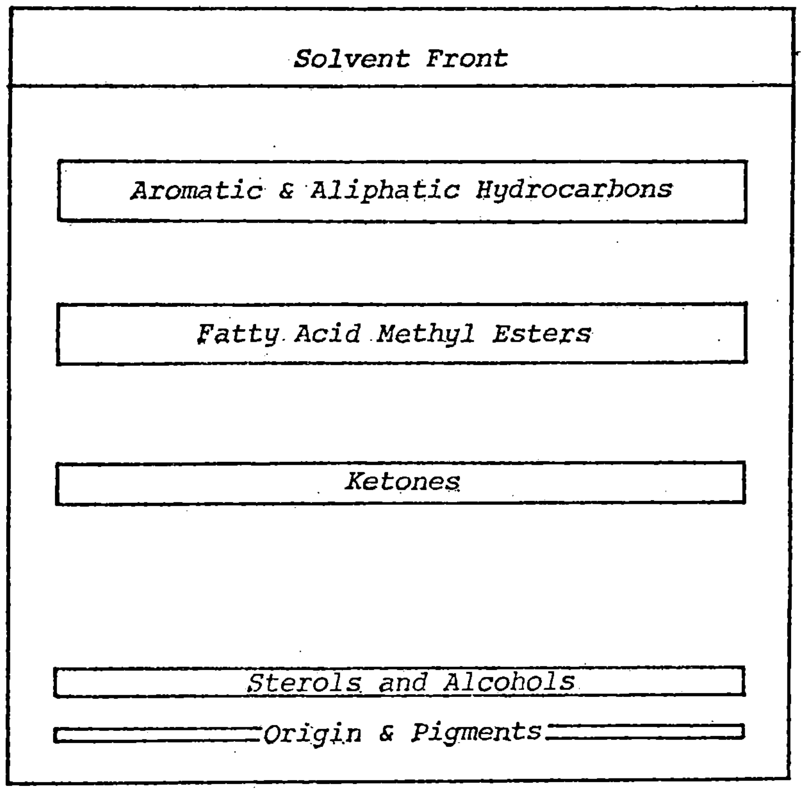


Fig. 6 *Separation of various components by thin-layer chromatography on silica gel using CH_2Cl_2 as eluant.*

more slowly. The plate is visualized as before, and the bands corresponding to saturated and unsaturated hydrocarbons are scraped and extracted with CH_2Cl_2.

IX. Anticipated Problems:

It may not be possible to meet our requirements as outlined in sections VII and XIV of this proposal on NOAA vessels because of the lack of an A-frame that can handle the UCLA sampling device. In such an event, we hope to be able to obtain the service of the USGS R/V SEA SOUNDER.

X. Data Submission Schedule:

Quarterly and Annual Reports will be submitted as required.

XI. Information Required from Other Investigators:

Data from other investigators are not required to carry out the proposed research. However, complementary data from other research units, e.g., 153, 162, 275, 290 in chemistry, 430, 152 in geology, and 5 in benthic biology will be obtained from the principal investigators for incorporation into our narrative reports.

XII. Quality Assurance Plans

Duplicate samples for quality assurance shall be collected and sent to Harry Hertz, National Bureau of Standards. The number of these quality assurance samples shall be approximately 10% of the total number of samples collected.

In addition, our laboratory has participated in a nationwide inter-laboratory comparison of analytical methods. A sediment sample spiked with crude oil has been analyzed by a number of laboratories involved in analysis of hydrocarbons in sediments for evaluation of analytical methods.

XIII. Special Sample and Voucher Specimen Archival Plans

When sufficient sediment is available, duplicate samples are collected for archive. These archive samples are stored in a freezer at UCLA.

XIV. Logistics Requirements:

A. SHIP SUPPORT

1. Study areas are indicated in the maps included in Section IV. Specific sample grids will be determined by consultation with U.S.G.S. personnel prior to or during a cruise (as result of on site geophysical measurements, i.e., location of seeps and bubble formation in water).

2. Surface sediment samples will be collected at each station with a frame supported Van Veem-type grab sampler or a box corer. The Van Veem grab sampler will be used for sampling the surface layer of the sediments, while the box corer will be used to obtain samples at depth in the sediment. Samples for low molecular weight hydrocarbons and high molecular weight hydrocarbons will be sealed in tin cans and glass jars and frozen until analysis at UCLA.

3. Ice-free sampling area.

4. Seven days (7) collection in each area for a total of 21 sea days.

5. Our investigation in site specific study areas will require collection of uncontaminated, undisturbed surface sediments and thus will require collection of sediments with our frame-supported Van Veem grab sampler or box corer. We will not use the entire volume of sample collected, hence other investigators requiring sediment subsamples (e.g., microbiology, trace metals) may share the sediment recovered.

   Approximately 3-4 hrs/day will be required for each station. There are no requirements for daylight sampling, and processing time between stations will involve approximately 2 hours for cleaning of sampling equipment.

6. We would expect the ship to provide the following equipment:

   (a) An A-frame that can accommodate a sampling device 5' x 5' x 7' high and weighing 1500 lbs. (700 kg).

   (b) A winch with a minimum of 500 m of at least 7/16" diameter cable.

   (c) An operating tensiometer, meters out indicator, and rate indicator.

   (d) A 12 kHz precision depth recording system and pinger.

   (e) A navigation system such as radar, Loran or other such system that meets the requirements set by NOAA for this project.

(f) Laboratory space with at least 10 feet counter space, having at least one sink with running water.

(g) freezer space of at least 30 cu. ft.

We would require the ship to provide one winch operator and two marine technicians during the sampling operation.

7. See item 6(a).

8. No

9. One (1) 151-cubic-foot tank of compressed helium.

10. No special requirement other than one of the large NOAA ships capable of deploying coring or sediment sample equipment.

11. N/A

12. At least two people for each leg; participants will be identified at a later time.

B,C,D,E = N/A

XV. Management Plan:

The project management will be divided into budgetary, technical and administrative sections. The Institute of Geophysics and Planetary Physics has an office to completely control the budget and personnel administration. The management of the technical aspects will be under the control of the P.I.'s, Drs. I.R. Kaplan and W.E. Reed. They will be responsible for the overall project.

Sampling Scheme, 1977-1978

July 11-15, 1977:	Norton Sound (USGS R/V SEA SOUNDER)
Summer 1978:	Lower Cook Inlet Kodiak Shelf

Analytical Scheme, 1977-1978

LMWHC analyses for samples collected in 1976:	Dec. 1977
HMWHC analyses for samples collected in 1976:	March 1978
Completion of LMWHC samples collected in 1977:	June 1978
Completion of HMWHC analyses of samples collected in 1977:	Sept. 1978
Completion of LMWHC and HMWHC samples collected in 1978:	June 1979

XVI. Outlook:

1. Nature of Final Results

We believe that at the completion of this program, we will have a much firmer understanding of the distribution of carbon in the sediments of the Bering Sea, the Beaufort Sea, and the Gulf of Alaska. In addition, we will have a general feeling for the type and nature of low molecular weight hydrocarbon gases coming from the sediments. The measurements of carbon isotope ratios, $^{13}C/^{12}C$, should help identify the source of the gas and carbon compounds.

The identification of heavy hydrocarbons relative to other carbon compounds will enable an understanding of the sources and steady-state content of the sedimentary paraffins and aromatics. We should ultimately be able to determine (1) whether the distribution pattern of the hydrocarbons represents biogenic or petroleum sources and (2) what the dynamics of the degradation process involve in terms of hydrocarbon alteration.

We believe that this study will represent the most comprehensive investigation of organic geochemistry yet conducted in the Alaska and Arctic region.

2. Milestones

Projected milestones are the completion of the analyses of samples collected approximately one year prior to the contract termination. Hence, sample analyses will be completed in September 1978 on samples collected in the summer of 1977.

3. Cost Estimates

The best estimates for the following four years are:

FY:	1978	1979	1980	1981
Est. Budget:	$100,744	$100,000	$100,000	$60,000

4. Major Equipment

It is estimated that during FY 1979 and 1980 equipment requests will be at a level of $5,000 or less. No equipment request will be made in 1981.

5. Location of Future Field Efforts

Sufficient samples have been collected to define the distribution of hydrocarbons in Lower Cook Inlet, Kodiak Shelf, S. Bering Sea, and Norton Sound. However, significant gaps still exist in the survey of the distribution and concentration of hydrocarbons in sediments from various regions of the Alaskan continental shelf.

Only 12 samples have been collected in the Beaufort Sea and a greater number of samples should be collected to complete the survey of this part of the shelf. Similarly, only a small number of samples have been collected from the Western Gulf of Alaska, near the Alaskan Peninsula, and from the Eastern Gulf of Alaska, near Prince William Sound. There have not been any sediment samples collected from the Chuchki Sea for analysis of hydrocarbons. Future field efforts should continue to survey the distribution of hydrocarbons in these regions of the Alaskan outer continental shelf.

Cruises planned for 1977-1978 will concentrate on areas that may contain petroleum hydrocarbons, either as a result of natural seepage or anthropogenic activities. If subsequent field surveys indicate additional areas impacted by petroleum hydrocarbons, future collection efforts should concentrate on such areas.

6. Logistics

Requirements are not expected to differ greatly from those of FY 1978.

XVII. 1. Update Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Not applicable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Not applicable.

6. Not applicable.

7. Not applicable.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship.

I.R. KAPLAN

PUBLISHED PAPERS

1953: 1. 4-Alkyl-diphenylketimine Hydrochlorides and Related Ketones, *J. Am. Chem. Soc. 75; 4341 (1953)*, with H.N. Parton and J. Vaughan.

1956: 2. The Microbiological Origin of the Sulphur Nodules of Lake Eyre, *Trans. Roy. Soc., S. Australia 79;* 529 (1956), with L.G.M. Baas Becking.

3. Evidence of Microbiological Activity in Some of the Geothermal Regions of New Zealand, *N.Z.J. Sci. Technol. 37;* 639 (1956).

4. Biological Processes in the Estuarine Environment - III. Electrochemical Considerations Regarding the Sulphur Cycle, *Konikl. Ned. Adak. Wetenschap. Proc. Ser., B59;* 97 (1956), with L.G.M. Baas Becking.

5. Biological Processes in the Estuarine Environment - IV. Attempts at Interpretation of Observed Eh-pH Relations of Various Members of the Sulphur Cycle, *Knoikl. Ned. Akad. Wetenschap. Proc. Ser. B59;* 98 (1956), with L.G.M. Baas Becking.

6. Biological Processes in the Estuarine Environment - VIII. Iron Bacteria as Gradient Organisms, *Konikl. Ned. Akad. Wetenschap. Proc. Ser. B59;* 398 (1956), with L.G.M. Baas Becking & E.J.F. Wood.

1957: 7. Biological Processes in the Estuarine Environment. X. The Place of the Estuarine Environment Within the Aqueous Milieu, *Konikl. Ned. Akad. Wetenschap. Proc. Ser. B60;* 88 (1957), with L.G.M. Baas Becking and E.J.F. Wood.

1958: 8. Fractionation of Stable Isotopes of Sulfur by Thiobacilli, *Science 127;* 517 (1958), with T.A. Rafter.

9. The Separation of Chlorophylls by Paper and Cellulose Column Chromatography, *Arch. Biochem. Biophys. 75;* 56 (1958), with A. Angapindu, H. Silberman and P. Tantivatana.

1959: 10. Spectroscopy of Bacterial Chlorophylls Separated by Paper and Cellulose Column Chromatography, *Arch. Biochem. Biophys. 80;* 114 (1959), with H. Silberman.

1960: 11. Limits of the Natural Environment in Terms of pH and Oxidation Reduction Potentials, *J. Geol. 68;* 243 (1960), with L.G.M. Baas Becking and D. Moore.

12. Sulphur Isotopic Variations in Nature 7. Sulphur Isotopic Measurements in New Zealand Geothermal and Volcanic Areas, *N.Z.J. Sci. 3;* 209 (1960), with T.A. Rafter and J.R. Hulston.

13. Sulphur Isotopic Variations in Nature. 8. Application to Some Biogeochemical Problems, *N.Z.J. Sci. 3;* 338 (1960), with T.A. Rafter and J.R. Hulston.

1962: 14. Transformations of Sulphur Compounds in the Sediments of Milford Sound, *Bull. New Zealand Oceanographic Institute No. 17* (1962), with T.A. Rafter.

15. Chapter: Basin Sedimentation and Diagenesis, *In: The Sea, Vol. 3* Ideas and Observations. Interscience Publishers, Inc.; 583 (1962), with S.C. Rittenberg.

16. Fractionation of Isotopes in Relation to the Problem of Elemental Sulphur Transport by Micro-organisms, *Nature 194;* 1098, with S.C. Rittenberg.

17. Chapter: Microbiological Fractionation of Sulphur Isotopes *In: Biogeochemistry of Sulfur Isotopes* (Ed. M.L. Jensen), Yale Press; 80 (1962), with S.C. Rittenberg.

1963: 18. Organic Compounds in Stony Meteorites, *Geochim. et Cosmochim. Acta 27*; 805 (1963), with E.T. Degens and J.H. Reuter.

19. The Distribution and Isotopic Abundance of Sulphur in Recent Marine Sediments off Southern California, *Geochim. et Cosmochim. Acta 27;* 297 (1963), with K.O. Emery and S.C. Rittenberg.

1964: 20. Carbon Isotope Fractionation During Metabolism of Lactate by Desulfovibrio desulfuricans, *J. Gen. Microbiol. 34;* 213 (1964), with S.C. Rittenberg.

21. Microbiological Fractionation of Sulphur Isotopes, *J. Gen. Microbiol. 34;* 195 (1964), with S.C. Rittenberg.

1966: 22. The Isotopic Abundance and Content of Sulfur in Meteorites, *Geochim. et Cosmochim. Acta 30;* 479 (1966), with J.R. Hulston.

23. Isotope Geochemistry of Sedimentary Sulfates, *Chem. Geol. 1;* 93 (1966), with W.T. Holser.

24. Anamalous Carbon-Isotope Ratios in Non-Volatile Organic Material. *Science 153;* 744 (1966), with A. Nissenbaum.

25. Origin of the Beeri (Israel) Sulfur Deposit, *Chem. Geol. 1;* 295 (1966), with A. Nissenbaum.

1967: 26. Determination of Copper in Saline Waters by Atomic Absorption Spectrophotometry Combined with APDC-MIBK Extraction, *Anal. Chim. Acta. 38;* 321 (1967), with R.R. Brooks and B.J. Presley.

27. APDC-MIBK Extraction System for the Determination of Trace Elements in Saline Waters by Atomic Absorption Spectrophotometry, *Talanta 14;* 809 (1967), with R.R. Brooks and B.J. Presley.

28. Manganese and Related Elements in the Interstitial Water of Marine Sediments, *Science 158;* 906-910 (1967), with B.J. Presley and R.R. Brooks.

1968: 29. Trace Elements in the Interstitial Waters of Marine Sediments, *Geochim. et Cosmochim. Acta 32;* 397 (1968), with R.R. Brooks and B.J. Presley.

30. High Pressure pH Sensor for Oceanographic Applications, *Rev. Sci. Inst. 39;* 1133 (1968), with S. Ben-Yaakov.

31. A Versatile Probe for In Situ Oceanographic Measurement, *J. Ocean Tech. 14;* 25 (1968), with S. Ben-Yaakov.

32. Changes in Dissolved Sulfate, Calcium and Carbonate from Interstitial Water of Near-Shore Sediments, *Geochim. et Cosmochim. Acta 32;* 1037 (1968), with B.J. Presley.

33. pH-Temperature Profiles in Ocean and Lakes Using an In Situ Probe, *Limnol. & Oceanogr. 13;* 688-693 (1968), with S. Ben-Yaakov.

1969: 34. Book Review, "Petroleum Microbiology", J.B. Davis, Elsevier, 1967, 604 pages, *Sedimentology 11;* 125. Published in 1969.

35. Interstitial Water Chemistry: JOIDES Leg 1, *Special Report on Description of Deep Sea Drilling Operations - NSF and Scripps Inst. of Oceanogr.,* 411 (1969).

36. Differences Between Barites of Marine and Continental Origins, *Geochim. et Cosmochim. Acta 33;* 287 (1969), with Edward D. Goldberg, B.L.K. Somayajulu, James Galloway and Gunter Faure.

37. Determination of Carbonate Saturation of Seawater with a Carbonate Saturometer, *Limnol. & Oceanogr. 14;* 874 (1969), with S. Ben-Yaakov.

38. Sulfur Isotope Studies on Red Sea Geothermal Brines and Sediments, *In: Hot Brines and Recent Heavy Metal Deposits in the Red Sea,* 180 pp. (Eds. E. Degens and D. Ross), Springer-Verlag, N.Y. (1969), with R.E. Sweeney and A. Nissenbaum.

39. Trace Element Composition of Red Sea Geothermal Brines and Interstitial Water, *In: Hot Brines and Recent Heavy Metal Deposits in the Red Sea,* 180 pp. (Eds. E. Degens and D. Ross), Springer-Verlag, N.Y. (1969), with R.R. Brooks and M.N.A. Peterson.

1970: 40. Search for Organic Compounds in the Lunar Dust from the Sea of Tranquility, *Science 167;* 760 (1970), with C.D. Philpott, J. Smith, J.W. Schopf, C. Gehrke, G. Hodgson, R.A. Breger, B. Halpern, A. Duffield, K. Krauskopf, E. Barghoorn, H. Holland and K. Keil.

41. Evidence for Extraterrestrial Amino Acids and Hydrocarbons in the Murchison Meteorite, *Nature 228;* 923 (1970), with K. Kvenvolden, J. Lawless, K. Pering, E. Peterson, J. Flores, and C. Ponnamperuma.

42. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 4, *Initial Reports of the Deep Sea Drilling Project, V. IV;* 415 (1970), with B.J. Presley.

43. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 5, *Initial Reports of the Deep Sea Drilling Project, V. V;* 513 (1970), with B.J. Presley and M.B. Goldhaber.

44. Carbon and Oxygen Isotopes in Apatite CO_2 and Co-existing Calcite from Sedimentary Phosphorite, *J. Sed. Pet. 40;* 954 (1970), with Y. Kolodny.

45. Biological Productivity in the Dead Sea - Part I: Microorganisms in the Water Column. *Israel J. Chem. 8;* 513 (1970), with A Friedman.

46. Biological Productivity in the Dead Sea: Part II. Evidence for Phosphatidyl Glycerophosphate Lipid in Sediment. *Israel J. Chem. 8;* 529 (1970), with M.J. Baedecker.

47. Carbon and Sulfur Concentration and Isotopic Composition in Apollo 11 Lunar Samples. *Proceedings of the Apollo 11 Lunar Science Conference. Vol. II: Chemical and Isotope Analyses.* Pergamon Press (Ed. A.A. Levinson), p. 1317 (1970), with J.W. Smith and E. Ruth.

48. Extractable Organic Matter in Precambrian Cherts. *Geochim. et Cosmochim. Acta 34;* 659 (1970), with J.W. Smith and J.W. Schopf.

49. Endogenous Carbon in Carbonaceous Meteorites. *Science 167;* 1367 (1970), with J.W. Smith.

50. Carbon Compounds in Lunar Fines from Mare Tranquillitates: IV. Evidence for Oxides and Carbides. *Geochim. et Cosmochim. Acta Special Issue 167;* 1857 (1970), with S. Chang, J. Smith, J. Lawless, K. Kvenvolden and C. Ponnamperuma.

51. Concentration and Isotopic Composition of Carbon and Sulfur in Apollo 11 Lunar Samples. *Science 167;* 541 (1970), with J.W. Smith.

52. Light Hydrocarbon Gases, C^{13}, and Origin of Organic Matter in Carbonaceous Chondrites. *Geochim. et Cosmochim. Acta 34;* 257 (1970), with T. Belsky.

53. Uranium Isotopes in Sea-Floor Phosphorites. *Geochim. et Cosmochim. Acta 34;* 3 (1970), with Y. Kolodny.

1971: 54. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 6. *Initial Reports of the Deep Sea Drilling Project Vol. VI;* 823, (1971), with B.J. Presley.

55. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 7. *Initial Reports of the Deep Sea Drilling Project Vol. VII, Part II;* 883 (1971), with B.J. Presley.

56. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 8. *Initial Reports of the Deep Sea Drilling Project Vol. VII;* 853 (1971), with B.J. Presley.

57. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 9. *Initial Reports of the Deep Sea Drilling Project, Vol. IX;* 841 (1971), with B.J. Presley.

58. Carbon, Carbides and Methane in an Apollo 12 Sample. *Science 171;* 474 (1971), with S. Chang, K. Kvenvolden, J. Lawless and C. Ponnamperuma.

59. An Oceanographic Instrumentation System for In Situ Applications. *Mar. Tech. Soc. J. 5;* 41 (1971), with S. Ben-Yaakov.

60. Deep Sea In Situ Calcium Carbonate Saturometry. *J. Geophys. Res. 76;* 722 (1971), with S. Ben-Yaakov.

61. Book Review, "Microbial Biogeochemistry", J.E. Zajic. Academic Press, 1969, 345 pp. 38 illus. 53 tables. *Engineering Geology 5;* 247 (1971).

62. "Hydrogen". Chapter from book, *Elemental Abundances in Meteorites* (Ed. B. Mason), Gordon & Breach Science Publishers, p. 21 (1971).

63. Carbon and Sulfur Isotope Studies on Apollo 12 Lunar Samples, *Proceedings of the Second Lunar Science Conference Vol. 2;* 1397, M.I.T. Press (1971), with C. Petrowski.

1972: 64. Studies on Dissolved Organic Matter from Interstitial Water of a Reducing Fjord. *Adv. in Org. Geochem. 1971;* 427 (1972), with A. Nissenbaum and M.J. Baedecker.

65. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 11. *Initial Reports of the Deep Sea Drilling Project Vol. XI;* 1009, (1972), with B.J. Presley

66. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 14. *Initial Reports of the Deep Sea Drilling Project Vol. XIV;* 763, (1972), with B.J. Presley and C. Petrowski.

67. Organic Geochemistry of Dead Sea Sediments. *Geochim. et Cosmochim. Acta 36;* 709 (1972), with A. Nissenbaum and M.J. Baedecker.

68. Sulfur Cycle. Chapter from book, *Encyclopedia of Geochemistry and Environmental Sciences* (Ed. R.W. Fairbridge), Van Nostrand Reinhold (1972).

69. Biogeochemistry. Chapter from book, *Encyclopedia of Geochemistry and Environmental Sciences* (Ed. R.W. Fairbridge), Van Nostrand Reinhold (1972).

70. Early Diagenesis in a Reducing Fjord, Saanich Inlet, British Columbia--I. Chemical and Isotopic Changes in Major Components of Interstitial Water. *Geochim. et Cosmchim. Acta 36;* 1007 (1972), with A. Nissenbaum and B.J. Presley.

71. Early Diagenesis in a Reducing Fjord, Saanich Inlet, British Columbia--II. Trace Element Distribution in Interstitial Water and Sediment. *Geochim. et Cosmochim. Acta 36;* 1073-1090 (1972), with B.J. Presley, Y. Kolodny and A. Nissenbaum.

72. Early Diagenesis in a Reducing Fjord, Saanich Inlet, British Columbia--III. Changes in Organic Constituents of Sediment. *Geochim. et Cosmochim. Acta 36;* 1185-1203 (1972), with F.S. Brown, M.J. Baedecker and A. Nissenbaum.

73. Chemical and Isotopic Evidence for the In Situ Origin of Marine Humic Substances. *Limnol. & Oceanogr. 17;* 570-582 (1972), with A. Nissenbaum.

74. Carbon, Nitrogen and Sulfur Released During Pyrolysis of Bulk Apollo 15 Fines. *The Apollo 15 Lunar Samples* (Eds. J.W. Chamberlain and C. Watkins), 291-293 (1972), with S. Chang, J. Smith, H. Sakai, C. Petrowski and K. Kvenvolden.

75. Distribution of Carbon and Sulfur in Hydrolyzed Apollo 15 Lunar Fines. *The Apollo 15 Lunar Samples* (Eds. J.W. Chamberlain and C. Watkins); 319-323 (1972), with H. Sakai, S. Chang, C. Petrowski and J. Smith.

76. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 13. *Initial Reports of the Deep Sea Drilling Project Vol. XIII;* 801-811 (1972), with B.J. Presley and C. Petrowski.

77. Distribution and Isotopic Abundance of Biogenic Elements in Lunar Samples. *Space Life Sciences 3;* 383-403 (1972).

1973: 78. Comments on "Redox Potentials by Equilibration" by W.G. Breck. *J. Mar. Res. 31;* 79-82 (1973), with S. Ben-Yaakov.

79. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 10. *Initial Reports of the Deep Sea Drilling Project, Vol. X;* 613-614 (1973), with B.J. Presley and C. Petrowski.

80. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 17. *Initial Reports of the Deep Sea Drilling Project, Vol. XVII;* 515-516 (1973), with B.J. Presley, J.H. Culp and C. Petrowski.

81. Gas Analyses in Sediment Samples from Legs 10,11,13,14,15,18 and 19. *Initial Reports of the Deep Sea Drilling Project, Vol. XIX;* 879-884 (1973), with G.E. Claypool and B.J. Presley.

82. C_{18}-Isoprenoid Ketone in Recent Marine Sediment. *Nature 244;* 154-155 (1973), with R. Ikan and M.J. Baedecker.

83. Distribution and Diagenesis of Organic Compounds in JOIDES Sediment from Gulf of Mexico and Western Atlantic. *Geochim. et Cosmochim. Acta 37;* 1881-1989 (1973), with Z. Aizenshtat and M.J. Baedecker.

84. Pyrite Framboid Formation - Laboratory Synthesis and Marine Sediments. *Econ. Geol. 68;* 618-634 (1973), with R.E. Sweeney.

85. Growth Pattern and $^{13}C/^{12}C$ Isotope Fractionation of Cyanidium caldarium and Hot Spring Algal Mats. *Chem. Geol. 12;* 161-169 (1973), with J. Seckbach.

86. Interstitial Water Chemistry: Deep Sea Drilling Project, Leg 12. *Initial Reports of the Deep Sea Drilling Project, Vol. XIV;* 891-892 (1973), with B.J. Presley and C. Petrowski.

87. Interstitial Water Studies--Leg 15--Major Ions Br, Mn, NH_3, Li, B, Si, and δC^{13}. *Initial Reports of the Deep Sea Drilling Project, Vol. XX;* 805-809 (1973), with B.J. Presley, J. Culp and C. Petrowski.

88. Deposition of Uranium in the Sediment and Interstitial Water of an Anoxic Fjord. *Vol. 1 - Hydrogeochemistry (Proc. of Symp. on Hydrogeochemistry and Biogeochemistry)* Tokyo, Japan, Sept. 7-9, 1970. The Clarke Co. Publisher; 418-442 (1973), with Y. Kolodny.

89. Carbon, Nitrogen, Sulfur, Helium, Hydrogen and Metallic Iron in Apollo 15 Drill Stem Fines. *Proc. 4th Lun. Sci. Conf.* (Supplement 4 - Geochim. et Cosmochim. Acta Vol. 2), 1651-1656 (1973), with J.W. Smith and C. Petrowksi.

1974: 90. Carbonate Compensation Depth: Relation to Carbonate Solubility in Ocean Waters. *Science 184;* 982-984 (1974), with S. Ben-Yaakov and E. Ruth.

91. Carbon, Nitrogen and Sulfur in Lunar Fines 15012 and 15013: Abundances, Distributions and Isotopic Compositions. *Geochim. et Cosmochim. Acta 38;* 853-872 (1974), with S. Chang, J. Lawless, M. Romiez, C. Petrowski, H. Sakai and J.W. Smith.

92. Calcium Carbonate Saturation in Northeastern Pacific: In Situ Determination and Geochemical Implications. *Deep-Sea Res. 21;* 229-243 (1974), with S. Ben-Yaakov.

93. Sulfur Isotope Studies on Evaporites and Shales from Sites 225, 227 and 228 in the Red Sea. *Initial Reports of the Deep Sea Drilling Project, Vol. XXIII;* 947-950 (1974), with W.C. Shanks and J.L. Bischoff.

94. Chapter 17, "The Sulfur Cycle". In: *The Sea - Vol. V Marine Chemistry*, (Ed. E.D. Goldberg), John Wiley & Sons, Inc., 569-655 (1974), with M.B. Goldhaber.

95. *Natural Gases in Marine Sediments* (I.R. Kaplan, Ed.), Marine Science, Vol. 3, Plenum Press, N.Y.; 324 pp. (1974).

96. Chapter: "The Origin and Distribution of Methane in Marine Sediments" In: *Natural Gases in Marine Sediments* (I.R. Kaplan, Ed.) Plenum Press; 99-140 (1974), with G.E. Claypool.

97. Chapter: "pH Sensors" In: *Geoscience Instrumentation* (Eds. E.A. Wolff and E.P. Mercanti), John Wiley & Sons, N.Y.; 386-400 (1974), with S. Ben-Yaakov.

98. Fractionation of Sulfur Isotopes by the Yeast Saccaromyces cerevisiae. *Geochim. et Cosmochim. Acta 38;* 1239-1253 (1974), with R.G.L. McCready and G.A. Din.

99. Accumulation and Isotopic Evolution of Carbon on the Lunar Surface. *Proc. of the 5th Lun. Sci. Conf. Vol. 2;* 1855-1868 (1974), with J.F. Kerridge and F.D. Lesley.

100. Light Element Geochemistry of the Apollo 17 Site. *Proc. of the 5th Lun. Sci. Conf. Vol. 2;* 1939-1948, with C. Petrowski and J.F. Kerridge.

1975: 101 Thermal Alteration Experiments on Organic Matter in Recent Marine Sediment - I. Pigments. *Geochim. et Cosmochim. Acta 39;* 173-185 (1975), with R. Ikan, Z. Aizenshtat, M.J. Baedecker.

102 Thermal Alteration Experiments on Organic Matter in Recent Marine Sediment - II. Isoprenoids. *Geochim. et Cosmochim. Acta 39;* 186-194 (1975), with R. Ikan and M.J. Baedecker.

103. Thermal Alteration Experiments on Organic Matter in Recent Marine Sediment - III. Aliphatic and Steroidal Alcohols. *Geochim. et Cosmochim. Acta 39;* 195-203 (1975), with R. Ikan and M.J. Baedecker.

104. Light Element Geochemistry of the Apollo 16 Site. *Geochim. et Cosmochim. Acta 39;* 137-162 (1975), with J.F. Kerridge and C. Petrowski.

105. Controls and Consequences of Sulfate Reduction Rates in Recent Marine Sediments. *Soil Sciences 119;* 42-55 (1975), with M.B. Goldhaber.

106. Stable Isotopes as a Guide to Biogeochemical Processes. *Proc. R. Soc. Lond. B. 189;* 183-211 (1975).

107. Apparent Dissociation Constants of Hydrogen Sulfide in Chloride Solutions. *Mar. Chem. 3;* 83-104 (1975), with M.B. Goldhaber.

108. Isotopic Fractionation of Dissolved Nitrate During Denitrification in the Eastern Tropical North Pacific Ocean. *Mar. Chem. 3; 271-299* (1975), with J.D. Cline.

109. Evidence for Meteoritic Sulfur in the Lunar Regolith. *Proc. Lun. Sci. Conv. 6th (1975);* 2151-2162 (1975), with J.F. Kerridge and C. Petrowski.

1976: 110. Sulfur and Carbon Isotopic Evidence for Biogeochemical Processes in the Dead Sea Ecosystem. *Proc. 2nd International Symp. on Environmental Biogeochemistry;Vol. 1: Carbon, Nitrogen, Phosphorus, Sulfur and Selenium Cycles* (J.O. Nriagu, Ed.); Ann Arbor Science Publishers, Inc., Ann Arbor; 309-325, (1976), with A. Nissenbaum.

111. Micro-determinations of C, N, S, H, He, metallic Fe, $\delta^{13}C$,$\delta^{15}N$ and $\delta^{34}S$ in geologic samples. *Geochem. Jour. 10;* 85-96 (1976), with H. Sakai, J.W. Smith, and C. Petrowski.

112. Thermal Alteration of Young Kerogen in Relation to Petroleum Genesis. *Nature 264;* 347-349 (1976), with R. Ishiwatari, M. Ishiwatari, and B.G. Rohrback.

113. Light Element Geochemistry of the Apollo 15 site, *Proc. Lunar Sci. Conf. 7th (1976),* 481-492, with J.F. Kerridge and C. Petrowski.

1977: 114. Thermal Alteration Experiments on Organic Matter in Recent Marine Sediments as a Model for Petroleum Genesis. In: *Chemistry of Marine Sediments* (T.F. Yen, ed.) (1977), Ann Arbor Science Publishers, Inc., Ann Arbor.

115. Petroleum and Anthropogenic Influence on the Composition of Sediments from the Southern California Bight, *Proc. 1977 Oil Spill Conference,* 183-188, with W.E. Reed, M. Sandstrom, and P. Mankiewicz.

116. Color of Kerogen as Index of Organic Maturity, *Amer. Assoc. Petrol. Geol. Bull. 61 (4),* 504-510, with K.E. Peters and R. Ishiwatari.

117. The Chemistry of Marine Petroleum Seeps, *J. Geochem. Explor. 7,* 255-293, with W.E. Reed.

118. Thermal Alteration Experiments on Organic Matter from Recent Marine Sediments in Relation to Petroleum Genesis, *Geochim. Cosmochim. Acta 41,* 815-828, with R. Ishiwatari, M. Ishiwatari, and B.G. Rohrback.

WALTER E. REED

PUBLICATIONS

1964 "Data on the distribution of amino acids and oxygen isotopes in petroleum brine waters of various geologic ages". Sedimentology 3, 199-225 (with E.T. Degens, J.M. Hunt and J.H. Reuter).

1969: "Organic geochemistry of some Late Pleistocene sediments, Mono Basin, California" Abstract - Cordilleran Section Meeting, Geol. Soc. Amer. (with C.M. Gilbert).

1970: "Lunar organic compounds: Search and characterization". Science 167, 751-752 (with A.L. Burlingame, M. Calvin, J. Han, W. Henderson and B.R. Simoneit).

"Study of carbon compounds in Apollo 11 lunar samples". Proc. Apollo 11 Lun. Sci. Conf. Vol. 2, 1779-1791 (with A.L. Burlingame, M. Calvin, J. Han, W. Henderson and B.R. Simoneit).

"Transport of water away from a buried heat source with special reference to hydrologic phenomena observed at Aardvark Nuclear Detonation". Jour. Geophys. Res. 75, 415-430.

"Sourcebook in Petroleum Geology" (Book Review) Science 167, 1481.

1971: "Isolation and identification of sterols from a Pleistocene sediment". Nature 231, 308-310 (with W. Henderson, G. Steel and M. Calvin).

"The origin and incorporation of organic molecules in sediments as elucidated by studies of the sedimentary sequence for a residual Pleistocene Lake". Advances in Organic Geochemistry 1972, 335-352, Vieweg (with W. Henderson and G. Steel).

"The organic diagenesis of steriods in sediments as related to the origin and formation of petroleum". In: Advances in Organic Geochemistry 1971 (H.R. von Gaertner and H. Wehner Eds.), 353-364, Vieweg (with G. Steel and W. Henderson).

"Study of carbon compounds in Apollo 11 and Apollo 12 returned lunar samples". Proc. of Second Lun. Sci. Conf. Vol. 2, 1901-1914 (with W. Henderson, W.C. Kray, W.A. Newman, B.R.T. Simoneit and M. Calvin).

Discussion of "Transport of water away...." by S.N. Davis and "Reply", Jour. Geophys. Res. 76, 630-634.

Walter E. Reed - Publications

1971: "Proposed stratigraphic controls for crude oil composiiton, Green River Formation, Uinta Basin, Utah". Advances in Organic Geochemistry 1972 (H.R. von Gaertner and H. Wehner, Eds)., Vieweg, 499-515 (with W. Henderson).

1975: "Molecular stratigraphy" Nature 254, 127-129 (with P. Mankiewicz).

"Depositional environment interpretation from settling velocity (Psi) distributions" Bull. Geol. Soc. Amer. 86, 1321-1328 (with R. La Fever and G. Moir).

"Stratigraphic utility of organic geochemical analysis" Abstract - Amer. Assoc. Petr. Geol. Program with Abstracts Vol. 2, (with P. Mankiewicz).

"Comparison of analytical procedures for environmental hydrocarbon pollutants" Paper presented at National Bureau of Standards Seminar, Oct. 6-7, 1975, Santa Barbara (with B. Rohrback and I.R. Kaplan).

1976: "Biogeochemical studies of intermontaine lacustrine sequences: An independent appraisal of climatic fluctuations" Abstract - Geol. Soc. America Program with Abstracts 8 (6), 1062.

"Sulfur isotopic evidence for the depositional environment of the lower Tulare Formation, San Joaquin Valley, California" Abstract - Geol. Soc. Amer. Program with Abstracts 8 (6), 1158 (with B. Wall).

1977: "Molecular compositions of weathered petroleum and comparison with its possible source" Geochim. et Cosmochim. Acta 41, 237-247.

"Petroleum and anthropogenic influence on the composition of sediments from the southern California bight" Proc. 1977 Oil Spill Conf. (Prevention, Behavior, Control, Cleanup), EPA/API/USCG (with I.R. Kaplan, M. Sandstrom, P. Mankiewicz).

"The chemistry of marine petroleum seeps" J. Geochem. Expl. in press (with I.R. Kaplan).

"Biogeochemistry of Mono Lake, California" Geochim. et Cosmochimica Acta in press.

WALTER E. REED

MANUSCRIPTS IN PRESS

"Evaluation of extraction techniques for hydrocarbons in marine sediments", National Bureau of Standards Technical Report (with B. Rohrback).

"Molecular compositions of weathered petroleum and comparison with its possible source", Geochimica et Cosmochimica Acta.

"The chemistry of marine petroleum seeps", invited chapter for Application of Geochemistry to the Search for Crude Oil and Natural Gas (B. Hitchon, Editor). Society of Geochemical Exploration Volume.

MANUSCRIPTS SUBMITTED

"Organic Geochemistry of Mono Lake, California". Geochimica et Cosmochimica Acta.

"Compaction: A factor in organic diagenesis?" Bull. Geol. Soc. Amer. (with G. Oertel).

WALTER E. REED

MANUSCRIPTS COMPLETE AND UNDER REVISION

"The relationship between textural parameters and bathymetric depth Southern California Borderland", submitted to <u>Marine Geology</u> (with R. LeFever and R. Anderhalt).

ABSTRACTS ACCEPTED FOR LECTURES

"Biogeochemical studies of intermontane lacustrine sequences: An independent appraisal of climatic fluctuations", <u>Geol. Soc. Amer. Program with Abstracts</u> (1976).

"Sulfur isotopic evidence for the depositional environment of the Lower Tulare Formation, San Joaquin Valley, California", <u>Geol. Soc. Amer. Program with Abstracts</u> (1976) (with B. Wall).

"Criteria for identification of sources of hydrocarbon pollutants", NOAA Conference on Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms. Seattle, Washington (with I.R. Kaplan).

"An evaluation of criteria to differentiate sources of hydrocarbons in the Southern California Borderland". API/EPA/USCG Oil Spill Conference: Prevention, Behavior, Control, Cleanup, New Orleans, La. (with I.R. Kaplan)

A SURVEY OF CETACEANS OF PRINCE WILLIAM SOUND AND ADJACENT VICINITY - THEIR NUMBERS AND SEASONAL MOVEMENTS - RESEARCH UNIT 481

John D. Hall - Senior Ecologist (Marine Mammals)

7 November 1977

U. S. Fish & Wildlife Service
Office of Biological Services
Anchorage, Alaska

Principal Investigator:

John D. Hall

Date: 11/11/77

John D. Hall
Fish and Wildlife Service
Office of Biological Services
Coastal Ecosystems
800 A Street, Suite 110
Anchorage, Alaska 99501
Phone: 907-265-5401

Approved by:

Gordon W Watson

Date: 11/11/77

Area Director
Fish and Wildlife Service
Alaska Area Office
813 D Street
Anchorage, Alaska 99501
Phone: 907-265-5401

Francis J. Pratt for
Financial Officer
Date: 11/11/77

Joy Bartlett, Fish and Wildlife Service, Office of Biological Services/
Coastal Ecosystems, 800 A Street - Suite 110, Anchorage, Alaska 99501
Phone: 907-265-5401

I. TITLE:

A SURVEY OF CETACEANS OF PRINCE WILLIAM SOUND AND ADJACENT REGIONS OF THE GULF OF ALASKA

Research Unit No: 481
Contract No: 01-6-022-15670
Dates of Contract: 1 October 1977 to 31 September 1978.

II PRINCIPAL INVESTIGATOR:

John D. Hall
U.S. Fish and Wildlife Service
Office of Biological Services/Coastal Ecosystems
800 A Street - Suite 110
Anchorage, AK 99502

III COST OF PROPOSAL: (FY-78)

Total: $35,000

Distribution of Effort by Lease Area - NEGOA - 100%.

IV BACKGROUND:

Historical information as well as surveys by the Fish and Wildlife Service (FWS), Alaska Department of Fish and Game (ADFG), and private consultants or fishermen indicate that a large population of cetaceans probably including seven or more species, inhabit Prince William Sound and adjacent regions of the Gulf of Alaska (ADFG, 1973, Pitcher; 1975, K. Schneider, pers. comm.; Rosenthal, pers. comm.; and 1975-1976, FWS field records).

Some species, such as the endangered Humpback whale, Megaptera novaeangliae, normally occur only seasonally. Observations of this whale extend from February through early December in numbers of up to 50 or 60 animals. It is uncertain to which stock this group of animals belongs, but work by the National Marine Fisheries Service presently underway in Mexico, Southeast Alaska, and the Hawaiian Islands in conjunction with this project may identify the racial origin or relationship between these groups. Because only a few hundred humpback whales remain in the North Pacific (counts of 50 in Prince William Sound and 60 in SE Alaska north of Frederick Sound during summer; 337 in the Hawaiian Islands and 102 in Mexico during winter), identification of the origin and size of local populations is of primary interest, and the potential impact from OCS development on such populations are of real concern. Other species such as the killer whale, _Orcinus orca_, Dal porpoise, _Phocoenoides dalli_, the harbor porpoise, _Phocoena phocoena_, and the minke whale, _Balaenoptera acutorostrata_, are reported throughout the year. Additional species occurring during migration include the Pacific white side porpoise, _Lagenorhynchus obliquidens_, the (endangered) fin whale, _Balaenoptera physalus_, the sperm whale, _Physeter catodon_, and the gray whale, _Eschrichtius robustus_. Annual counts of gray whales by the NMFS over the past decade indicate that the total population of this endangered species is 10,000 to 12,000 animals. Although the gray whale may infrequently occur in the Sound, virtually the entire population may pass through proposed development areas on their semi-annual migration between their wintering areas off southern California and Mexico and their summer foraging areas in the Bering and Chukchi Seas.

Oceanographic data including current patterns and seasonal storm tracks indicate that waters of Prince William and adjacent nearshore areas are likely to be affected by the projected development of petroleum resources in both the Northeast and Northwest Gulf of Alaska (Defense Mapping Agency Hydrographic Center Pub. No. 55) Increased ship traffic associated with the Arctic Pipeline terminue in Valdez poses an additional threat.

Impacts from development may occur directly as a result of whales' encounter with polluted water or by excessive disturbance, and indirectly by changes in abundance or contamination of food resources. Prior experience in Alaska is lacking, but Norris (1975) has shown that porpoises quickly detect new activity in an area and if disturbance persists may abandon the region. Recent observations indicate that porpoises and whales draw surface water into upper sacs of their respiratory systems upon inhalation (Kooyman _et al_., 1975). The inhalation of water containing petroleum could seriously affect health of animals or cause direct mortality if the condition persisted as in the case of an extensive oil spill.

Surveys conducted under this RU during TQ 76 and FY 77 have found seasonal concentrations of porpoise and endangered whales in Hinchinbrook Entrance, Montague Strait, the Chenage Island/Knight Island area and near Naked Island. The porpoise species sighted include the Dall porpoise, *Phocoenoides dalli* and the harbor porpoise, *Phocoena phocoena*, while the endangered whales include the humpback, *Megaptera novaeangliae*, the finback, *Balaenoptera physalus*, and the gray, *Eschrichtius robustus*. These animals are all protected under the Marine Mammal Protection Act of 1972, and the whales are also protected under the Endangered Species Act of 1973.

V OBJECTIVES:

This proposal addresses Tasks E-1 and E-2 of the Draft Study plan for Environmental assessment of the Alaskan Continental Shelf. The proposal is geographically limited to Prince William Sound and adjacent waters which have been identified as habitat of unusual or critical importance for marine mammals and which may be affected by developments in either the Northeastern or Northwestern Gulf of Alaska. Specific objectives include:

1. Determine seasonal distribution and abundance of principal cetacean species utilizing Prince William Sound and adjacent areas in the northern Gulf of Alaska.

2. To determine major foraging areas and critical habitats for principal species.

3. To determine food habits of the Dall porpoise, *Phocoenoides dalli*.

VI GENERAL STRATEGY AND APPROACH

Existing information on the occurrence and distribution of cetaceans in the Prince William Sound Area has been summarized and will be available as digitized data by October 1977. A primary source of data has been the observations made by the late L. V. Haddock (FWS) during aerial and surface surveys of birds during 1972 and 1973.

Effort in FY 78 will be limited to meeting digital data products requirements, analysis of data and completion of the Annual and Final Reports.

VII EXPECTED RESULTS:

The study will provide a comprehensive evaluation of size and seasonal distribution of populations, areas of critical habitat, and areas and populations most likely to be affected by impending development activities.

VIII ANTICIPATED PROBLEMS:

None.

IX DELIVERABLE PRODUCTS:

A. Digital data on sightings during aerial transects, ship censuses, and shore stations, and supplementary data as appropriate to be provided on magnetic tapes in format specified by the Environmental Data Service.

Data Processing - by Principal Investigator
Data Formating - as specified by EDS

Data Product	Media	Volume
Digital Recording of Observations	Tape	Equiv. 5,000 cards
Digital Records of Food Analysis	Tape	Equiv 500 cards

B. Narrative Reports

Quarterly and/or survey reports providing summary and preliminary analysis of work completed including results of censuses and incidental sighting, seasonal distribution patterns, critical habits, and food analysis.

C. Visual Data

Maps illustrating transect or survey routes, seasonal distribution patterns of principle species, and areas of critical habitat will be provided as a part of narrative reports, and if requested, will be included as part of the Data Documentation Form.

D. Other Non-Digital Data: None.

E. Data Submission Schedule: Digital Data by 1 December 1977. All other data and reports by 30 September 1978

X INFORMATION REQUIRED FROM INVESTIGATORS:

Information on sightings of cetaceans obtained in OCEAP Research Units 337, 341, and 342, (Lensink and Bartonek, FWS) will be required as a supplementary source of data. This study, concentrating on inland or nearshore waters, will complement and extend information from OCSEAP RU 68 (Fiscus and Harry, National Marine Fishery Service) which by its nature is confined largely to offshore regions. Participation by both the NMFS and FWS in this project assured maximum coordination with these ongoing research units.

In addition, information will be available from other studies of marine mammals, in particular the humpback whale by NMFS and of birds and marine mammals by the FWS.

Marine mammal data collected by RUs 337, 341 and 342 will be made available to RU 481 in the form of a computer printed edited output of file 033.

XI MANAGEMENT PLAN:

Quarterly reports of completed activities will be provided. Ninety days (90) after the completion of the contract a final report will be sumbitted to the contracting office. This report will include all data products noted in section X as well as a narrative analysis and overview of all project activities, results, and conclusions,

XII REQUIRED STATEMENTS:

1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OSCEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U. S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard.

"This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

REFERENCES CITED

Alaska Dept. of Fish & Game. 1973. Alaska's Wildlife and Habitat.

Calkins, D. G., K. W. Pitcher and K. Schneider. 1975. Distribution and Abundance of Marine Mammals in the Gulf of Alaska. Alaska Dept. of Fish and Game Publication.

Evans, W. E., J. D. Hall, A. B. Irvine, J. S. Leatherwood. 1972. Methods for Tagging Small Cetaceans. Fishery Bulletin, 70(1):61-65.

Hall, J. D. In Preparation. The Development of a Non-lethal Technique for Sampling Marine Mammal Stomach Contents.

Kooyman, G. L., K. S. Norris, and R. L. Gentry. 1975. Spout of the Gray Whale: Its Physical Characteristics. Science, 190(4217): 908-910.

Norris, K. S. 1975. Marine Mammal - Seabird Baseline Study of the Southern California Bight. A Proposal funded by the Bureau of Land Management for OCS Baseline Studies.

Dept. of Defense. 1975. Pilot Chart of the North Pacific Ocean. Defense Mapping Agency Hydrographic Center, Washington, D. C. Publ. No. 55.

Perrin, W. F. and C. J. Orange. 1971. Porpoise Tagging in Eastern Tropical Pacific. Proc. 21st Tuna Cont., Lake Arrowhead, Calif. October 1970, p. 5.

Sergeant, D. E. and P. F. Brodie. 1969. Tagging White Whales in the Canadian Arctic. J. Fish. Res. Bd. Canada, 25:2201-2205.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P. O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

RFx41-481-94

Date: Jan 16 1978

To : Rudy Engelmann, Director
OCSEAP-Alaska Program Office-Boulder

From: Herbert E. Bruce, Manager
OCSEAP-Juenau Project Office

Subj: OCSEAP Research Unit 481

Required Acceptance Letter for R.U. 481, John Hall

The enclosed FY78 renewal proposal dated November 7, 1977 entitled "A Survey of Cetaceans of Prince William Sound and Adjacent Regions of the Gulf of Alaska," and addendum data December 5, 1977 have been reviewed by the Juneau Project Office and judged acceptable at the funding level of $31,826. Obligated funds in the amount of $10,000 for the continuation of FY78 work, were given to R.U. 481 on 10/26/77 (requisition #RK-8-0024). Therefore, the total amount yet to be funded is $21,826. Please send an acceptance letter to Mr. Hall and initiate contracting procedures based on the proposal for $31,826.

Mr. Hall now resides in California, so all personal correspondence should be sent to the following address:

Mr. John Hall
USF&WS Ecological Services
2800 Cottage Way, Rm. D-2727
Sacramento, California 95825

Enclosure

cc:
John Hall-USF&WS, California
USF&WS financial Officer, Anchorage
Sue Anderson

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Office of Biological Services
Coastal Ecosystems
800 A Street - Suite [illegible]
Anchorage, Alaska [illegible]

December 5, 1977

Dr. Herbert E. Bruce
Bering Sea-Gulf of Alaska Project Manager
NOAA
P.O. Box 1808
Juneau, AK 99802

Dear Dr. Bruce,

Per your revised guidance letter of 12/2/77 I have included the changes/additions requested below.

1) No mention of Dall porpoise, Phocoenoides dalli, food habits will be made in either the Annual of Final reports.

2) The final verified 1600 BPI magnetic tape with all RU-481 records was sent by separate cover to your office this morning (12/5/77). Included in the DDF was a copy of the coding format which should make clear the arrangement of the data on the tape.

3) The only documents left to produce are the Annual Report (due 4/1/77) and the Final Report (due 10/1/78). These reports will follow the format of the RU-481 Annual Report (submitted on 4/1/77) and include an expanded section dealing with population estimates on a seasonal/annual basis and utilize either photographic analysis based on a Lincoln Index Technique or average density based on mean sightings distances taken from the survey aircraft.

4) Prior to submission all coding sheets were hand verified by the P.I., them key punched an floppy discs. These discs were then listed and hand verified by the P.I. The resulting corrected floppy discs was then transferred to EBCDIC 1600 BPI magnetic tape for submission to the JPO.

   Analysis of data has/and will continue to be done on a H-P 9830 computer utilizing a concatonated data string and H-P's statistical package. Analysis to date has include mean, std. deviation, variance, std. error, correlation and polynomial regression. Future statistical routines will include linear regression, chi-square and analysis of variance.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

5) Since project funding was cut less than halfway through the anticipated field life of the project, a revised Milestone Chart seems superfluous at best. ROSCOP II's were submitted and are available for all surveys, and the digital data tape was submitted on 12/5/77. The photographic analysis (visual) has produced photos of 35 individual humpback whales. Internegatives were made from the original 35mm slides, and if funding is available from non-OCSEAP sources, sets of color prints will be made available to other humpback investigators throughout the Eastern and Central North Pacific. It is hoped that these fluke pattern photos will enable other investigators to identify the stock from which the Prince William Sound humpbacks originate.

Sincerely,

John D. Hall

John D. Hall
Senior Ecologist

Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P. O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

RFx41-ADM-967

DEC 2 1977

Dr. John D. Hall
USF&WS
800 A Street, Suite 110
Anchorage, Alaska 99501

Reference: (1) OCSEAP FY 78 Proposal Solicitation letter dated 5/18/77

(2) Revised guidance letter of 9/19/77

(3) Telephone conversations of 10/20/77 and 11/21/77

Dear Dr. Hall:

Your FY 78 revised renewal proposal, entitled "A Survey of Cetaceans of Prince William Sound and Adjacent Vicinity - Their Numbers and Seasonal Movements - Research Unit 481", has been reviewed by the Juneau Project Office. The following additional revisions are required before your work statement can be sent to our contracting office for funding:

(1) The research objective of determination of food habits of the Dall porpoise Phocoenoides dalli should be deleted together with relevant sections from the deliverable products. These are, specifically, a) Digital Records of Food analysis and b) Narrative Reports: food analysis. The deletion is necessary since no data of this type was obtained during FY 77 field surveys.

(2) The revised guidance required inclusion of a list of parameters and their probable limits under digital data. These parameters would have been included in a data management plan and form a necessary part of acceptable proposals. Such inputs are essential to our knowledge of data submissions from each research unit and contribute greatly to all intercomparative efforts.

(3) The section of your revised proposal entitled "General Strategy and Approach" and "Narrative Reports" must be expanded to provide more explicit detail.

(4) Methods utilized in quality assurance of both data processing and subsequent analyses should be included as requested in the revised guidance.

(5) A Milestone chart should be included to allow evaluation of

progress. This should include completion of steps involved in data analyses and the photographic analyses.

(6) It is understood that transfer of the Principal Investigator to the Sacramento, CA Office of the USF&WS, Environmental Services will probably take place in mid-year and should not impact completion of the FY 78 work since similar facilities for data analyses exist there. The Project Office must be notified of the exact date of transfer as soon as it is available.

The final funding commitment and level are contingent on approval of the FY 78 OCSEAP budget by the Bureau of Land Management.

If you have any questions concerning any of the above guidance, please phone the JuneauProject Office, (907) 586-7436.

Your letter agreeing to these changes, or a revised work statement, must be sent to and received in the Juneau Project Office, with a copy to Boulder no later than Dec. 5, 1977. If there are extenuating circumstances which prevent you from meeting this schedule, please phone the Project Office. The short deadline is required to ensure continuous funding of your project in FY 78.

Upon receipt of your work statement, revised on accordance with the above guidelines, we will initiate contracting procedures for FY 78. I look forward to your continued involvement in our porgram.

Sincerely,

Herbert E. Bruce, Ph.D.
Bering Sea-Gulf of Alaska Project Manager

cc:
Program Office

PROPOSAL TO

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

FOR

EVALUATION OF EARTHQUAKE ACTIVITY AROUND NORTON AND KOTZEBUE SOUNDS

OCSEAP RESEARCH UNIT NO.:	483
PRINCIPAL INVESTIGATORS:	N. N. Biswas L. Gedney
TOTAL COST OF PROPOSAL:	69,000
PERIOD OF WORK:	October 1, 1977 to September 30, 1978
INSTITUTION AND DEPARTMENT:	University of Alaska Geophysical Institute Fairbanks, Alaska 99701

June 1977

N. N. Biswas Date 6/28/77
N. N. Biswas, Principal Investigator
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7010

Date
Neta J. Stilkey, Business Manager
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7644

Larry Gedney Date 6/28/77
L. Gedney, Co-Principal Investigator
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7426

Keith B. Mather Date 6/29/77
Keith B. Mather, Vice Chancellor for Research and Advanced Study
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7282

T. Neil Davis Date 6/28/77
T. Neil Davis, Acting Director
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7393

C. TECHNICAL PROPOSAL

I. A. Title: Evaluation of Earthquake Activity around Norton and Kotzebue Sounds

B. Research Unit Number: 483
C. Contract Number: 03-05-022-55, Task #12
D. Proposed Dates of Contract: October 1, 1977 to September 30, 1978

II. Principal Investigator(s)

A. N. N. Biswas

B. L. Gedney

C.

III. Cost of Proposal Federal Fiscal year 1978

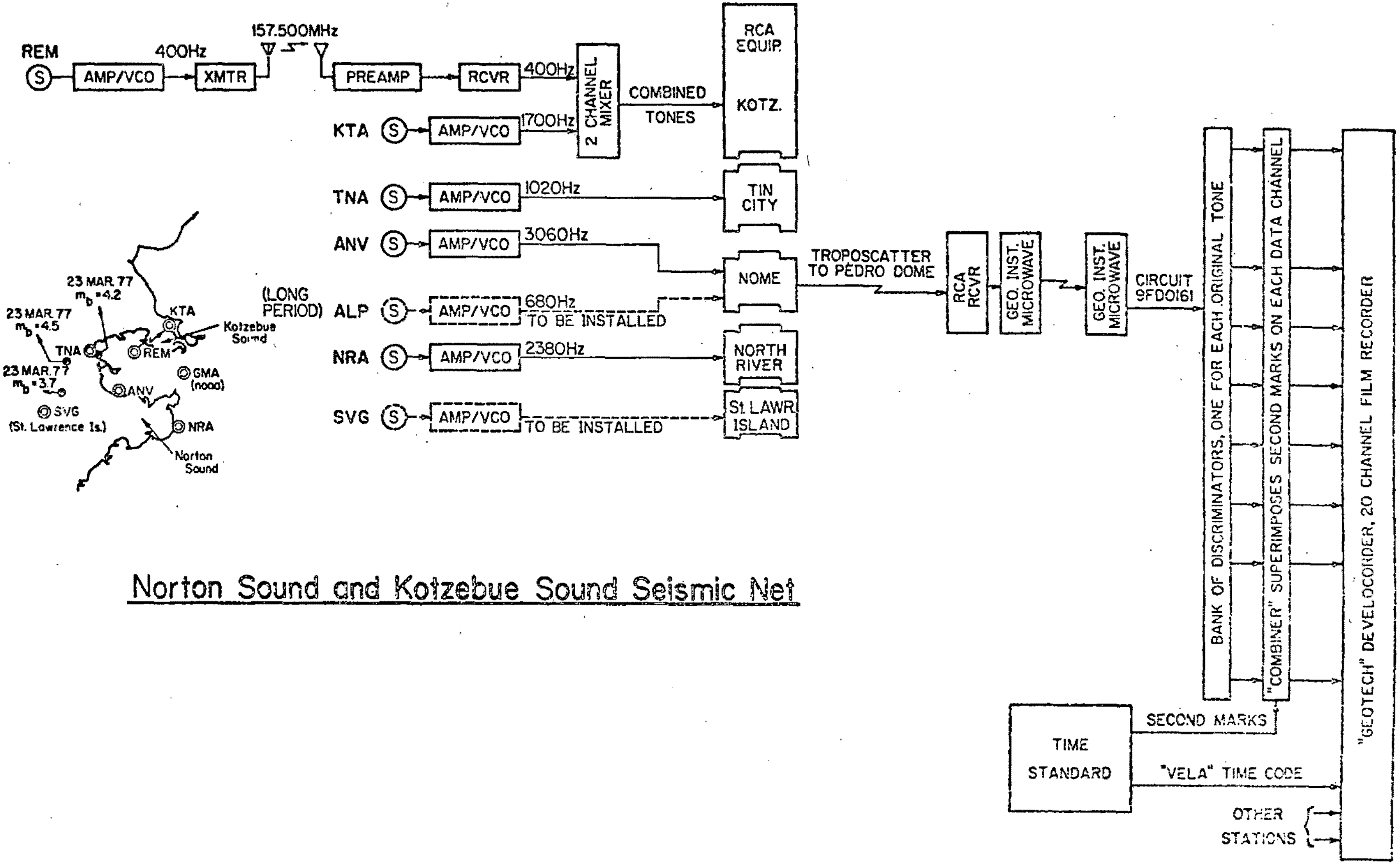
Total: $69,000

Distribution of effort by lease area

1. Norton Sound - 40 Percent
2. Kotzebue Sound 60 Percent

IV. Background:

A six-station seismographic network was installed to provide seismic coverage to the Norton and Kotzebue Sounds during the field seasons of 1976 and 1977. The stations of the network (Figure 1) are operating satisfactorily. The records in general seem to indicate that the study area is seismically more active than thought previously. Most of the cost for this project involves the maintenance of the field sites and telemetering the seismic data to the central recording site at Fairbanks. The high cost entailed in the installation and operation of the network can only be justified if the network is operated for another year. This will allow us to obtain a representative earthquake catalog for the area of interest.



Norton Sound and Kotzebue Sound Seismic Net

V. Objectives:

The primary purpose of this study is to assemble a representative catalog of local earthquakes of different magnitudes in order to obtain an understanding of the nature of earthquake hazards for the study area. In addition, during the early part of 1977, one of the stations (Kotzebue) of the network recorded well the seismic signals generated by the movements of sea ice. Thus, a detailed study of this problem has been incorporated as a part of the seismicity study for the Norton and Kotzebue Sounds.

VI. General Strategy and Approach:

We propose to continue to operate the seismographic network in conjunction with the seismographic station (GMA) of NOAA at Granite Mountain and to maintain the existing quality of the recorded data. The data are recorded in real time and the universal time is superimposed with a precision of $\pm$ 15 m sec. The daily record consists of 160 ft. of 16 mm film which is scaled for each earthquake within $\pm$ 0.1 sec of the first arrival wave phase.

VII. Sampling Methods:

Any scientific sampling is difficult in Alaska. In the past, we were forced to locate our stations where there was access to power to run the equipment package and a microwave or ground satellite station to telemeter the data back to the central recording site at the University.

Over the past several years we have developed methods which largely overcome these difficulties. A successful procedure has been to equip each remote system with its own power supply (air-cell batteries which will power a station for 1-2 years) and to telemeter the seismic signal by VHF to a microwave station of the Alaska Communications System (and thence to Fairbanks). We have established VHF links in this manner up to distances of over 80 miles on only 100 milliwatts of radiated power.

In the study area we were able to locate the seismographic stations of the network so as to provide the widest possible coverage for earthquake detection, and yet enable us to utilize the above method of data retrieval, or to emplace the station directly at a microwave site for transmission to Fairbanks.

VIII. Analytical Methods

Methods for the treatment of seismic data, especially location, depth and magnitude routines, have become fairly standardized in recent years. Although we may utilize special readings (such as frequency in the wave train for spectral analysis) for further studies at a later date, the routine readings used are arrival times of the P and S waves, amplitude for magnitude determinations, and "first motions" of the P (and S, if possible) waves for focal mechanism studies of earthquakes in the area.

The program used for these purposes is (primarily) HYPO 71 by Lee and Lahr (see reference) which has been adapted for use on the University of Alaska's Honeywell 66/20 computer.

<u>Reference</u>: Lee, W. H. K. and J. C. Lahr, HYPO 71 revised, U.S.G.S. Open File Report 75-311, 1975.

IX. Anticipated Problems:

We anticipate no problems, with the exception of unusual weather conditions which may cause temporary station outages.

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by P.I. (Yes or No)	Collection Period (Month/Year to Month/Year)		Submission (Month/Year)
Seismic	Tapes	One 9-track 800 BPI	Standard USGS earthquake catalog format	Yes	October 1976	September 1977	October 1977
					October 1977	September 1978	October 1978

X. Deliverable Products:

A. Digital Data:

1. Recorded Parameters:

Arrival times and amplitudes of P and S- wave phases and first motions of P- wave phase.

2. List of Digital Products:

Day, month, year, hour, minute and record of the occurrence of each earthquake and its location (Latitude, Longitude), focal depth and magnitude. Also details of the accuracies with which the above parameters are determined.

B. Narrative Reports:

Catalog of earthquake occurrences, the nature of their distributions, mechanisms at the source regions, cumulative energy release and possible correlation of the concentration of earthquake epicenters with the active faults in the study area.

C. Visual Data:

Maps of epicenters of earthquakes and their fault plane solutions in relation to the tectonic features of the area.

XI. Information Required from other Investigators:

There should be none absolutely required. However, information which will be helpful to the study will be obtained from the U.S.G.S. and their ocean bottom network, from NOAA and the Palmer Tsunami Warning Network, and (in the case of larger earthquakes) from the Standard Canadian Net and the World-Wide Standard System.

XII. Quality Assurance Plans

The network is operated with matched instruments at each site and the stations are maintained as well as calibrated by frequent checking of the system responses. The quality of the seismic data gathered is comparable to to that of the USGS network operated along the coastal belt of Alaska and central Alaska and coastal belt networks of the Geophysical Institute, University of Alaska. The processing of the data is carried out by the same computer program as used by the National Center of Earthquake Research of USGS.

XIII. Management Plan:

Most of the stations are in and operating at present. The final installation will be made on St. Lawrence Island during the summer of 1977, and the long period instrument at Anvil Mountain set up as well. By the fall of 1977, all telemetry problems should be resolved and routine data flow being recorded at the Geophysical Institute in Fairbanks. Thereafter, real time record scaling and data processing will be maintained and quarterly reports made of results to date. Personnel will be available at all times to visit the sites in the event that an equipment breakdown occurs.

XIV. Outlook:

1. Nature of final results and data products:

Final results and data products will be dual in nature. Primary emphasis will be placed on obtaining a definitive knowledge of the seismicity level and distribution of earthquakes in and around the Seward Peninsula. An attempt will be made to relate seismic activity with active tectonic elements. Data products will include an earthquake catalog on magnetic tape, on punched cards, and in printed format. Epicentral maps will be produced, and cross-sectional views of hypocentral distribution in active areas will be drawn up.

The second area of interest centers around the movement of sea ice through the Bering Strait and in Kotzebue Sound. It was noticed during the winter of 1976-77 that "icequakes" had a very distinctive seismic signature, and that periods of intense activity could be related to weather conditions, particularly with respect to wind direction. We intend to continue this investigation during the winter of 1977-78.

A continuing project of this nature would be of value in determining the temporal aspects of earthquake behavior in this largely unknown region, including whether or not there is a migration with time, as has been noted in other seismic zones. The project also provides a rare opportunity to test the feasibility of determining the sea ice stress conditions from the seismic signals generated by its movement.

2. Significant milestones:

(a) Emplacement of final station at Savoonga on St. Lawrence Island. This will greatly enhance the location capability of the network for offshore earthquakes.
(b) Emplacement of long-period instrument at existing Anvil Mountain station near Nome. This, and item (a) will be accomplished during the summer of 1977.
(c) Indeterminate period of monitoring with network at full strength.
(d) Analysis and interpretation of data accumulated. Both earthquake and "icequake" phenomena will be investigated.
(e) Report writing and preparation of material for publication.

3. Cost by Fiscal year:

Approximately $75,000, most of which will be utilized for the leasing of telemetry lines.

4. Additional major equipment required:

NONE

5. Location of future field efforts:

At existing five field stations for purposes of maintenance. It may be necessary to relocate one or more stations slightly because of the Alaska Communication Systems ongoing change over to satellite relay of communication channels. The station on St. Lawrence Island must be emplaced, and a battery change made at station REMOTE.

6. Logistics Requirements:

Primarily air travel to and from the Seward Peninsula, and rotary and fixed wing transportation to visit the field sites.

XV. Contractual Statements:

1. A schedule for data submission for each task order has been, and will continue to be, submitted and updated each quarter.

2. This statement is in accordance with our base contract, and we will continue to comply.

3. See section XIII of this proposal. The University of Alaska will continue to negotiate a Voucher Specimen Policy with NOAA/OCS. We will comply with the then agreed to policy.

4. See section XV of this proposal. The University of Alaska agrees that the Principal Investigators can travel to the Project Office at least twice during the contract year, provided that such travel is in accordance with University of Alaska travel policy and consistent with other University duties of the Principal Investigator.

5. Data will be provided in the form and format agreed to by the University and NOAA/OCS in the negotiating of the Data Management Plans for each of the tasks falling under the jurisdiction of this office.

6. As per Article 9 of the base contract, the University of Alaska agrees to the following: "...all archivable data is to be submitted by the contractor to the Contract Data Manager within 120 days after acquisition. Certain data sets such as plankton counts or volumes are not available until sorting of samples is complete. The data so obtained are archivable 120 days following the actual sorting or other laboratory procedure."

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager by the Chief Scientist. If the Chief Scientist represents the contracts covered by this office, the form will be sent through this office.

8. This is in accordance with the base contract with which we shall comply.

9. Three copies of all publications or presentation abstracts or manuscripts pertaining to technical or scientific material developed under OCSEAP funding will be submitted to the COTR sixty days prior to publication or presentation. Copies of all news releases mentioning OCS or using information gathered by OCS funding will be sent to the COTR two working days prior to release.

10. The following acknowledgment of sponsorship will be used:

    "This study was supported under contract 03-5-022-56 between the University of Alaska and NOAA, Department of Commerce through the Outer Continental Shelf Environmental Assessment Program to which funds were provided by the Bureau of Land Management, Department of Interior."

MILESTONE CHART

RU #: 483 PI: N. N. Biswas

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Residual data telemetry problems resolved															
Routine data flow and subsequent recording started and results obtained reported in the Annual Report submitted on 1 April, 1977.															
Servicing of stations and progress on data scaling reported in the Quarterly Report submitted on 1 July 1977.															
Detailed results of seismicity studies will be reported on 1 October 1977.															
Further progress on analysis will be reported in the Quarterly Report on 1 January, 1978.															

Published Articles

Biswas, N. N. and L. K. Knopoff, Exact earth flattening calculation for Love wave, Bull. Seismol. Soc. Amer., 60, 4, 1970.

Biswas, N. N., Earth flattening procedure for Rayleigh wave propagation, Pure and Appl. Geophys., 96, 61-74, 1972.

Biswas, N. N., P wave travel-time anomalies: Aleutian - Alaska region, Tectonophysics, 19, 361-367, 1973.

Biswas, N. N. and L. K. Knopoff, Structure of the upper mantle under the United States from the dispersion of Rayleigh waves, Geophys. J. Roy. Astr. Soc., 36, 515-540, 1974.

Biswas, N. N. and B. Bhattacharya, Travel time relations for the upper mantle P-wave phases from central Alaska data, to appear in Bull. Seis. Soc. Am., 64, 1974.

Biswas, N. N. Magnitude relations and Rayleigh wave amplitude spectral variations for earthquakes and underground explosions from Aleutian seismic zone (in press).

Gedney, L., N. N. Biswas, P. Huang, S. Estes and C. Pearson, Seismicity of northeast Alaska (in press).

Papers

Roy, A., N. N. Biswas, S. K. Choudhury and S. K. Guha, Results of gravity and magnetic survey around West Bengal, India, presented in the Indian Science Congress, 1957, Abstract-Proc. Indian Science Congress, 1957.

Bhattacharya, B. and N. N. Biswas, Earthquake source mechanics in central Alaska, presented in the Eastern Section Annual Meeting of the Seismological Society of America, Harvard University, on October 1974.

Reports

Biswas, N. N., B. Bhattacharya, J. D. VanWormer, J. Davis and L. Gedney, Seismological Research in Central Alaska, Final Technical Report to Advanced Research Projects Agency, ARPA order NO. 1827, 1974.

Biswas, N. N., L. D. Gedney and P. Huang, Seismicity studies in southeast Alaska by a localized seismological network, Geophysical Institute Report No. UAG R-241, 1977.

Published Articles

Ryall, A. S., D. B. Slemmons and L. D. Gedney, Seismicity, tectonism and surface faulting in the Western United States during historic time, Bull. Seism. Soc. Amer., 56, 1105-1135, 1966.

Hanson, K., E. Berg and L. Gedney, A Seismic refraction profile and crustal structure in central interior Alaska, Bull. Seism. Soc. Amer., 58, 1657-1665, 1968.

Gedney, L. and E. Berg. The Fairbanks earthquake of June 21, 1967: aftershock distribution, focal mechanisms and crustal parameters, Bull. Seism. Soc. Amer., 59, 73-100, 1969.

Gedney, L. and E. Berg, Some characteristics of the tectonic stress pattern in Alaska, Geophys. Jour. Roy. Astr. Soc., 17, 293-304, 1969.

Gedney, L., E. Berg, H. Pulpan, J. Davies and W. Feetham, A field report on the Rampart, Alaska earthquake of October 29, 1968, Bull. Seism. Soc. Amer., 59, 1421-1423, 1969.

Gedney, L., C. Matteson and R. Forbes, Seismic refraction profiles of the ash flow in the Valley of 10,000 Smokes, Katmai National Monument, Alaska, Jour. Geophys. Res., 75, 2619-2624, 1970.

Gedney, L., Tectonic stresses in Southern Alaska in relationship to regional seismicity and the new global tectonics, Bull. Seism. Soc. Amer., 60, 1789-1802, 1970.

Gedney, Larry, "Finding faults" with ERTS-1, The Northern Engineer 5(1), 3-6, Spring, 1973.

Gedney, Larry and James D. VanWormer, Some aspects of active tectonism in Alaska as seen in ERTS-1 imagery. Symposium on significant results obtained from the Earth Resources Technology Satellite-1, Vol. 1, Section A, 451-457, NASA SP-327, 1973.

Gedney, Larry and James D. VanWormer, Tectonic mapping in Alaska with ERTS-1 imagery, Photo Interpretation, Editions Technip, Paris, 1-1973, fascicule 4, 23-27, 1973.

Gedney, Larry and James VanWormer, In Alaska: Remote sensing of seismic hazards, Geotimes, 19(2), 15-17, 1974.

Gedney, Larry and James VanWormer, ERTS-1, earthquakes, and tectonic evolution in Alaska, Third Earth Resources Satellite-1 Symposium, Volume 1: Technical Presentations, Section A, 745-756, 1974.

VanWormer, James, John Davies and Larry Gedney, Seismicity and Plate tectonics in south-central Alaska, Bull. Seism. Soc. Amer., 64, 1467-1476, 1974.

Gedney, Larry and James VanWormer, Tectonic lineaments and plate tectonics in south-central Alaska, Proceedings of the First International Symposium on the New Basement Tectonics, 27-34, Utah Geological Association Publication No. 5, 1974.

Vanwormer, J. D., L. D. Gedney, J. N. Davies and N. Condal, Vp/Vs and b-values: A test of the dilatancy model for earthquake precursors, Geophysical Research Letters, 2(11), 514-516, 1975.

Gedney, Larry, Everything you always wanted to know about earthquakes The Northern Engineer, 6(4), 22-31, Winter, 1974-1975.

Gedney, Larry, Seismic hazards of reservoir loading, The Northern Engineer, 7(1), Spring, 1977.

Gedney, Larry, Niren Biswas, Paul Huang, Steve Estes and Chris Pearson, Seismicity of Northeast Alaska, Geophysical Research Letters, in press.

Reports

Berg, E., L. Gedney, S. Kubota, K. Hanson and J. Kienle, The June 21, 1967 earthquake series at Fairbanks, Alaska; aftershock locations, depths, and magnitudes, Geophysical Institute, University of Alaska, Rept. UAG R-193, 1967.

Bufe, C. G., L. D. Gedney, L. K. Thomas and J. D. VanWormer, Observations at Stone Canyon, ESSA Technical Report ERL 182-ESL 11, 73-78, 1970.

Gedney, L., L. Shapiro, J. D. VanWormer and F. Weber, Earthquake epicenters in interior Alaska, 1968-1971, and their correlation with mapped faults, Geophysical Institute, University of Alaska Scientific Report UAG R-218, 1972.

Gedney, L., L. Shapiro, J. D. VanWormer and F. Weber, Correlation of epicenters with mapped faults, east-central Alaska, 1968-1971, U. S. Geological Survey, Open-File Report, 1972.

Gedney, Larry and James VanWormer, Tectonic mapping in Alaska with ERTS-1 imagery, interim scientific report, NASA Contract NAS5-21833, 25 May 1973.

VanWormer, J., J. Davies and L. D. Gedney, Central Alaska earthquakes during 1972, Scientific report UAGR-224, Geophysical Institute, University of Alaska, 1973.

Gedney, Larry and James VanWormer, Seismically active structural lineaments in south-central Alaska as seen on ERTS-1 imagery, interim scientific report, NASA contract NAS 5-21833, November, 1973.

Gedney, Larry and James VanWormer Tectonic lineaments and plate tectonics in south-central Alaska, Scientific report, NASA contract NAS 5-21833, 1974.

Gedney, Larry, Seismicity of the Knik fault, consulting seismologist's report, Dynamic Response Analysis Community Hospital, Anchorage, Alaska, 44-55, Harding-Lawson Associates, Feb. 1974.

Forbes, R. B., L. Gedney, D. VanWormer and J. Hook, A geophysical reconnaissance of Pilgrim Springs, Alaska, Geophysical Institute, University of Alaska Scientific Report UAG R-231, 1975.

Gedney, L., Seismic risk evaluation in the Anchorage area, consulting seismologist's report, Harding-Lawson Associates, Feb. 1975.

PUBLICATIONS (Cont'd):

Rogers, James C., William D. Harrison, Lewis H. Shapiro, Thomas E. Osterkamp, Larry D. Gedney and James D. VanWormer, Nearshore permafrost studies in the vicinity of Pt. Barrow, Alaska, Geophysical Institute Report No. UAG R-237, May 1975.

Gedney, Larry and Lewis Shapiro, Structural lineaments, seismicity and geology of the Talkeetna Mountains area, Alaska, prepared for the U. S. Army Corps of Engineers, Alaska Division, Anchorage, Alaska, September 1975.

Forbes, R. B., L. Leonard, D. H. Dinkel, L. Gedney, D. VanWormer and J. Kienle, Utilization of geothermal energy resources in Alaska, Scientific Report UAG R-232, 1975.

Forbes, R. B., H. Pulpan and L Gedney, Seismic risk and the Denali fault, prepared for Gulf Interstate Engineering Company, October, 1976.

Biswas, N. N., L. D. Gedney and P. Huang, Seismicity studies in Northeast Alaska by a localized seismographic network, Geophysical Institute Report No. UAG R-241, March, 1977.

Papers

Slemmons, D. B., A. S. Ryall, and L. D. Gedney, Seismicity of Nevada, Geol. Soc. Amer. Spec. Ppr., 1965.

Ryall, A. S., D. B. Slemmons and L. D. Gedney, Active seismic zones in the western United States, Proceedings of the 62nd annual meeting of the Seismological Society of America, Reno, Nevada, 1966.

Berg, E., L. Gedney, S. Kubota, K. Hanson and J. Kienle, The June 21, 1967 earthquake series at Fairbanks, Alaska, Proceedings 16th Alaskan Science Conference, September 1, 1967.

Gedney, L. and E. Berg. Some characteristics of the tectonic stress pattern in Alaska, Trans. Am. Geophys. Union, 50, p.235, April 1969.

Bufe, C. G., L. D. Gedney, D. Tocher, Local deformations near the San Andreas Fault, Proceedings of the 66th annual meeting of the Seismological Society, Milwaukee, Wisconsin 1970.

Gedney, Larry and J. D. VanWormer, Some aspects of active tectionism in Alaska as seen in ERTS-1 imagery, Symposium on significant results obtained from ERTS-1, NASA/Goddard Space Flight Center, paper G-23, p.49, March 1973.

VanWormer, D., L. Gedney, J. Davies and L. H. Shapiro, Central Alaska seismicity, Program with Abstracts, 69th Annual Meeting of the Seismological Society of America, Golden, Colorado, p.49, May 1973.

Gedney, Larry and James D. VanWormer, Earthquake probabilities in selected areas of Alaska based on b-slope monitoring, Joint U.S. - Japan symposium on earthquake prediction, p. 38, Boulder, Colorado, August 1973.

PUBLICATIONS (Cont'd):

Gedney, Larry and James VanWormer, ERTS-1, earthquakes, and tectonic evolution in Alaska, Third ERTS Symposium, paper G-10, p. 46, Washington, D. C., December 1973.

VanWormer, J., J. Davies and L. Gedney, Some characteristics of the subduction zone in south-central Alaska, Program with Abstracts, 70th Annual Meeting of the Cordilleran Section, Geol. Soc. of Amer. 6(3), p.270, Las Vegas, Nevada, March, 1974.

Gedney, Larry, James VanWormer and Lewis Shapiro, Tectonic lineaments and plate tectonics in south-central Alaska, First International Symposium on the New Basement Tectonics, Salt Lake City, Utah, Paper 2-3, p. 14, June 1974.

Rogers, James, Lewis Shapiro, Larry Gedney and Doug VanWormer, Near-shore permafrost in the vicinity of Pt. Barrow, Third International Conference on Port and Ocean Engineering under Arctic Conditions, Fairbanks, Alaska, August 1975.

Miller, J. M., A. E. Belon, L. D. Gedney and L. H. Shapiro, A look at Alaskan resources with LANDSAT data, Proceedings of the 10th International Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, Michigan, October 1976.

Letters

Gedney, Larry and James VanWormer, Quakes and Lineaments, Geotimes, 19(7), 11, July 1974.

April 1977

Title:	NODC Field Representative to the Outer Continental Shelf Environmental Assessment Program (OCSEAP)
Research Unit:	497
Total Cost:	$55,000
Instution & Department:	NOAA, Environmental Data Service, National Oceanographic Data Center 707 A. Street Anchorage, Alaska 99501
Date of Proposal:	28 July 1977
Signatures: Principal Investigator:	Michael Crane
Date:	28 July, 1977
Address:	National Oceanographic Data Center (D781) 3300 Whitehaven Street, N. W. Washington, D. C. 20235
Telephone Number:	(202) 634-7441
Organizational Approval:	(DIRECTOR)
Date:	28 July, 1977
Address:	National Oceanographic Data Center (D7) 3300 Whitehaven Street, N. W. Washington, D. C. 20235
Telephone Number:	(202) 634-7232
Financial Officer:	
Date:	28 July, 1977
Address:	National Oceanographic Data Center (D7x3) 3300 Whitehaven Street, N. W. Washington, D. C. 20235
Telephone Number	(202) 634-7510

C. Technical Proposal

I. NODC Field Representative to the Outer Continental Shelf Environmental Assessment Program (OCSEAP)

RU 497

1 October 1977 to 30 September 1978

II. Principal Investigator

Michael L. Crane

III. Cost of Proposal

C. Total $55k

D. Totally non-lease-area specific management work.

IV. Background

The OCSEAP Data Base proposed the establishment of a field Liaison person to support the Data Base in Technical areas of format development, investigator interaction, and data receipt. The first 18 months concentrated on establishing working formats, Investigator support in data processing, and designing management files to track the data anticipated by the OCSEA Program. The next phase identified a potential for an extended delay in data receipt and a data processing facility was established in

Anchorage. A substantial portion of the backlog of digital data was completed in nine months of operation of that facility. The guidance given this renewal proposal stipulated a shift to data checking and project office support.

V. Objectives

This research unit (couples to RU 370, University of Alaska, Arctic Environmental Information and Data Center) has the primary objectives of assisting the data gathering components in delivering timely and accurate environmental information, of assisting the Data Base in checking and certifying quality digital data, and of supporting the OCSEAP offices in Juneau, Fairbanks and Boulder. In each of these three activities, the research unit proposes to insure the continued flow of information to the OCSEA Program by giving technical assistance in data processing. As one component of the OCSEAP Data Base, the activities directly support the information base in the decision making process of offshore oil and gas development.

VI. General Strategy and Approach

Five basic tasks have been identified to meet the objectives of these research units. These tasks are (1) Consulting services to principal investigators, (2) Data entry, (3) Data checking activities in support of the ~~to~~ project offices ~~support~~, (4) Initial processing of data received by the OCSEAP Data

Base, and (5) Data product support to Boulder in responding to BLM requests. It is proposed that RU 497 (Crane) concentrate on tasks (1) and (5) and that RU 370 (AEIDC support) divide ~~three~~ two and a half ~~man~~ years of effort on tasks (2), (3) and (4). WTF 10/11/77

The tasks identified as (1), (2) and (3) will be ~~at the request of and responsive to~~ in cooperation with the Juneau and Fairbanks offices. WTF 10/11/77 Task number (4) will be jointly an NODC/AEIDC activity and task (5) will be supervised by the Boulder OCSEAP office. Conflicts between these tasks will be brought to the attention of Dr. W. Fischer for resolution.

The research unit 497 will continue as a Liaison function with emphasis on consulting services for principal investigators. The Research Unit 370 will provide the data processing capability to accomplish the data entry support, the data checking and the initial processing for the OCSEAP data base. The staffing of Research Unit 370 depends on the time and volume constraints required by the OCSEA Program.

Concerning research unit 370, the University proposes to staff a data processing facility to assist in the certification of data. The data entry task will concentrate on forms design, methods of coding, limited keyentry and assistance to RU 497 for task (1). The data checking activity will use local computer facilities in certifying format compliance, data inventories and data summaries.

The style and content of the output of data checking activities will be negotiated with the Juneau and Fairbanks offices. It is anticipated that all data from the OCSEA Program delivered for checking will be assigned a priority by the project offices. All correspondence concerning data parameters, inventory summaries or status will fall under this section of the activities.

The initial processing of the data ~~for the Data Base~~ carried out by the Anchorage Processing Center will be coordinated with the NODC and the handling of will be determined by the requirements of the Data ~~Base~~ Center. ~~Because scheduling of this activity is dependent on Data Base priorities, all data processing control will rest with research unit 362~~.

WTF 10/11/77

It is anticipated that all reports will be generated by the Data Base and no status reports will be generated by RU's 497/370 for this activity (4). A summary will be attached to the quarterly and annual reports of research unit 362.

The principal advantages of an OCSEAP processing facility are control of data delivery schedule, data checking, direct investigator support, and a quick response team to solve data management problems.

VII. Sampling Methods

Not applicable

VIII. Analytical Methods

Not applicable

IX. Anticipated Problems/Recommended Solutions

1) To provide the necessary access to data check programs, telecommunication capability must be established between Anchorage and the Data Base. To date, no telecommunication lines have been installed in the Anchorage Processing Office.

1) Solution: Request GSA Region X install data telecommunications lines.

2) Data checking programs must be developed and delivered to Anchorage or access to existing computer programs with

Remote Job Entry equipment.

2) Solution: Install ADP hardware for high volume data transmission, such as Remote Job Entry hardware.

Both of these problems can be minimized by installing an FTS telecommunication line in Anchorage and installing adequate Remote Job Entry equipment to meet the requirements of data checking and certification. ADP procurement procedures may complicate these installations dramatically.

It is anticipated that all software be delivered for local computer facilities and that no major telecommunication equipment will be installed this fiscal year. Any delay in delivery of data checking software or data inventories software will decrease the volume of checking and increase the time required to develop adequate inventories and summaries.

For the data processing assistance to the data base, it is anticipated that operating manuals, inventory file formats and media configurations will be specified in advance by the Data Base. Delay in delivery would cause an increase in start-up time.

X. Deliverable Products

A. Digital Data

No data generated by the research unit.

B. Narrative Reports

Quarterly and annual reports plus periodic status reports will be delivered in partial fulfillment of this agreement.

C. Visual Data

Not applicable

D. Other Non Digital Data

Not applicable

E. Data Submission Schedule

Not applicable

XI. Information Required from Other Investigators

Adequately coded digital data or coding forms are required of other investigators when keyentry service is to be provided.

Properly annotated data sets are required when computer compatible media are delivered.

From RU 362, guidance on data processing steps and scheduling would be required. Manuals and operating guides would be required.

XII. Quality Assurance Plans

Not applicable

XIII. Special Sample and Voucher Specimen Archival Plans

Not applicable

XIV. Logistics Requirements

No OCSEAP supported logistics are required. Logistics provided by the investigator's agency or provided by the University of Alaska for RU 370 will depend on the anticipated requirements of supporting the OCSEAP management in data certification, data product development and management information networking. Current ADP equipment provides keyentry capability, low volume unit-record transmission and limited file capability. As complexity/volume constraints increase, either time delays will occur or the necessary hardware must be installed to meet the specific requirements.

Considering only the technical support by RU 370 and the activities of RU 497, data processing equipment is needed to accomplish the tasks of data entry, project office support in data checking, initial processing of data by the OCSEAP Data Base and BLM data product support. The keyentry task will be handled by a lease of IBM 3741 equipment in the initial phase and replaced by discette-based, intelligent entry equipment. To have access to the data inventory files, a telecommunications line connected to an interactive graphics terminal would be installed to support the BLM data product support. The intelligent entry equipment will provide the means to enhance the data checking and initial processing of environmental data.

XV. Management Plan

The processing facility will be managed by the Principal Investigator on a daily contact basis. The Research Unit 497 provides the technical and administrative guidance to Research Unit 370 (processing facility proper). The Principal Investigator is under the direct supervision of the chief, Special Projects Branch, National Oceanographic Data Center.

The performance of RU 370 will be monitored using critical path analysis, and data processing will be analyzed using queuing theory algorithms. Status reports to the OCSEAP management will provide the necessary management oversight to the data processing activity. In addition to quarterly reports, copies of monthly reports will be available to OCSEAP management.

XVI. Outlook

1. Develop data product interface to users from the Data Base.
2. a. Interactive data access to OCSEAP data files, 1 October 78.
   b. Data analysis programs developed to support investigators 1 March 1979.
3. FY 79 $105k labor plus hardware costs
   FY 80 $115k labor plus hardware costs.
4. Remote Job Entry and Direct Data Entry equipment.
5. Not applicable
6. Not applicable

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher speciments that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office, the P. I. is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfacotry to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U. S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following standard acknowledgement is acceptable.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) office."

MILESTONE CHART

RU #: ____________________ PI: ____

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Completion of back log keyentry 15%			1												
Completion of keyentry for Arctic P.I.'s 35%													1		
Installation of FTS phone line -0-	1														
Installation Interactive terminal 10%		1													
Installation of High Volume transmitting hardware 5%					1										
Programmer training completion Fortran 5%								1							
Access to Powerful Software															
a. local			1												
b. central Data Base					1										
Utilization of Equipment with above software 25%						1									
Record keeping (continuous)	1	through											1		

A. Modeling Algorithms for the Weathering of Oil in the Marine Environment

Research Unit 499

Renewal Proposal from the
Marine Assessment Division
Center for Experiment Design and Data Analysis
Environmental Data Service
National Oceanic and Atmospheric Administration
Washington, D. C. 20235

to the

Outer Continental Shelf Environmental Assessment Program
Environmental Research Laboratories
National Oceanic and Atmospheric Administration
Bering Sea - Gulf of Alaska Project Office
Juneau, Alaska 99802

for the period
October 1, 1977 - September 30, 1978

Principal Investigator

Dr. James S. Mattson
Physical Scientist
(202) 634-7379

Proposed Cost

$29,000

Date Submitted

July 1, 1977

Thomas S. Austin
Director, Environmental Data Service

The Center for Experiment Design and Data Analysis supports RU #499 primarily with computing hardware, an interactive graphics system, and specialized system software. The CEDDA computing facility is capable of identically simulating the system employed by RU #140 (Dr. Jerry Galt, P.I.) at NOAA/PMEL in Seattle. Additional support, necessary for the type of literature surveying conducted under RU #499, is available at no cost to the project from the Environmental Data Service's "OASIS" system, an on-line literature retrieval system maintained by EDS.

C. Technical Proposal

I. Title: Modeling Algorithms for the Weathering of Oil in the Marine Environment

Research Unit Number: 499

Proposed Dates: October 1, 1977 - September 30, 1978

II. Principal Investigator: James S. Mattson, Ph.D.

III. Cost of Proposal: FY 1978

Total: $29,000

D. Distribution of Effort by Lease Area: Non-specific

IV. Background:

Prediction of the physical movement of possible oil spills constitutes a major objective of the Alaskan Outer Continental Shelf Environmental Assessment Program. The oil trajectory prediction research effort was initially focussed by Dr. Jerry Galt (RU #140) and co-workers of NOAA's Pacific Marine Environmental Laboratory, and was restricted to two-dimensional transport of oil at the sea-air interface. The emphasis on two-dimensional transport was not based on any misunderstanding of the problem, but was a conscious choice based upon an acknowledgment of the complexity of the overall oil transport problem. After the two-dimensional modeling program approached operational status in 1976-77, the present research (RU #499) was initiated on February 1, 1977 to examine the physical, chemical, and biological processes that alter the composition of surface oil slicks and result in oil movement into the atmosphere, the water column, sediments, and the biosphere. Collected under the single appellation of "weathering," these processes have been divided into five general headings; i) interactions with suspended sediments, ii) evaporation and dissolution, iii) emulsification, iv) photo- and autooxidation, and v) microbial degradation of oil.

We acknowledged that the incorporation of many of the known weathering processes in a grandiose attempt at three-dimensional modeling of oil movement would be difficult because of a) a substantial lack of requisite field or laboratory data on rates and mechanisms, and b) potential overwhelming of computing capabilities resulting from inefficient algorithms. We then proposed that an independent evaluation of potential weathering algorithms be conducted by NOAA's Center for Experiment Design and Data Analysis, with recommendations to be made, based upon state-of-the-art theories and available data, to Dr. Galt's research program (RU #140).

Along with the initiation of the weathering algorithm research program (RU #499), and in conjunction with the two-dimensional modeling program at PMEL (RU #140), the Spilled Oil Research (SOR) Team program (P #102) was initiated under OCSEAP sponsorship. Both principal investigators, Dr. Galt and Dr. Mattson, as primary users of SOR Team data, have assumed major roles in the direction of the SOR Team's research objectives, Dr. Galt directing the Team's efforts to acquire trajectory and physical data, Dr. Mattson directing the efforts to obtain weathering, accommodation, and chemical data.

During its first year, RU #499 (weathering) is to produce five topical reports, along the lines of the five areas into which weathering processes were divided, as well as a proposal for field and laboratory studies to be conducted by other research units and the SOR Team. Some of these topical reports; in particular, "evaporation" and "interaction with suspended sediments," contain algorithms suited for immediate implementation. The remaining topical reports will carry descriptions of state-of-the-art theoretical and/or empirical approaches to emulsification and the three principle oxidative processes; photooxidation, autooxidation, and microbial degradation. The research recommendations prepared during the first year are to address the major weathering processes and prioritize them in such a way as to maximize the usefulness of research results in improving three-dimensional modeling results.

The work proposed for FY 78 involves finishing the 12-months of research outlined in the initial proposal, and to upgrade those topical reports produced under the original guidelines so that each process can be directly implemented in the modeling effort at PMEL. RU #499 will continue a high level of participation in and scientific guidance of the activities of the SOR Team, and assist OCSEAP in the initiation and monitoring of field and laboratory research activities supporting the modeling of weathering processes.

V. Objectives:

The objectives of RU #499 during FY 1978 are:

1. to provide documented and tested algorithms to the OCSEAP oil spill trajectory modeling program (RU #140), and to review and upgrade those submitted in FY 1977, that will represent the state-of-the-art in each of the identifiable pathways under the collective appellation of "weathering" and

2. to identify specific areas of field and laboratory research which offer promise of improving the validity of weathering modeling algorithms in the near-term, and

3. to work with the two- and three-dimensional modelers in prioritizing the field and laboratory research, and to assist in the preparation of work statements, requests for proposals or other management needs in guiding this research.

Specifically, the processes to be addressed during FY 1978 include:

1. Emulsification. There are two emulsification algorithms needed; the formation of oil-in-water emulsions (micelle formation) and the formation of "mousse." The latter has been the object of most research and will probably be the first of the two to reach the algorithm stage.

A considerable amount of fundamental physical chemistry has been applied to micelle formation, and this problem should yield to a concentrated study. The fact that hydrocarbons are often found at levels exceeding their solubility in water beneath oil implies that micelle formation is a topic that needs a careful examination. As the micelle algorithm is developed, a need will arise to make the nonlinear correction to the oil-sediment interaction algorithm produced in FY 1977, taking into account the interaction between suspended sediments and micelles.

2. Photooxidation and autooxidation. These pathways could be minor when the losses from a surface slick are considered, but when one considers that the reaction products can often act as surfactants, the oxidation processes gain added significance. It takes a relatively small amount of a surfactant to emulsify an oil slick, so these processes need to be included until we have proof to the contrary.

3. Microbial degradation. Certainly the least subject to mathemathical description, microbial degradation is the key to weathering over the long term. Thus it must be modeled. The products of microbial degradation also influence emulsification and dissolution, as do the other oxidative pathways.

Those processes which have been modeled, at least preliminarily, and will be produced as finished algorithms during FY 1977, include:

1. Interaction of surface slicks with suspended sediments. A draft of a simplified approach to this process is attached. During FY 1977, this algorithm will be expanded to include actual subsurface mechanisms, rather than an empirical approach.

2. Evaporation and spreading. As physical chemical processes, these pathways have reached the highest level of sophistication to date. These processes are addressed in the accompanying draft topical report, which develops an approach to describe the physical behavior of an oil slick as a function of evaporation, the "skinning" effect observed in many spills, and the process of "differential spreading."

Both of the above topics will be reexamined during the FY 1978 renewal period, in order to assess their compatability with newly-produced algorithms, as well as take advantage of new information.

VI-IX. Not applicable

X. Deliverable Products

The report on each algorithm will contain the theory behind each pathway, documentation of the theory as well as any constants necessary PDP-11-compatible subroutines for implementing the effect in the OCSEAP (RU #140), and graphical output demonstrating its use and range of effect.

XI-XV. Not applicable

XVI. Outlook

By FY 1979, it is highly likely that we will find ourselves driven to the acquisition of new field and laboratory data to add veracity to the three-dimensional modeling algorithms developed during FY's 1977-78. The field and laboratory phase of this research should realistically be estimated to require on the order of at least $300,000 per year for three fiscal years.

XVII.

1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office, the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard.

> "This study was support by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

PUBLICATIONS

BOOKS

1. 1971 J. S. Mattson and H. B. Mark, Jr., ACTIVATED CARBON: SURFACE CHEMISTRY AND ADSORPTION FROM SOLUTION, Marcel Dekker, Inc., New York, 248 pp.

2. 1972 J. S. Mattson, H. B. Mark, Jr. and H. C. MacDonald, Jr., Editors, COMPUTERS IN CHEMISTRY AND INSTRUMENTATION, Marcel Dekker, Inc., New York.

   Volume 1 - COMPUTER FUNDAMENTALS FOR CHEMISTS, 376 pp, 1973.

   Volume 2 - ELECTROCHEMISTRY: CALCULATIONS, SIMULATION, AND INSTRUMENTATION, 480 pp, 1972.

   Volume 3 - SPECTROSCOPY AND KINETICS, 376 pp, 1973.

   Volume 4A- COMPUTER ASSISTED INSTRUCTION IN CHEMISTRY: GENERAL APPROACH, 288 pp, 1974.

   Volume 4B- COMPUTER ASSISTED INSTRUCTION IN CHEMISTRY: APPLICATIONS, 258 pp, 1974.

   Volume 5 - LABORATORY SYSTEMS AND SPECTROSCOPY, 304 pp, 1977.

   Volume 6 - COMPUTER APPLICATIONS IN POLYMER CHEMISTRY, 392 pp, 1977.

   Volume 7 - INFRARED, FOURIER TRANSFORM, AND CORRELATION SPECTROSCOPY (*in press*).

3. 1977 P. L. Grose and J. S. Mattson, Editors, THE ARGO MERCHANT OIL SPILL: A PRELIMINARY SCIENTIFIC REPORT, National Oceanic and Atmospheric Admin., March, 1977.

4. 1977 H. B. Mark, Jr. and J. S. Mattson, Editors, WATER QUALITY: THE CHEMICAL POINT OF VIEW, Marcel Dekker, Inc., New York.

   Volume 1 - RECENT ADVANCES IN ANALYTICAL METHODOLOGY (*in press*).

Technical Papers

1. 1967 B. S. Pons, J. S. Mattson, L. O. Winstrom and H. B. Mark, Jr. "Application of deposited thin metal films as optically transparent electrodes for internal reflection spectrometric observation of electrode-solution interfaces" *Analytical Chemistry*, 39, 685-688.

2. 1969 J. S. Mattson, H. B. Mark, Jr. and W. J. Weber, Jr. "Identification of surface functional groups on active carbon by internal reflection spectrophotometry" *Analytical Chemistry*, *41*, 355-358.

3. J. S. Mattson and H. B. Mark, Jr. "Application of internal reflectance spectroscopy to water pollution analyses." *Environmental Science and Technology* 3, 161-164.

4. H. B. Mark, Jr., U. Eisner, J. M. Rottschafer, F. J. Berlandi and J. S. Mattson. "Application of semipermeable ion exchange membranes to the *in situ* analysis of trace metal ions in aqueous systems by electrochemical and thermal neutron activation techniques." *Environmental Science and Technology*, 3, 165-168.

5. J. S. Mattson, H. B. Mark, Jr., M. D. Malbin, W. J. Weber, Jr. and J. C. Crittenden. "Surface chemistry of active carbon: Specific adsorption of phenols." *Journal of Colloid and Interface Science*, *31*, 116-130, Addendum published, *Journal of Colloid and Interface Science*, *48*, 181 (1974).

6. J. S. Mattson and H. B. Mark, Jr. "Infrared internal reflectance spectroscopic determination of surface functional groups on carbon." *Journal of Colloid and Interface Science*, *31*, 131-144.

7. J. S. Mattson, J. C. Crittenden and H. B. Mark, Jr. "Determination of ^{16}O in microcrystalline carbon by indirect neutron activation analysis." *Nuclear Application and Technology*, *7*, 383-384.

8. 1970 J. S. Mattson, H. B. Mark, Jr. and W. J. Weber, Jr. "Investigation of optically dense systems by internal reflection spectroscopy; experimental considerations." In DEVELOPMENTS IN APPLIED SPECTROSCOPY, Vol. 8 (Ed. by E. L. Grove), pp. 91-104, Plenum, New York.

9. J. S. Mattson, H. B. Mark, Jr., R. L. Kolpack and C. E. Schutt. "A rapid, non-destructive technique for the identification of crude oils by internal reflection spectrometry." *Analytical Chemistry*, *42*, 234-238.

10. J. S. Mattson, L. Lee, H. B. Mark, Jr. and W. J. Weber, Jr. "Surface oxides of activated carbon: Internal reflectance spectroscopic examination of activated sugar carbons." *Journal of Colloid and Interface Science*, 33, 284-293.

11. 1971 J. S. Mattson, H. B. Mark, Jr., A. Prostak and C. E. Schutt. "Application of an infrared spectroradiometer for remote detection and identification of oil slicks on water." *Environmental Science and Technology*, 5, 415-420.

12. B. D. Epstein, E. Dalle-Molle and J. S. Mattson. "Electrochemical investigations of surface functional groups on isotropic pyrolytic carbon." *Carbon*, *9*, 609-615.

13. J. S. Mattson and F. W. Kennedy. "Evaluation criteria for granular activated carbons." *Journal of the Water Pollution Control Federation*, *43*, 2210-2217.

14. J. S. Mattson and A. C. McBride III. "Digital data acquisition from a Hilger-Watts H-1200 infrared spectrophotometer." *Analytical Chemistry*, *43*, 1139-1141.

15. J. S. Mattson. "Fingerprinting oil by infrared spectrometry." *Analytical Chemistry*, *43*, 1872-1873.

16. R. L. Kolpack, J. S. Mattson, H. B. Mark, Jr. and T. C. Yu. "Hydrocarbon content of Santa Barbara Channel sediments" in BIOLOGICAL AND OCEANOGRAPHIC SURVEY OF THE SANTA BARBARA CHANNEL OIL SPILL 1969-70, Vol. II, Ed. by R. L. Kolpack, Allen Hancock Foundation, University of Southern California, 1971, pp. 276-295, 385-389.

17. 1972 A. D. Foord, H. Marsh, J. S. Mattson and J. M. Thomas. "Kinetic and spectroscopic study of surface oxides formed on carbon surfaces by atomic oxygen." In PROCEEDINGS OF *CARBON '72* Deutsche Keramische Gesellschaft E. V., Koln, Germany, p. 53.

18. H. B. Mark, Jr., T. C. Yu, J. S. Mattson and R. L. Kolpack. "Infrared estimation of oil content in sediments in presence of biological matter." *Environmental Science and Technology*, *6*, 833-834.

19. 1973 J. S. Mattson. "Application of thin metal and carbon films in infrared internal reflectance spectrometry." *Analytical Chemistry*, *45*, 1473-1477.

20. J. S. Mattson and C. A. Smith. "Enhanced protein adsorption at the solid/solution interface: Dependence on surface charge." *Science*, *181*, 1055-1057.

21. J. S. Mattson. "Preparation of granular activated carbons from petroleum residues." *Industrial and Engineering Chemistry Product Research & Development*, *12*, 312-317.

22. J. S. Mattson. "Oil spill identification," *Environmental Science and Technology*, *7*, *1151*.

23. 1974 J. S. Mattson and C. A. Smith. Reply to Technical Comment, "Surface Charge, Protein Adsorption and Thrombosis," by L. Vroman, *Science*, *184*, *586*.

24. J. S. Mattson, C. A. Smith, T. T. Jones, S. M. Gerchakov and B. D. Epstein. "Continuous Monitoring Of Dissolved Organic Matter By UV-Visible Photometry," *Limnology and Oceanography 19*, 530-535.

25. H. Marsh, A. D. Foord, J. S. Mattson, J. M. Thomas and E. L. Evans. "Surface Oxygen Complexes On Carbons From Atomic Oxygen: An Infrared (IRS), High Energy Photoelectron Spectroscopic (XPS) And Thermal Stability Study," *Journal of Colloid and Interface Science*, *49*, 368-382.

26. 1975 J. S. Mattson. "Computerized Infrared Spectroscopy," *Industrial Research*, *17*, 56-59.

27. J. S. Mattson, C. A. Smith and K. E. Paulsen. "Infrared Internal Reflection Spectrometry Of Aqueous Protein Films At The Germanium-Water Interface," *Analytical Chemistry*, *47*, 736-738.

28. C. A. Smith and J. S. Mattson. "Infrared Internal Reflection Spectroelectrochemical Study Of Calcareous Deposits At The Cathode In Sea Water," *Corrosion Science*, *15*, 173-181.

29. J. S. Mattson and C. A. Smith. "Optically Transparent Carbon Film Electrodes For Infrared Spectroelectrochemistry," *Analytical Chemistry*, *42*, 1122-1125.

30. 1976 J. S. Mattson and C. E. Schutt. "Application Of Digital Minicomputers In Color Matching," in COMPUTERS IN CHEMISTRY AND INSTRUMENTATION, Volume 5, J. S. Mattson, H. B. Mark, Jr. and H. C. MacDonald, Jr., Eds. Marcel Dekker, Inc., New York, pp. 141-155.

31. J. S. Mattson. "Exchange of Comments: Systems Chemical Analysis Of Petroleum Pollutants," *Analytical Chemistry*, *48*, 2022-2023.

32. J. S. Mattson and T. T. Jones. "Infrared Spectrophotometric Observations Of The Adsorption Of Fibrinogen From Solution At Optically Transparent Carbon Film Electrode Surfaces," *Analytical Chemistry*, *48*, 2164-2167.

33. 1977 J. S. Mattson, C. S. Mattson, M. J. Spencer and S. A. Starks. "Multivariate Statistical Approach To The 'Fingerprinting' Of Oils By Infrared Spectrometry," *Analytical Chemistry*, *49*, 297-302.

34. J. S. Mattson, "Design And Applications Of An On-Line Minicomputer System For Dispersive Infrared Spectrophotometry," *Analytical Chemistry*, *49*, 470-478.

35. J. S. Mattson, C. S. Mattson, M. J. Spencer and F. W. Spencer. "Classification of Petroleum Pollutants Using Linear Discriminant Function Analysis of Infrared Spectral Patterns," *Analytical Chemistry*, *49*, 500-502.

36. J. S. Mattson and C. A. Smith. "An on-line minicomputer system for infrared spectrophotometry," in COMPUTERS IN CHEMISTRY AND INSTRUMENTATION, Volume 7, J. S. Mattson, H. B. Mark, Jr., and H. C. MacDonald, Jr., Eds. Marcel Dekker, Inc., New York, pp. 71-118.

37. J. S. Mattson. "Statistical Considerations of Oil Identification by Infrared Spectroscopy," in "Proceedings, Workshop on Pattern Recognition Applied in Oil Identification," November 11-12, 1976, Coronado, CA. (*in press*).

38. J. S. Mattson, "Petroleum Hydrocarbon Analysis in the Marine Environment: Analytical and Statistical Considerations," in "Proceedings, NBS-EPA Workshop on SRMs for Offshore Drilling-Petroleum," NBS Spec. Pub., Washington, D.C. (*in press*).

39. T. P. DeAngelis, R. W. Hurst, A. M. Yacynych, H. B. Mark, Jr., W. R. Heineman and J. S. Mattson. "Carbon and Mercury-Carbon Optically Transparent Electrodes," *Analytical Chemistry* (*in press*).

40. J. S. Mattson. "State-federal relationships on OCS oil and gas development," submitted to *The Environmental Law Reporter*.

41. T. T. Jones and J. S. Mattson. "The Effect of Amino Acids on the Crystal Growth of $CaCO_3$ and Their Posulated Role in the Shell Growth of Calcareous Organisms," submitted to *Geochimica et Cosmochimica Acta*.

APPENDIX I

DRAFT REPORT

MODELING ALGORITHMS FOR THE WEATHERING OF OIL IN THE MARINE ENVIRONMENT

I. AN EMPIRICAL APPROACH TO THE INTERACTION OF OIL WITH SUSPENDED SEDIMENTS

by

JAMES S. MATTSON

Center for Experiment Design and Data Analysis
National Oceanic and Atmospheric Administration
Washington, D.C.

Topical Report under:

Research Unit #499
Outer Continental Shelf Environmental Assessment Program
National Oceanic and Atmospheric Administration

Submitted to:

Research Unit #140

Dr. Jerry Galt, Principal Investigator
Pacific Marine Environmental Laboratory
National Oceanic and Atmospheric Administration
Seattle, WA

July 1, 1977

Kolpack and Plutchak (1976) divide the marine environment into five major reservoirs for convenience in modeling the fate of an oil spill, including the water surface, the water column, the atmosphere, the sediments, and the near-shore regime. Only the first two reservoirs will be of interest to us in this analysis. For reasons that will become apparent, Kolpack and Plutchak (1976) include the upper portion of the water column, to a maximum depth of 10 meters, in their definition of the "water surface" reservoir. By including that slice of the water column in the surface reservoir, it is possible to empirically model the interaction of a surface oil slick with subsurface suspended particulate matter without considering the processes which govern transport of oil downward from the actual sea surface. Such an approach acknowledges the paucity of data available to model the downward flux.

An oil slick is most likely to be significantly affected by suspended sediments in coastal regimes impacted by rivers or glacial streams. Suspended sediments associated with these freshwater plumes are at their highest concentrations in the upper few meters of the water column as the plume spreads seaward. Thus the inclusion of the entire turbid layer in the surface reservoir. Drake et al. (1972) found that the turbid surface layer produced by floods during the Santa Barbara Channel blowout in 1969 varied from 10 to 20 meters thick off the mouth of the Santa Clara River. Investigators working in Port Valdez, Alaska reported turbid surface layers varying between 2 and 10 meters in thickness (Sharma and Burbank, 1973). To compute the removal of oil from the surface one needs to know, besides the area of the turbid surface layer covered by a surface oil slick and the depth of the layer, the "sorption" capacity of the suspended particulate matter present in the turbid layer.

The sorption capacity of suspended particulate matter depends on physical and chemical characteristics of the material; i.e., grain size, composition, porosity, and organic content. After the Santa Barbara Channel oil spill, concentrations of oil measured in the bottom sediments ranged from less than 200 up to 19,500 μg/g (dry weight), with the median for 352 samples analyzed being 1,630 μg/g (Kolpack et al., 1971; Mark et al., 1972). DiSalvo and Guard (1975), measuring hydrocarbon concentrations in the *suspended* sediments of San Francisco Bay, found concentrations ranging from 190 to 6,188 μg/g, with a mean level of 1,176 μg/g. DiSalvo and Guard (1975) also report that the average level of total hydrocarbons in Bay sediments was 1,588 μg/g. Wide variations, as reported by the above investigations, are expected as a consequence of varying sediment composition, grain size, the patchy distribution of oil during an oil spill, and so on. In both of the studies mentioned above, the suspended sediments involved were predominantly clay minerals (Drake et al., 1971; DiSalvo and Guard (1975), citing Storrs et al., 1969).

In laboratory studies, Meyers and Quinn (1973) measured sorption capacities for natural sediments from Narragansett Bay, seived only to <44μ, ranging from 3 to 12 μg/g for hexadecane (n-$C_{16}H_{34}$), to a maximum of 176 to 435 μg/g for eicosane (n-$C_{20}H_{42}$). An increase in adsorption capacity with increasing molecular weight of a hydrocarbon might be expected from Traube's Rule consi-erations (Adamson, 1967), but the low sorption capacity reported by Meyers and Quinn (1973) for hexadecane seems out of line with the above-mentioned studies. This may well be a result of several competing effects, including agglomeration of particles during drying and the fact that the sediments were not "fresh;" i.e., were not recently terrigeneous origin. The presence of organic matter in the sediments also served to decrease the capacity for the natural sediment to sorb hydrocarbons. Meyers and Quinn (1973) reported laboratory experiments where [unreported quantities of] clay minerals (<44μ) were added to an aqueous emulsion of No. 2 fuel oil. From their reported data, Meyers and Quinn (1973) infer that bentonite sorbs twice as much oil as does kaolinite, which in turn sorbs twice that of illite, which sorbs three to four times more oil than does montmorillonite (bentonite > kaolinite > illite > montmorillonite). The immediate question to be addressed to their results comes from the observation that "bentonite" is predominantly comprised of montmorillonite (Wells, 1962). It is suggested that the variations in sorptive capacities of the several clay minerals, as reported by Meyers and Quinn (1973), are related more to particle size distribution than to composition.

Poirier and Thiel (1941) conducted a drastic, analog of the proposed empirical model. They mixed one gram of <125μ sediment, 2.15 g of crude oil, and 200 ml of artifical sea water ("suspended" sediment concentration = 5,000 mg/l) in a blender for periods ranging from 5 to 30 minutes. The quantity of oil employed, if completely sorbed, would yield a sorption capacity of 680,000 μg/g. In fact, they (Poirier and Thiel, 1941) reported capacities of anywhere from 150,000 to 390,000 μg/g after five minutes of mixing, and 520,000 to 630,000 μg/g after thirty minutes of mixing. In a similar experiment, Hartung and Klinger (1968) found that 10,000 mg/l of diatomaceous earth could sediment 80,000 μg/g of "white oil" in 3% NaCl, and up to 320,000 μg/g in distilled water.

The significant aspects of studies of oil sorption capacities for various minerals can be summarized as follows: i) oil sorption is inversely related to particle size; i.e., proportional to surface area, ii) for clay minerals, oil sorption capacities on the order of 200 to 1,500 μg/g are not unreasonable as *a priori* estimates, and iii) either a low porosity (i.e., quartz sediment) or a high (>1%) organic content can cut the sorption capacity of even fine-grained sediments by a factor of two (Meyers and Quinn, 1973; Meyers, 1976).

The next step is an analysis by example of the proposed approach to the interaction of oil with suspended sediments. If one knows the depth of the turbid surface layer and the mean suspended sediment concentration over that layer, the approach is straightforward. If there is no distinct surface layer, but only a low background level of suspended sediments over the entire water column, it seems reasonable initially to follow Kolpack's (1977) lead and establish a cutoff for the surface layer somewhere between zero and 10 meters, depending on sea state. For the first example, using the suspended sediment data for the Santa Barbara Channel during the 1969 blowout (Drake et al., 1972), one obtains the following.

Example 1.

For a 10-meter surface layer, an average suspended sediment concentration of 7 mg/l, and a sorptive capacity of 1,000 μg/g, each square kilometer of the sea surface reservoir should remove 7.0×10^4 g of oil by "sorption."

As a second example, using Sharma and Burbank's (1973) data for maximum concentrations of suspended sediments in Port Valdez, Alaska, one calculates the following interaction.

Example 2.

In early September of 1972, average concentrations of suspended sediments were on the order of 150 mg/l, and the turbid surface layer was only 2 meters thick. Using a sorption capacity of 1,000 μg/g, each square kilometer could sorb 3.0×10^5 g of oil.

As Port Valdez has an area of about 95 km^2, its total "instantaneous" sorption capacity would be about 28.5 metric tons under maximum suspended sediment conditions.

In example 2, the data taken from Sharma and Burbank's (1973) report represent the highest level of suspended sediments observed during their study. In situations similar to either of the above examples, where river input of terrigenous sediments is high, the capacity of the sea surface reservoir to remove oil by sorption is being continually renewed. For example, during the September 1972 sampling period in Port Valdez (Sharma and Burbank, 1973), the sediment input from the Lowe River was about 1.1 x 10^4 metric tons/day. An oil slick that intersected the plume of the Lowe River during such a high-flow period could lose 11 metric tons of oil per day to sorption on the Lowe River-introduced sediments alone. However, during November 1972, the Lowe River flow was low (22 m^3/sec) as was the suspended sediment load (60 mg/l). An oil spill during such a low-flow period would experience maximum sediment-sorption losses of only 0.14 metric tons (140 kg) per day.

To compare this approach with the only oil spill-related suspended sediment data in the literature to date, we turn again to the survey conducted by Drake et al. (1972) after the 1969 Santa Barbara Channel oil spill. They report USGS data on water discharge and suspended sediment load for the Santa Clara River, as well as estimated discharges for the Ventura River, during 1969. The winter rains of 1969 fortuitously coincided with the oil spill in the Santa Barbara Channel, and the bulk of the river runoff into the Channel occurred while the oil was present on the sea surface. Approximately 50 million metric tons of sediments were input to the Channel from the Santa Clara

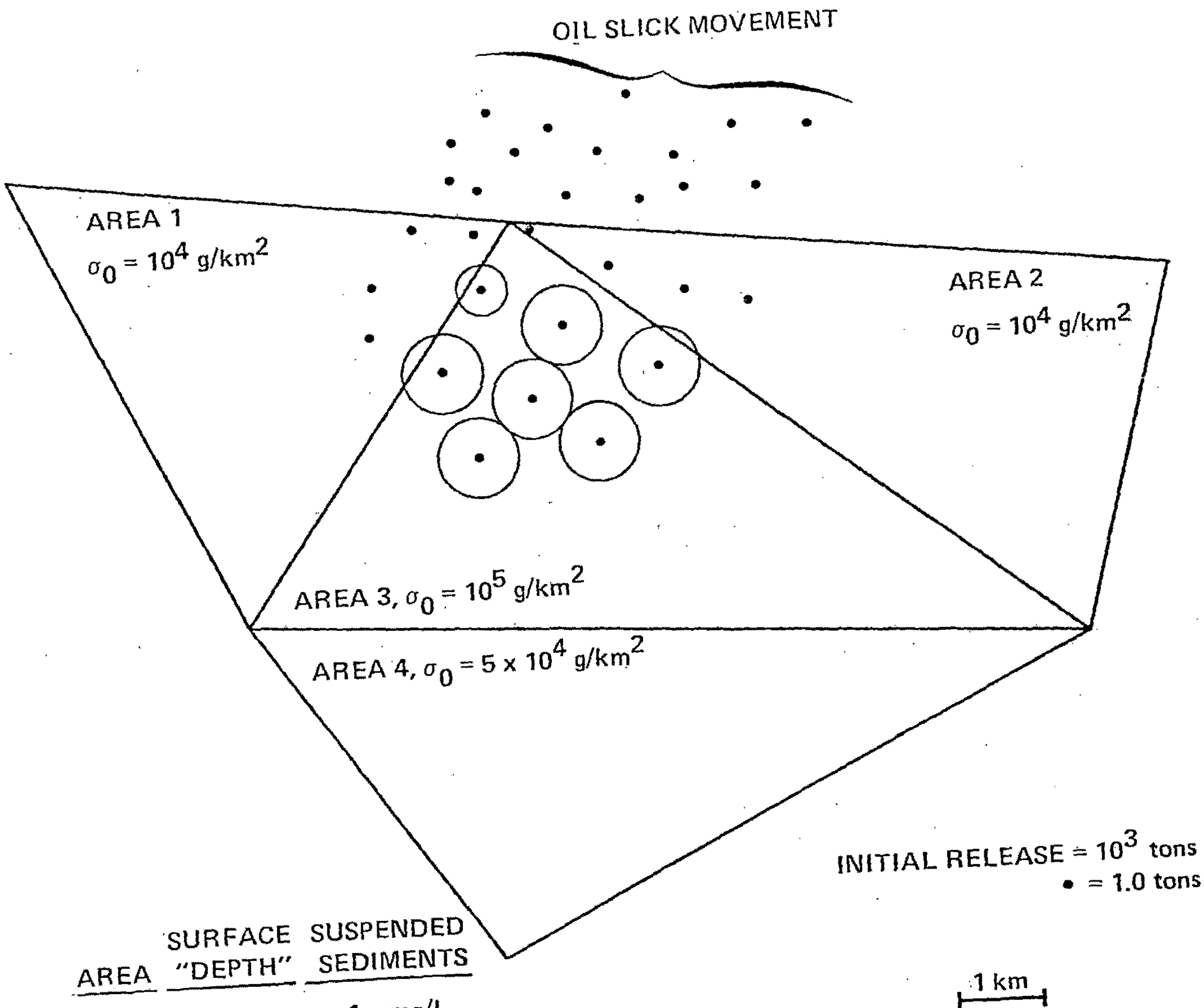
River during 1969, with 70% of the total entering the Channel on two days, January 25 (13 million tons) and February 25, 1969 (22 million tons) (Drake et al., 1972). The blowout occurred from January 28 to February 8, 1969. About 6 million tons of sediment were introduced to the Channel from the Ventura River, and approximately 9 million tons were introduced by numerous small creeks from Ventura to Point Conception (Drake et al., 1971). Drake et al. (1972) report U.S. Army Corps of Engineers data indicating that about one-third of the sediment discharge from the Santa Clara River settled out and formed a delta extending from 700 to about 2,000 meters offshore. The delta formation was due to the settling of the "sand" (>62μ) fraction of the river sediments, comprising 30 to 40% of the total. Assuming that similar settling of the sand fraction of the other suspended sediment inputs took place, about 40 million metric tons of predominantly (80-90%) clay minerals were input to the Channel during the winter of 1969 (Drake et al., 1971). Assuming a sorption capacity of 500 μg/g, the oil sorption capacity for this much sediment would be 20,000 metric tons. This exceeds the maximum estimates of the magnitude of the Santa Barbara Channel blowout, (15,000 tons) and is in accord with the opinion of some investigators (Kolpack, 1971, 1977; Kolpack et al., 1971) that the bulk of the oil was sedimented out by sorption on and flocculation with suspended sediments, ultimately becoming incorporated in the bottom sediments of the Channel.

This approach to oil sedimentation is most easily applied in two-dimensional surface slick trajectory modeling where the volume of a low-salinity surface layer is large compared to the rate of freshwater input, or where there exists a widespread "background" level of suspended sediments rather than a well-defined low-salinity plume. For such a situation, depending on the spatial inhomogeneity of the suspended sediment concentrations below the surface, the sea surface is divided into area elements, each element including a "slice" of the water column, representing either the turbid surface layer or some approximation of the mixed layer. Based either upon a priori assumptions or field observations, an initial sorption capacity, in g/km^2, is assigned to each area element. If sorption capacity data do not exist, a default initial capacity of either 250, 500, or 1,000 μg/g can be used, depending on the following criteria. If the sediments are likely to be fresh, highly-oxidized clay minerals, the higher sorption capacity is appropriate. A high percentage of quartz in the silt or clay particle size ranges, calls for a reduction in sorption capacity by a factor of two. The second factor that would call for the use of a lower capacity is the presence of a substantial concentration (i.e., >3-5 mg/l) of dissolved organic matter in the freshwater source of the suspended sediments. If substantial dissolved organic matter is known to be present, the default sorption capacity should be divided by two.

The intersection of the area of the oil slick with each area element must then be computed, as well as the mass of surface oil in each intersection. For example, if the two-dimensional oil slick model consists of 1,000 "dots" of oil, each initially representing identical mass, one way to avoid a conversion to an isopleth representation is to employ a nearest-neighbor approach to finding the area of intersection, in order to impute a mass loss to each dot based on the sorptive capacity of the area. Spreading the cumulative mass of all dots in the element over the entire area element might be acceptable under limited circumstances, but it seems preferable to minimize the area assumed to be represented by each dot in order to not accentuate the extent of sinking.

The nearest-neighbor approach involves computing the Euclidean distance between each dot in the area element and its nearest neighbor in the same or adjacent element. The mass of oil represented by that dot is then assumed to be spread uniformly over a circle with a radius equal to one-half the nearest-neighbor distance. Applying the sorptive capacity of the area element to the area now represented by the oil dot yields the mass change to be applied to the dot. Summing all of the mass losses gives the change to be applied to the sorptive capacity for the entire area element. Figure 1 is a graphical illustration of this procedure. The nearest-neighbor circles surrounding the seven dots in area 3 represent a combined area of about 4.4 km^2. For a sorption capacity, σ, of 10^5 g/km^2, the total oil mass loss in area 3 for this step amounts to 4.4×10^5 g. Apportioning the losses to the oil dots according to their respective areas, six of the dots each undergo a mass reduction of 6.9×10^4 g, and the seventh loses 2.7×10^4 g, out of initially equal masses of 10^6 g per dot. The sorption capacity of area 3 decreases by 4.4×10^5 g, which, when spread over the entire area (22.6 km^2), reduces σ for the next step to 8.0×10^4 g/km^2

This approach can be viewed as a steady-state model of the suspended sediment plume, ignoring water movement across area boundaries, and perturbed only by the presence of oil. Water movement does exist, but it is not reasonable to ascribe the same movement to the suspended sediments because, as the plume spreads away from its source, the concentration of suspended sediments within the plume decreases. This is due both to a decrease in water velocity, and an increase in salinity which causes double-layer compression around clay particles, resulting in flocculation and settling. Thus as long as the model is operating offshore, where the effect of incoming freshwater and suspended



AREA	SURFACE "DEPTH"	SUSPENDED SEDIMENTS
1	10 m	1 mg/l
2	10 m	1 mg/l
3	15 m	6.7 mg/l
4	15 m	3.3 mg/l

Figure 1. Sinking of an Oil Slick by Sorption on Suspended Sediments, using Empirical Algorithm and Nearest-Neighbor Approach to Area Intersection.

sediments is reduced by virtue of the large area of the plume, the steady-state approach should yield satisfactory results. Where the oil spill is approaching the source of the turbid plume, additional accounting for the source term, and for fluxes between adjacent "surface" area elements will have to be considered. Such nearshore processes have not been considered here.

The above approach to the process of sedimentation of oil spills is an oversimplification of the process, ignoring interface-crossing processes and substituting instantaneous flocculation and mixing for time-dependent models of those processes. Some behavioral aspects of oil slicks are acknowledged; the nearest-neighbor approach recognizing that central regions of oil slicks are thick and less reactive. The research recommendations due under RU #499 discuss many of the processes that were necessarily ignored in the empirical approach above, as well as outline a laboratory and field research program intended to provide necessary rate and mechanistic data in an expeditious manner.

References

Adamson, A. W., 1967. The Physical Chemistry of Surfaces, 2nd Ed., Inter-Science, New York.

DiSalvo, L. H. and H. E. Guard, 1975. "Hydrocarbons associated with suspended particulate matter in San Francisco Bay waters," Proc., 1975 Conference on Prevention and Control of Oil Pollution, San Francisco, Amer. Petrol. Inst., Wash., D.C., pp. 169-173.

Drake, D. E., P. Fleischer and R. L. Kolpack, 1971. "Transport and deposition of flood sediment, Santa Barbara Channel, California," in R. L. Kolpack, Ed., Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970, Vol. II, Physical, Chemical and Geological Studies, Allan Hancock Foundation, Univ. of Southern Calif., Los Angeles, pp. 181-217.

Drake, D. E., R. L. Kolpack and P. J. Fleischer, 1972. "Sediment transport on the Santa Barbara-Oxnard Shelf, Santa Barbara Channel, California," in Swift, Duane and Pilkey, Eds., Shelf Sediment Transport, Dowden, Hutchinson & Ross, Inc., Stroudsburg, Pa., pp. 307-331.

Hartung, R. and G. W. Klinger, 1968. "Sedimentation of floating oils," Mich. Acad. Sci., 53, 23-27.

Kolpack, R. L., 1977. "Priorities in fate of oil spill research," Proc., 1977 Oil Spill Conference, New Orleans, Amer. Petrol. Inst., Washington, D.C., pp. 483-485.

Kolpack, R. L., J. S. Mattson, H. B. Mark, Jr. and T. C. Yu, 1971. "Hydrocarbon content of Santa Barbara Channel sediments," in R. L. Kolpack, Ed., Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill 1969-1970, Vol. II, Physical, Chemical and Geological Studies, Allan Hancock Foundation, Univ. of Southern Calif., Los Angeles, pp. 276-295, 385-389.

Kolpack, R. L. and N. B. Plutchak, 1976. "Elements of mass balance relationships for oil released in the marine environment," Proc., Symp. on Sources Effects and Sinks of Hydrocarbons in the Aquatic Environment, Washington, D.C., Amer. Inst. Biol. Sci., Arlington, VA., pp. 345-357.

Mark, H. B., Jr., T. C. Yu, J. S. Mattson and R. L. Kolpack, 1972. "Infrared estimation of oil content in sediments in presence of biological matter," Environ. Sci. Technol, 6, 833-834.

Myers, P. A., 1976. "Sediments-sources or sinks for petroleum hydrocarbons," Proc., Symp. on Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment, Washington, D.C., Amer. Inst. Biol. Sci., Arlington, VA., pp. 309-324.

Meyers, P. A. and J. G. Quinn, 1973. "Association of hydrocarbons and mineral particles in saline solution," Nature, 244, 23-24.

Poirier, O. A. and G. A. Thiel, 1941. "Deposition of free oil by sediments settling in sea water," Bull. Amer. Ass'n. Petrol. Geol., 24, 2170-2180.

Sharma, G. D. and D. C. Burbank, 1973. "Geological oceanography," in Hood, D. W., W. E. Shiels and E. J. Kelley, Eds., Environmental Studies of Port Valdez, Inst. of Marine Sci. Occ. Pub. No. 3, Univ. of Alaska, Fairbanks, pp. 13-100.

Storrs, P. N., E. A. Pearson and R. E. Selleck, 1969. "A comprehensive study of San Francisco Bay. Final Report VI. Water and sediment quality and waste discharge relationships," Sanitary Eng. Res. Lab Rept. #67-4, Univ. of Calif., Berkeley (cited in DiSalvo and Guard, 1975).

Wells, A. F., 1962. Structural Inorganic Chemistry, 3nd Ed., Oxford Press, Ely House, London.

APPENDIX II

DRAFT REPORT

MODELING ALGORITHMS FOR THE WEATHERING OF OIL IN THE MARINE ENVIRONMENT

II. SPREADING, FRACTIONATION, AND EVAPORATION OF SURFACE SLICKS

by

JAMES S. MATTSON

Center for Experiment Design and Data Analysis
National Oceanic and Atmospheric Administration
Washington, D.C.

Topical Report under:

Research Unit #499
Outer Continental Shelf Environmental Assessment Program
National Oceanic and Atmospheric Administration

Submitted to:

Research Unit #140

Dr. Jerry Galt, Principal Investigator
Pacific Marine Environmental Laboratory
National Oceanic and Atmospheric Administration
Seattle, WA

July 1, 1977

INTRODUCTION

Oil at the air-sea interface has been the principal subject of interest to mathematical modelers of oil spill behavior (Stolzenbach et al., 1977). The extent to which the surface slick spreads determines the rate of mass loss due to evaporation, dissolution, oxidation, and oil-in-water emulsification. Were an oil slick to behave "nicely" and spread to a monomolecular thickness, the oil-water and oil-air interfacial areas would reach their theoretical maxima and degradative processes could proceed apace, unfettered by rate limitations imposed due to the finite film thickness of an actual surface slick. The majority, if not all, of the oil spill modelers today recognize that oil does not spread to monomolecular thicknesses. Yet, no models presented to date account for the nonuniform spreading of surface slicks; i.e., the tendency to form "pancakes" (lenses), "ropes" (windrows), and generally spread into a relatively small area of thick oil surrounded by a much greater area of thin oil ("sheen"). This report describes some of the physical chemical considerations that apply to surface slicks, particularly differential spreading and evaporation.

SPREADING

Crude oil behaves in such a complex, composition-dependent fashion that it would be a mistake to suppose that any of the physical models proposed to date are adequate to describe what happens in the real world. As the chemical composition of weathered crude oils and residual fuels is predominantly high-boiling hydrocarbons, it is surprising to find that such oils spread at all, other than that required from gravity alone. Theoretically, high-molecular-weight hydrocarbons on water should appear as large, relatively thick lenses. Langmuir (1933) defined the "spreading coefficient," F_s, for immiscible liquids of different densities by equation [1], where γ_1 is the surface tension of the

$$F_s = \gamma_1 - \gamma_2 - \gamma_{12}, \qquad [1]$$

heavier liquid, γ_2 is the surface tension of the floating liquid, and γ_{12} is the interfacial surface tension. Oil will not spread on water unless $F_s > 0$, and so long as F_s remains positive, uncontained spreading will continue until a monomolecular film is obtained. When $F_s < 0$ the oil will contract into lenses of thicknesses limited by gravity. For pure hydrocarbons on pure water, *n*-alkanes larger than octane (C_8H_{18}) will not spread, as they exhibit negative spreading pressures; and none of the cyclic hydrocarbons spread spontaneously (Garrett and Barger, 1970).

For nonspreading substances, F_s can be determined from the measurement of the central thickness of a free-floating lens. According to Langmuir (1933), lenses of more than 6 cm diameter exhibit a uniform central thickness, approximating closely the thickness of a lens of infinite radius, t_∞. The limiting thickness, t_∞, is computed from equation [2] (Langmuir, 1933), where

$$t_\infty{}^2 = -2F_s\rho_1/g\rho_2(\rho_1-\rho_2) \qquad [2]$$

ρ_1 and ρ_2 are the specific gravities of the denser and lighter substances respectively, and g is the gravitational constant. For example, substituting the value of $\rho_2 = 0.96$ for Argo Merchant oil, and an approximation to F_s of -12 dynes/cm, yields a predicted lens thickness of 0.65 cm, as compared to visual estimates of 2 to 3 cm made by divers at the scene of the Argo Merchant spill.

The spreading theory of Langmuir (1933) requires some adjustments for two non-ideal phenomena, partial miscibility and the presence of surface-active impurities. For example, benzene would be expected to spread on water, as according to equation [1], F_s (benzene/water) = 72.8 - 28.9 - 35.0 = 8.9 dynes/cm, but for the fact that benzene and water are partially miscible, reducing both γ_1 and γ_2, so that actually: F_s (benzene/water) = 62.2 - 28.8 - 35.0 = -1.6 dynes/cm. Thus, when benzene is placed on water, an initial rapid spreading occurs. Then, as the two liquids equilibrate with each other, the benzene retracts and forms a lens. For almost all low-surface-tension liquids on water, the final spreading pressure will be negative, leaving a relative thick central lens surrounded by a monolayer film (Adamson, 1967). For an oil slick of substantial (i.e., km) dimensions, even where there may be significant shear forces immediately beneath the slick, it is unlikely that subsurface turbulence or shear would be able to carry away dissolved oil rapidly enough to defeat the effects of mutual dissolution as described in the previous paragraph. Thus, for actual oil slicks on water, the values of γ_1 and γ_2 will have to include the consideration of mutual miscibility.

The second non-ideal effect, vitally important in the spreading of petroleum oils, is the decrease in interfacial tension caused by the presence of surface-active molecules at the oil-water interface. Lowering γ_{12} increases F_s, and enables spreading to take place where it otherwise would not. Langmuir (1933) found that a small amount (≈1%) of stearic acid in tetradecane ($C_{14}H_{30}$) lowered the interfacial tension between tetradecane and water sufficiently to cause spreading of what in theory is a non-spreading liquid. Removal of the stearic acid resulted in lens formation, and an F_s for tetradecane on water of -6.2 dynes/cm. [Tetradecane itself does not dissolve in water to a significant extent, having a solubility in sea water of about 1.7 parts per billion (ppb) (Sutton and Calder, 1974)]. Adamson (1967) reports a lowering of interracial tension between a paraffin oil and water from 41 dynes/cm to 7.2 dynes/cm by addition of a trace of sodium oleate. The partial oxidation of *n*-octane to *n*-octanol reduces γ_{12} from 50.8 to 8.5 dynes/cm for the pure liquid on water (Weast and Selby, 1966, p. F-27), and Zisman (1941) reported that the addition of 0.2, 0.5, and 1.0% *n*-dodecanol to a nonspreading paraffin oil (F_s = -11.7 dynes/cm) resulted in spreading pressures of 3.0, 11.0, and 17.5 dynes/cm respectively. Berridge et al. (1968) measured spreading pressures ranging from +17 dynes/cm for Kuwait and Tia Juana (Velezuela) Medium crudes, up to 27 dynes/cm for Brega (Libya) crude. Garrett and Barger (1970) measured initial spreading pressures of 25-33 dynes/cm for a light crude (33 dynes/cm), a heavy crude (28 dynes/cm) a residual fuel (25 dynes/cm), and a diesel fuel (26 dynes/cm), and Barger (1973) reported initial spreading pressures ranging from 10.5 dynes/cm for JP-5 jet fuel to 29.6 dynes/cm for a No. 2 fuel oil. The high observed F_s values for petroleum oils are almost entirely due to the presence of partially oxidized hydrocarbons, exhibiting surface activity at the oil-water interface (Garrett, 1974).

The introduction of surface-active molecules into the oil-water interface serves to increase the radius of an oil lens, until a critical concentration of surfactant is reached where the lens is no longer stable, F_s changes sign, and active spreading begins to take place. One can imagine a population of oleophilic bacteria underneath an oil lens, slowly producing surface-active molecules by partial oxidation of hydrocarbons, reducing γ_{12} in a continuous fashion allowing F_s, and thus the radius of the lens, to increase steadily. Redistribution of the surface-active molecules over the larger area will slow the spreading somewhat, but could not stop the spread of the lens unless the surfactants were to redistribute vertically as well as horizontally; i.e., diffuse into the bulk oil or be removed from the interface by dissolution.

Fay (1971) incorporated the dissolution of oil into water in his consideration of the processes responsible for terminating the spreading of an oil spill. He assumed that molecular diffusion is rate-determining for this process, causing the spread of an oil slick to stop at a maximum area, A, described by equation [3].

$$A = k_a(F_s^2/\rho^2\nu D^3)^{1/8}(V/s)^{3/4} \qquad [3]$$

In equation [3], k_a is an empirical constant on the order of one, V is the volume of oil involved, ρ and ν are the density and kinematic viscosity of water, D is the molecular diffusion coefficient for the soluble components of the oil, and s is the solubility of those components (Fay, 1971). Because of the difficulty in determining F_s and s, Fay (1971) proposed that the maximum area A, in m^2, be related to the volume of a spill, in m^3 ($1 \ m^3 \approx 1$ metric ton), by the empirical relationship of equation [4]. Equation [4] is obtained from equation [3] by assuming $F_s = +10$ dynes/cm, $D = 10^{-5}$ cm^2/sec,

$$A = 10^5 \ V^{3/4} \qquad [4]$$

$s = 10^{-3}$g/cm^3, $k_a = 1$. Fay considered equation [3] a reasonable fit to data obtained by Allen and Estes (cited in Estes and Senger, 1972).

The value of s assumed by Fay is unreasonably high. The bulk of the water-soluble compounds in petroleum oil exhibit significantly lower solubilities. Several examples are listed in Table I, inspection of which shows that of all of the compounds listed, only a benzene spill would satisfy Fay's choice of $s \doteq 10^{-3}$. The light fractions of an oil spill tend to disappear by evaporation very quickly, and it is expected that concentrations of <u>thermodynamically dissolved</u> hydrocarbons beneath an oil slick will be quite low, particularly after a few hours of weathering. In a series of experimental spills of crude oils, two 10 bbl spills each of two crude oils, McAuliffe (1977a) found total dissolved hydrocarbon concentrations not exceeding 60 ppb in water samples taken five feet beneath the slicks. Particulate hydrocarbons were present, however, at much higher levels; i.e., 330 to 6,000 ppb, under the same spills (McAuliffe, 1977a). The concentrations of oil measured beneath actual slicks far exceed those based on solubility considerations alone. Besides the values reported by McAuliffe (1977a), values not exceeding 250 ppb were reported for samples taken beneath the Argo Merchant oil slick (Grose and Mattson, 1977), and the first preliminary analyses from the Ekofisk blowout in the North Sea

Table I

Solubilities of Representative Petroleum Hydrocarbons

Compound	Molecular Weight	Solubility ppm	Solvent	References
Aromatics				
Benzene	78	1250	Sea Water	Lassiter et al., 1974
"	"	1780	Dist. Water	McAuliffe, 1966
Toluene	92	515	"	"
o-Xylene	106	175	"	"
Ethylbenzene	106	152	"	"
1,2,4-Trimethylbenzene	121	57	"	"
Isopropylbenzene	120	50	"	"
Naphthalene	128	22	Artifical Sea Water	Eganhouse & Calder, 1976
1-Methylnaphthalene	142	26	"	"
Biphenyl	154	4.7	"	"
1,5-Dimethylnaphthalene	156	2.7	Dist. Water	"
Phenanthrene	178	0.7	Artifical sea water	"
Cycloparaffins				
Cyclohexane	84	159	Dist. water	McAuliffe, 1966
Methylcyclohexane	99	14	"	"
***n*-Paraffins**				
n-Hexane	86	9.5	Dist. water	McAuliffe, 1966
n-Heptane	100	2.9	"	"
n-Octane	114	0.7	"	"
Dodecane (C_{12})	170	2.9×10^{-3}	Sea Water	Sutton & Calder, 1974
"	"	1.8×10^{-3}	"	Button, 1976
Tetradecane (C_{14})	198	1.7×10^{-3}	"	Sutton & Calder, 1974
Hexadecane (C_{16})	226	0.4×10^{-3}	"	"
Octadecane (C_{18})	254	0.8×10^{-3}	"	"
Eicosane (C_{20})	282	0.8×10^{-3}	"	"
Hexacosane (C_{26})	366	0.1×10^{-3}	"	"

indicate subsurface hydrocarbon concentrations on the order of 100 to more than 300 ppb at depths of 1 and 5 meters (Bratberg, 1977). Freegarde et al. (1971) reported concentrations of total hydrocarbons ranging from less than 10 to 450 ppb beneath three intentional spills of Kuwait crude (25, 75, and 100 metric tons respectively). These values would appear to support an acceptable approximation to s in Fay's model of no more than $5 \times 10^{-7} g/cm^3$. Excess concentrations of petroleum hydrocarbons beneath oil slicks, over that expected from dissolution and molecular diffusion alone, most likely consists of stabilized colloidal and supracolloidal particles. Both the colloidal fraction and the supracolloidal particles may have their origin at lens-water interfaces, particularly at the edges of the lenses, rather than coming from the entire slick.

For actual oil spills, where no single component is likely to comprise more than one or two percent of the total mass of the spill, and there are thousands of individual chemical compounds present in the oil, the process of lens formation superimposed on complicated chemical composition results in *chemical fractionation* at the surface. Where lenses contain freshly spill oil, as in the San Francisco Bay spill of January, 1971, and in the Argo Merchant spill of 1976-77, visual observations of their behavior have given rise to speculation that the thin sheen surrounding each lens is being "fed" by the more volatile components of the lens (McAuliffe, 1977b; this author, personal observations). Phillips and Groseva (1975) demonstrated that a mixture of hydrocarbons with different spreading coefficients will chemically fractionate during spreading. In one experiment, they allowed an equimolar mixture of toluene (F_s = +6.8), *n*-octane (F_s = +0.22), and *n*-decane (F_s = -2.3 dyne/cm) to spread on water at 10°C. Five seconds after spreading started, the center of the slick was enriched in decane, the non-spreading component, while the periphery (≈10.5 cm radius) was enriched in toluene, the component with the highest spreading coefficient. Table II summarizes the results of Phillips and Groseva (1975), and shows that after 5 seconds of spreading, the toluene/decane ratio in the central portion of the oil was about 0.2 while at the periphery the ratio was approximately 4.6. After 15 seconds of spreading, the toluene/decane ratio near the center was unchanged, while the ratio at the periphery decreased to about 2.2. Similar results were obtained when the equimolar mixture of toluene/octane/decane was added to Norman Wells (Mackenzie River) crude oil. The data in Table II indicate that the concentration gradients for the three compounds decreased in order of their respective spreading coefficients, but with *n*-octane behaving as though it had a negative F_S, rather than the slightly positive one cited by Phillips and Groseva (1975) and other investigators (Langmuir, 1933).

EVAPORATION

Evaporation plays a role in the physical structure of a surface slick, as it changes the viscosity and surface tension of the oil, but these changes are difficult to describe mathematically (Wang et al., 1976; Regnier and Scott, 1975; Mackay and Matsugu, 1973). While not rate-limited by mass transport in thin films, evaporation is initially rate-limited by molecular diffusion within the oil in lenses. As the low-molecular-weight hydrocarbons volatilize from the surface of a lens, the less volatile components will form a semipermeable "skin" at the air-oil interface (Wang et al., 1976). The presence of this skin serves to stabilize the lens against continued evaporation. However, sea surface turbulence can break up the lens, allowing evaporation to continue. For freshly spilled oil, there can be a marked compositional difference between the outside

Table II

Differential Spreading of Petroleum Hydrocarbons[a]

A. Mixture of toluene/*n*-octane/*n*-decane.

mole fraction, at 5 - 5 sec	initial composition	r = 1 cm	r = 10.5 cm
toluene	0.33	0.14	0.73
n-octane	0.33	0.20	0.11
n-decane	0.33	0.66	0.16
at t - 15 sec			
toluene	0.33	0.13	0.62
n-octane	0.33	0.21	0.10
n-decane	0.33	0.66	0.28

B. Mixture of toluene/*n*-octane/*n*-decane/crude oil

mole fraction, at 5 = 5 sec	initial composition	r = 1 cm	r = 10.5 cm
toluene	0.17	0.22	0.54
n-octane	0.17	0.30	0.20
n-decane	0.17	0.48	0.26
at t = 15 sec			
toluene	0.17	0.16	0.65
n-octane	0.17	0.30	0.08
n-decane	0.17	0.54	0.27

[a]interpolated from Phillips and Groseva (1975).

and the interior of thick lenses of oil (McAuliffe, 1977b). While some laboratory studies (Kreider, 1971) showed that it required 20 days for components with boiling points up to 270°C (i.e., *n*-paraffins up to C_{15}) to evaporate, several investigators have shown that virtually all *n*-paraffins of carbon number less than 16 (boiling points $\leq$ 270°C) evaporated from actual oil slicks within hours to a few days (Sivadier and Mikolaj, 1973; McAuliffe, 1977b; Butler et al., 1973; Smith and MacIntyre, 1971). Sivadier and Mikolaj (1973) found that natural seepage oil from the Santa Barbara Channel lost everything up to about a boiling point of 270-280°C in a matter of hours, with 90% of the evaporative loss occurring in two to six hours (sea surface temperature 19-20°C, wind speed 4-6 m/sec, air temperature 28-30°C). After the initial loss of the low-molecular-weight fraction, oil lenses appear, in at least one study, to have relatively uniform chemical composition from the inside out (Butler, 1975). Butler's (1975) conclusion regarding uniform composition may not be applicable to crude oil spills, however, as he bases his conclusion on analyses of high-wax-content tar balls, which are often thought to originate primarily from episodes of tank washings. [Since the high-molecular-weight waxes in crude oil tend to coalesce on the tank walls during shipment, oily residues from the cleaning of tank vessels tend to be comprised primarily of such waxes.] Such residues would not be expected to have a liquid center surrounded by a semipermeable skin, where the residual oil left after a spill of crude oil may well have such character.

As it is acknowledged (Butler, 1973; McAuliffe, 1977b) that hydrocarbons below C_{16} disappear after several hours to a few days of weathering, one simple method that has been proposed for including this short-term evaporation process in mathematical models of oil spills (Lassiter et al., 1974) is to apply a single-step mass adjustment at a time of, say, 72 hours, removing everything with boiling points up to 270°C. These lower-boiling constituents make up

Table III

[a]Composition of Alaskan Crude Oils by Boiling Range

	McArthur R.	Swanson R.	Middle Ground	Trading Bay	[b]Prudhoe Bay
Boiling Range					
< 275°C	47.4%	40.9%	58.1%	39.1%	33.1%
[c]275– 308°C	3.3%	3.0%	3.9%	3.6%	2.8%
[c]308– 336°C	5.2%	6.2%	5.7%	7.9%	6.5%
[c]336– 364°C	7.0%	4.0%	4.9%	4.9%	6.8%
[c]364– 392°C	4.2%	6.1%	5.5%	4.3%	6.0%
> 392°C	29.8%	37.4%	19.2%	38.4%	43.7%
Specific Gravity					
crude oil	0.848	0.875	0.818	0.883	0.893
>275°C residue	0.938	0.951	0.915	0.955	0.949
>392°C residue	0.977	0.991	0.958	0.996	0.978
[d]1975 Production					
million barrels	40.9	8.8	8.7	6.1	n/a

[a]From U.S. Bureau of Mines, Bartlesville, Oklahoma.

[b]From Coleman et al. (1973).

[c]Converted from 40 mm Hg boiling points, according to Coleman et al. (1973).

[d]From Beazley (1976).

anywhere from 25 to 50 percent of a crude oil, and it requires little compositional data to determine the appropriate single-step mass adjustment. Composition data for four Cook Inlet crude oils and Prudhoe Bay crude are given in Table III. Ferraro and Nichols (1972) provide similar data on crude oils from 122 foreign oil fields that could be used in such an approach.

Once the initial rapid evaporation of low-molecular-weight constituents is over, an approach suggested by Butler (1975) is useful for computing subsequent mass losses from evaporation. Butler (1975) takes the approach that partially weathered residues are uniform in composition throughout, and that evaporation is slow enough that mass transport within the viscous residue is not rate-limiting, but that each constituent evaporates by a first order process according to its concentration, x_i, and vapor pressure, P_i, according to equation [5], where k_i is the empirical rate coefficient for the ith

$$x_i^t = x_i^0 \exp\ (-k_i t P_i / x_i^0) \qquad [5]$$

component, and x_i^0 and x_i^t are the quantities of the ith component in the original oil and at time t. Using tabulated ((Weast and Selby, 1966, pp. D-117-136) vapor pressure data for C_6 to C_{18} hydrocarbons, Butler (1975) obtained a regression fit for $P_N = \exp(10.94-1.06N)$, where N is the number of carbon atoms in the hydrocarbon molecule. For *n*-alkanes, the fit is quite good (±20% at 95% confidence level), and even for aromatics and other non-*n*-alkanes, the fit is fair (± a factor of 2.5).

Butler (1975), on examination of gas chromatograms of weathered tar balls on Bermuda beaches, obtained a value of $k_i/x_i^0 \simeq 35$ torr^{-1} day^{-1}. Substituting this value and the expression for P_N from tabulated vapor pressure data, and suming over all $N \geqq 16$, equation [6] is an approximation to the mass remaining

$$\text{mass}\ \ (t,\ \text{days}) = \sum_{N=16}^{\infty} \exp(-2\text{x}10^6 \cdot t \cdot e^{-1.06N}) \qquad [6]$$

Table IV

Mass Losses for C_{16}-C_{25} Hydrocarbons by Evaporation

Carbon Number, N	Boiling Point, °C	Mass remaining at time t: t = 10 days	t = 100 days	t - 1000 days
16	286.8	0.42	0.00	0.00
17	301.8	0.74	0.05	0.00
18	316.1	0.90	0.36	0.00
19	329.7	0.97	0.70	0.03
20	342.7	0.98	0.88	0.29
21	356.5	1.00	0.96	0.65
22	368.6	1.00	0.99	0.86
23	380.2	1.00	1.00	0.95
24	391.3	1.00	1.00	0.98
25	401.9	1.00	1.00	0.99

for petroleum fractions with boiling points greater than 270°C. From an examination of Table IV, one can readily see that this computation is not particularly tedious as, for example, only the 287-318° boiling range fraction exhibits significant evaporative losses during ten days of weathering, and even for a 100-day period, one need consider only the 287-357° boiling range fraction.

REFERENCES

Adamson, A. W., 1967. The Physical Chemistry of Surfaces, 2nd Ed., Interscience, New York.

Beazley, M., 1976. Mobil Oil Corporation, Denver, CO., personal communication.

Berridge, S. A., R. A. Dean, R. G. Fallows and A. Fish, 1968. "The properties of persistent oils at sea," J. Inst. Petroleum, 54, 300-309.

Bratberg, E., 1977. Redaktor, "The Bravo blowout. A report on marine research activities, April 23 to May 5, 1977, including some preliminary results," Inst. of Marine Research, Nordnesparken 2, 5011 Bergen Nordnes, Norway, May 11, 1977, 41 pp.

Butler, J. N., 1975. "Evaporative weathering of petroleum residues: the age of pelagic tar," Mar. Chem., 3, 9-21.

Butler, J. N., B. F. Morris and J. Sass, 1973. Pelagic Tar from Bermuda and the Sargasso Sea, Bermuda Biol. Sta., Spec. Pub. No. 10, St. George's West, Bermuda, 1973, 346 pp.

Button, D. K., 1976. "The influence of clay and bacteria on the concentration of dissolved hydrocarbon in saline solution," Geochim. et Cosmochim. Acta, 40, 435-440.

Coleman, H. J., J. E. Dooley, D. E. Hirsch and C. J. Thompson, 1973. "Compositional analysis of a high-boiling 370-535°C distillate from Prudhoe Bay, Alaska, crude oil," Anal. Chem., 45, 1724-1737.

Eganhouse, R. P. and J. A. Calder, 1976. "The solubility of medium molecular weight aromatic hydrocarbons and the effects of hydrocarbon co-solutes and salinity," Geochim. et Cosmochim. Acta, 40, 555-561.

Estes, J. E. and L. W. Senger, 1972. "The multispectral concept as applied to marine oil spills," Remote Sensing of Environ., 2, 141-163.

Fay, J. A., 1971. "Physical processes in the spread of oil on a water surface," in, Proc., 1971 Conf. on Prevention and Control of Oil Spills, Amer. Petrol. Inst., Washington, D.C., pp. 463-467.

Ferraro, E. P. and D. T. Nichols, 1972. "Analyses of 169 crude oils from 122 foreign oil fields," Bureau of Mines Information Circular 8542, 113 pp.

Freegarde, M., C. G. Hatchard and C. A. Parker, 1971. "Oil spilt at sea: its identification, determination, and ultimate fate," Lab. Practice (London), 20, 35-40.

Garrett, W. D. 1974. "Surface activity of petroleum and its influence on the spreading and weathering of oil films at sea," J. Rech. Atmos., 8, 555-562.

Garrett, W. D. and W. R. Barger, 1970. "Factors affecting the use of monomolecular surface films to control oil pollution on water," Environ. Sci. Technol., 4, 123-127.

Grose, P. L. and J. S. Mattson, Eds., 1977. The Argo Merchant Oil Spill. A Preliminary Scientific Report, National Oceanic and Atmospheric Admin., U.S. Gov't.Printing Office, Washington, D.C. 20402, 349 pp.

Kreider, R. E., 1971. "Identification of oil leaks and spills," in Proc., 1971 Conf. on Prevention and Control of Oil Spills, Amer. Petrol. Inst., Washington, D. C., pp. 119-124.

Langmuir, I., 1933. "Oil lenses on water and the nature of monomolecular expanded films," J. Chem. Phys., 1, 756-776.

Lassiter, J. B., III, R. J. Powers and J. W. Devanney III, 1974. "The role of mass transport in oil slick weathering," in "Primary, Physical Impacts of Offshore Petroleum Developments," report to Council on Environmental Quality, MIT Report No. MITSG 74-20.

Mackay, D. and R. S. Matsugu, 1973. "Evaporation rates of liquid hydrocarbon spills on land and water," Can. J. Chem. Eng., 51, 434-439.

McAuliffe, C. D., 1966. "Solubility in water of paraffin, cycloparaffin, olefin, acetylene, cycloolefin, and aromatic hydrocarbons," J. Phys. Chem., 70, 1267-1275.

McAuliffe, C. D., 1977a. "Evaporation and solution of C_2 to C_{10} hydrocarbons from crude oils on the sea surface," in Proc., Symp. on Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, Seattle, WA, Nov. 10-12, 1976, Pergamon Press (in press).

McAuliffe, C. D., 1977b. "Dispersal and alteration of oil discharged on a water surface," ibid.

Philips, C. R. and V. M. Groseva, 1975. "Separation of multicomponent hydrocarbon mixtures spreading on a water surface," Separation Sci., 10, 111-118.

Regnier, Z. and B. F. Scott, 1975. "Evaporation rates of oil components," Environ. Sci Technol., 9, 469-474.

Sivadier, H. O. and P. G. Mikolaj, 1973. "Measurement of evaporation rates from oil slicks on the open sea," in Proc., 1973 Conf. on Prevention and Control of Oil Spills, Amer. Petrol. Inst., Washington, D.C., pp. 475-484.

Smith, C. L. and W. G. MacIntyre, 1971. "Initial aging of fuel oil films on sea water," in Proc., 1971 Conf. on Prevention and Control of Oil Spills, Amer. Petrol. Inst., Washington, D. C., pp. 457-461.

Sutton, C. and J. A. Calder, 1974. "Solubility of higher-molecular-weight *n*-paraffins in distilled water and sea water," Environ. Sci. Technol., 8, 654-657.

Wang, H., W. C. Yang and C. P. Huang, 1976. "Modeling of oil evaporation in an aqueous environment," Univ. of Delaware, Coll. of Mar. Studies, Newark, DE 19711, Report No. CMS-RANN-5-76, 37 pp.

Weast, R. C. and S. M. Selby, Eds., 1966. CRC Handbook of Chemistry and Physics, 47th Ed., Chemical Rubber Pub. Co., Cleveland, Ohio.

Zisman, W. A., 1941. "The spreading of oils on water," J. Chem. Phys., 9, 789-793.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Outer Continental Shelf Environmental Assessment Program
Juneau Alaska Project Office
P. O. Box
Juneau, Alaska 99602
PH: 907-586-7432

RFx41-499-916

Date: 8 NOV 1977

To : Rudy Engelmann
OCSEAP/Alaska Program Office Rx4

From: Herbert E. Bruce
OCSEAP/Juneau Project Office, RFx41

for

Subj: Acceptance of Renewal Proposal for RU 499 "Weathering of Oil"

The proposal, "Modelling Algorithms for the Weathering of Oil in the Marine Environment by Dr. James S. Mattson has been reviewed in the Juneau Project Office. The scope of the proposal goes somewhat beyond the original guidance letter of 7 June 1977; however, it is recommended that it be accepted. The stipulation is made that the scope of work required is to complete the work begun late in FY 77 whose objectives were to provide an algorithm for weathering processes, together with recommendations for ways in which the algorithm may be improved by additional research.

The funding level of $29,000 is recommended, in accordance with previous agreements between CEDDA and OCSEAP Program Office.

Research Unit #500

PROPOSED RESEARCH PROGRAM
(Technical Proposal)

on

ACTIVITY-DIRECTED FRACTIONATION OF PETROLEUM SAMPLES

to

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

June 15, 1977

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

PROPOSED RESEARCH PROGRAM
(Technical Proposal)

on

ACTIVITY-DIRECTED FRACTIONATION
OF PETROLEUM SAMPLES

to

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

from

BATTELLE
Columbus Laboratories

June 15, 1977

Total Cost: $96,200

OBJECTIVES

The objectives of the proposed research program on activity-directed fractionation of petroleum samples are to isolate and characterize potentially hazardous fractions in crude oil or weathered crude oil that are not currently being studied in the Alaskan OCS program.

INTRODUCTION

Crude oils are comprised of many thousands of individual organic compounds that fall into many different classes including normal paraffins, isoparaffins, cycloalkanes (naphthenes), aromatic hydrocarbons (1 to 7-rings), partially aromatic fused-ring hydrocarbons, thiophenes, carbazoles, benzofuranes, carboxylic acids, and porphyrins. Some of the more polar, higher-molecular-weight, or less soluble components of these classes are referred to as a single fraction, the pentane-insolubles or asphaltenes. Many additional components are formed during weathering.

Our knowledge of the relative biological hazards associated with the various components or fractions of petroleum is very limited.

The main components that are known to be hazardous are the benzenes, and naphthalenes, which are toxic and the polynuclear aromatic (PNA) hydrocarbons, many of which are carcinogenic.

In an environmental situation the concentration of hazardous petroleum components relative to nonhazardous indicators may be drastically different than that found in a fresh crude oil.

Therefore, researchers concerned with the hazards of petroleum pollution need to acquire baseline data on those components from petroleum that are potentially the most hazardous as well as on components that are good petroleum indicators.

A major portion of the hydrocarbon analysis effort of the current BLM outer continental shelf program including the Alaskan OCS program is directed toward components that may not be very hazardous and may not be good petroleum indicators, namely the saturated hydrocarbons and the biogenic interfering components that frequently predominate in the so-called "aromatic hydrocarbon" fraction. The relatively nontoxic saturated hydrocarbons, which are good indicators for studying a gross oil spill situation, may be mostly biogenic at background levels and therefore not suitable as petroleum indicators. Aromatic hydrocarbons are much better petroleum indicators but in baseline studies, especially in tissue samples, they usually go undetected because of interference from biogenic olefins and fatty ketones. Even in the absence of interferences most of the benzenes and naphthalenes would be missed because their relatively high volatility puts them outside of the retention index range of 1400 to 3200 being studied. Consequently the PNA hydrocarbons are the only known hazardous petroleum indicators likely to be found in the current program. It is apparent that the analytical methods should be optimized for the detection of PNA hydrocarbons and the removal of interferences.

It is also apparent that more information needs to be acquired about the potential hazard of other components of petroleum and weathered petroleum. If there are other potentially hazardous components, they need to be identified and methods for their analysis need to be incorporated into the overall program.

Battelle's Columbus Laboratories is currently using activity-directed fractionation, which couples high pressure liquid chromatography (HPLC) with recently developed in vitro biological screening procedures, to isolate potentially hazardous components in organic mixtures. Activity-directed fractionation can be a particularly efficient approach to obtaining the information needed on the potential hazards of petroleum components. We are presently involved in Phase I of this research effort, which is the fractionation of weathered and non-weathered Prudhoe Bay crude oil by HPLC followed by in vitro biological screening.

CURRENT PROGRAM STATUS

The principal oil that we are currently working with is Prudhoe Bay crude. This oil was weathered in a 4 x 4 foot pine board square box moored in Auke Bay from July 12, 1976 to September 14, 1976. The depth of the oil slick was initially 1/4 inch. Approximately 100 ml samples of the oil were taken on each of the following dates: August 2, August 13, August 31, and September 14, 1976. In addition, one large (1 liter) sample was taken on August 16, 1976. These samples were received along with 500 ml of unweathered Prudhoe Bay oil in February, 1977.

Twenty grams of the unweathered Prudhoe Bay oil have, initially, been fractionated into pentane-soluble and tetrahydrofuran (THF) soluble fractions. Only a minor portion of oil was insoluble in THF (<1 percent) and, therefore, the trituration step with DMSO was eliminated. Residue weights were obtained giving 87 percent pentane-solubles, 3 percent THF-solubles for a 90 percent recovery. The pentane-solubles are presently being fractionated on silica gel.

PROPOSED RESEARCH PROGRAM

The present research effort has been concerned with applying modern liquid chromatographic fractionation methods to petroleum samples. This will allow chemical fractionation into major compound classes which can be assayed for relative toxicity. Once the most toxic fractions have been determined by Salmonella or cultures of mammalian fibroblasts, it will be necessary to test the biological effects of these classes of compounds on sensitive marine species or life stages, and to identify those components which are the most biologically effective.

The objectives of the proposed research program are threefold:

- Refractionate larger quantities of oil to obtain toxic fractions with sufficient quantity of material to test on marine species.
- Test the biological effects of these fractions containing specific classes of compounds found most toxic to sensitive marine species or life stages, such as larval fish, larval Dungeness crabs or Pandalid shrimp.
- Identify those compounds found most biologically effective and recommending analytical procedures suitable for their quantitative determination in environmental samples.

Fractionation

We are presently developing and validating analytical and semi-preparative fractionation methods for *in vitro* biological testing. It will be necessary to apply our knowledge of the best fractionation steps to the preparative isolation of toxic classes of compounds, so that sufficient quantities can be obtained for testing on marine species.

Solubility Fractionation

In this first separation step, the procedure will essentially remain the same. Initially a pentane-insoluble fraction, the asphaltenes, will be separated out. This fraction will be subfractionated by trituration with tetrahydrofuran followed by trituration with dimethyl sulfoxide (DMSO) to give a THF-soluble fraction and a DMSO-soluble fraction. It is likely that only the THF step will be necessary to dissolve the asphaltene fraction as evidenced by our initial analytical work. However, when using larger quantities of oil, DMSO may be necessary. DMSO is chosen because of its high solvency and because it is compatible with both HPLC size separation and the bioassay procedure. THF is compatible with HPLC size separation and can be readily exchanged with DMSO for bio-assay. Sample sizes of up to 1 kg of oil will be used to obtain fractions that contain sufficient quantities of material in both the THF-soluble and DMSO-soluble fraction. The DMSO-insoluble fraction will be discarded.

Silica Gel Chromatography

The bulk of the oil, the pentane-soluble fraction, will be separated on the basis of polarity using activated silica gel. Since we will have a better idea of where the most toxic activity lies, separation of this fraction will be improved. To do this, a more efficient preparative silica gel column (2000 theoretical plates vs 200 we are presently using) will be used. We now have the capabilities in our laboratory of high pressure (15,000 psi) slurry packing our columns to obtain high efficiency preparative columns. Our original elution scheme produced six fractions. Fraction 1, eluted with petroleum ether, will contain all of the saturated hydrocarbons; Fraction 2, eluted with 20 percent methylene chloride in petroleum ether, will contain the mono and diaromatic compounds; Fraction 3, also eluted with 20 percent methylene chloride in petroleum ether, will contain the tri and polyaromatic hydrocarbons and dibenzothiophenes; Fraction 4, eluted with straight methylene chloride, will contain the carbazoles and compounds with moderate polarity; Fraction 5, eluted with acetonitrile, will contain the phenols and other polar components; and Fraction 6, eluted by Soxhlet extraction with aqueous acetonitrile, will contain any traces of highly polar components.

A number of fractions will be collected on the higher resolution silica gel column, only where the most activity was observed in our previous study. In this way, a cleaner isolation of the toxic fractions can be obtained for further study.

HPLC Fractionation

The THF-soluble fraction, DMSO-soluble fraction, and the toxic fractions from the silica gel chromatography will be subfractionated on the basis of molecular size. This will be accomplished by using HPLC with a 100A° μ-Styragel^{TM} column which performs in the gel permeation mode. Our preliminary results from applying this HPLC method to Cook Inlet crude oil are shown in the chromatograpm of Figure 1. The fractions obtained were distinctly different as determined by gas chromatography and described in Table 1. The μ-Styragel^{TM} system gives resolution that is far superior to older gel permeation supports as shown by Figure 2, in which baseline resolution is achieved for small molecules as similar in size as benzene and anthracene. The capacity of this column will be increased if there is a need for fractionation of larger quantities of materials at this stage. Once again fractions will be collected only where toxic activity was observed in our previous study. Their toxicity will be reconfirmed by in vitro bioassay.

The most active fractions will be subfractionated by HPLC using a preparative bonded microparticulate ODS or cyanopropyl reverse-phase column which fractionates by the partitioning mode. With our new capabilities, high performance preparative columns of a specified capacity or efficienty can be slurry packed in our laboratory. The bonded reverse-phase systems, and the μ-Styragel^{TM} system, give essentially complete recovery of components. The most active fractions will be more closely monitored this time when further subfractionated into 5 to 10 fractions by more fully utilizing the resolution capabilities of a reverse-phase column or by using a silica gel column which fractionates by an adsorption mode.

The overall fractionation scheme described above is summarized in Figure 3. Short cuts can now be made in this scheme by isolating only those fractions which were toxic in our present study. Residue weights will be obtained on each active fraction in order to establish a material balance and to determine the concentrations subjected to bioassay and further fractionation. Procedural blanks will be run to detect any artifacts from solvents, silica gel, or HPLC columns. The HPLC runs will be monitored by a differential refractive index detector when large samples are involved,

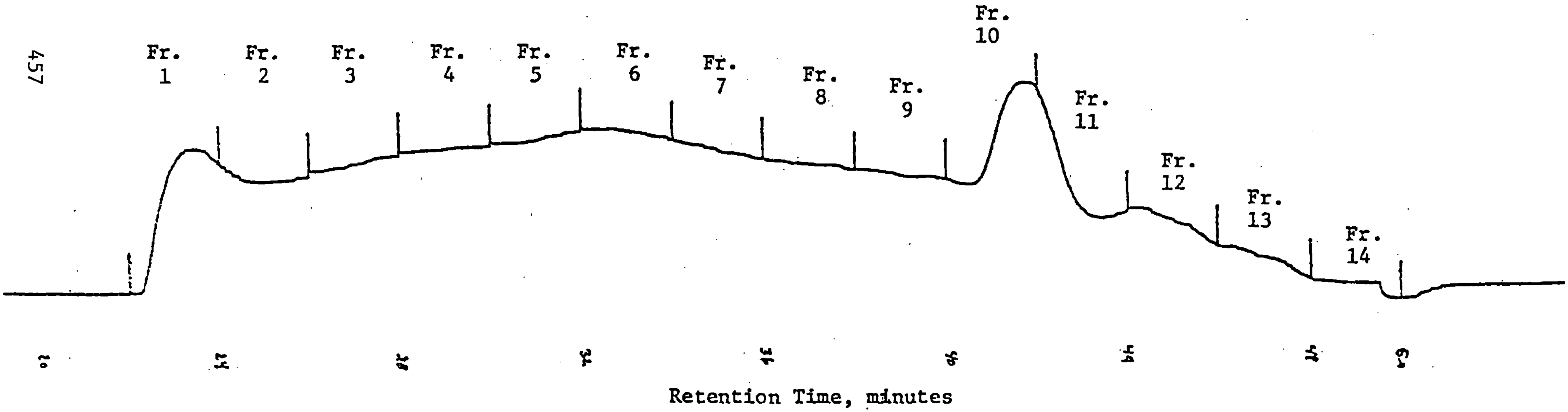


FIGURE 1. HPLC FRACTIONATION OF COOK INLET CRUDE OIL USING μ-STYRAGEL

TABLE 1. HPLC FRACTIONATION OF COOK INLET CRUDE OIL USING μ-STYRAGEL

Fraction Number[a]	Retention Time, min.	Representative Components Determined by GC Analysis
1	22-24	$>C_{30}$ n-Paraffins
2	24-26	$>C_{30}$ n-Paraffins
3	26-28	C_{24} to C_{30} n-Paraffins
4	28-30	C_{20} to C_{28} n-Paraffins
5	30-32	C_{18} to C_{26} n-Paraffins
6	32-34	C_{14} to C_{21} n-Paraffins
7	34-36	C_{10} to C_{15} n-Paraffins
8	36-38	C_9 to C_{13} n-Paraffins
9	38-40	C_8 to C_{11} n-Paraffins
10	40-42	C_7 to C_9 n-Paraffins
11	42-44	Alkylnaphthalenes
12	44-46	Alkylnaphthalenes
13	46-48	Alkylbenzenes
14	48-50	None determined

(a) See Figure 1.

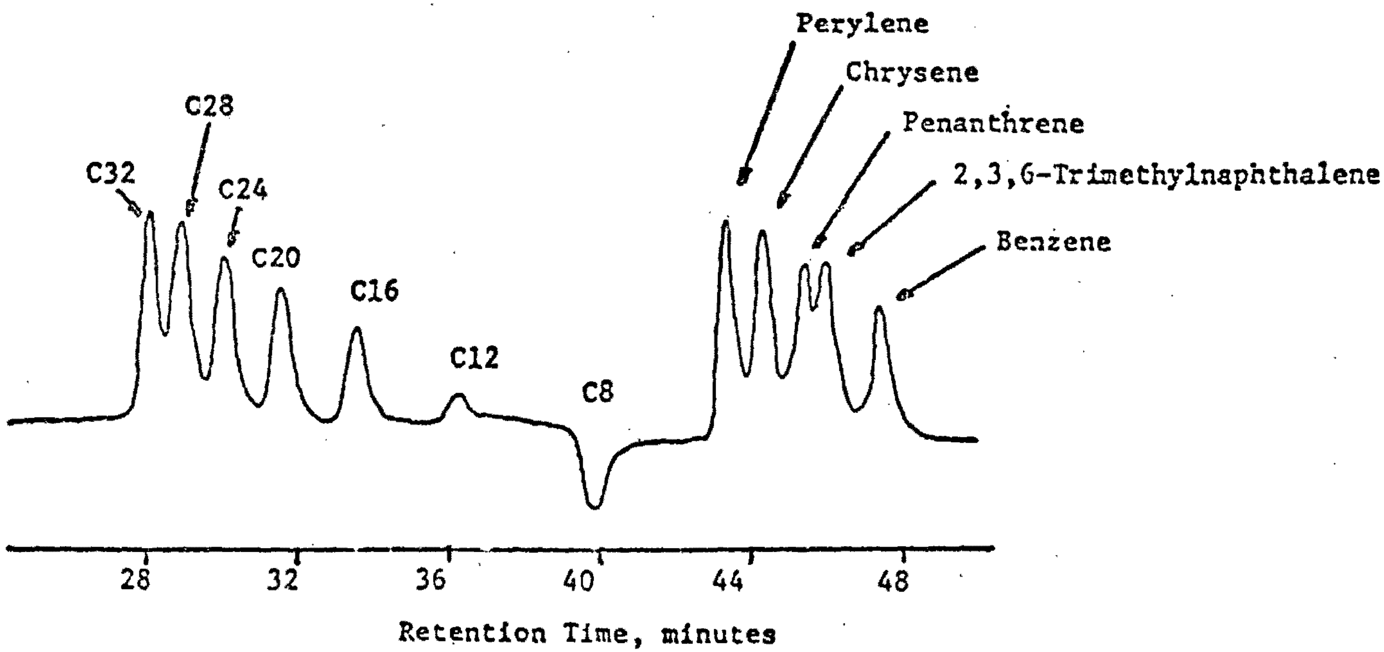


FIGURE 1. HPLC SEPARATION OF SELECTED HYDROCARBONS USING 100 A° μ-STYRAGEL

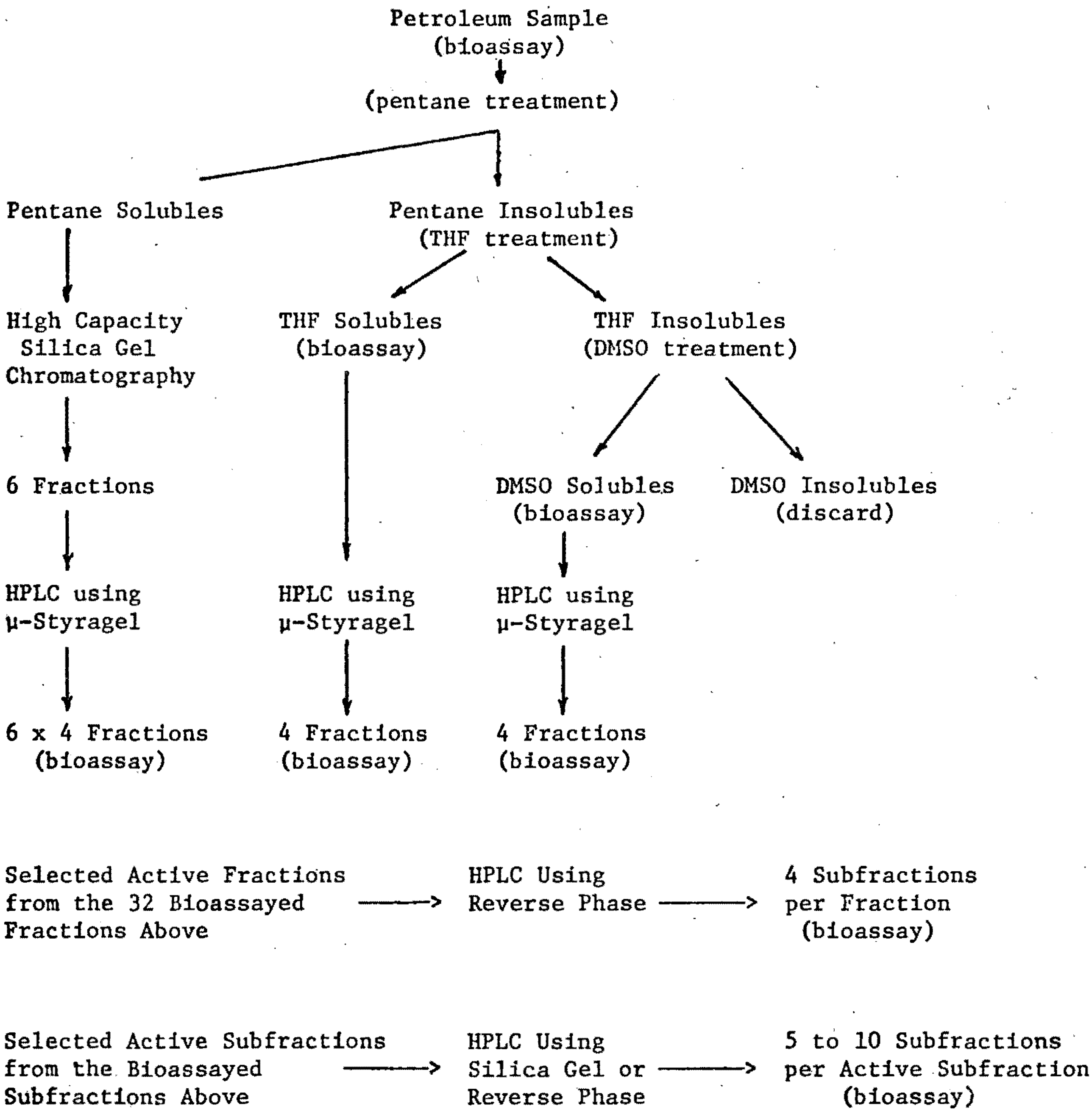


FIGURE 3. FRACTIONATION SCHEME

and by serial 220 nm UV, 254 nm UV, and fluorescence detectors when small samples are involved. All solvents will be replaced by dimethyl sulfoxide for the biological assays.

The selection of fractions for further subfractionation will be based primarily upon biological activity but will also be based upon the relative amount of the fraction and the physical characteristics of the fraction. For example, a fraction which represents 1 percent of the whole oil would be chosen over a fraction which represents only 0.01 percent of the whole oil if the activity per gram were the same. A fraction of unknown composition would be chosen over a fraction which is probably comprised of known types of PHA hydrocarbons.

Fractionation of Weathered Oil

The weathered oil sample will be fractionated by the same scheme as used for fresh oil, however, fewer fractions will be screened for biological activity. Fractions 1 to 4 from the initial silica gel fractionation of weathered oil would be expected to contain the same types of components as those from fresh oil and would not be subfractionated and screened. If none of the high-molecular-weight fractions from the μ-Styragel™ fractionation of fresh oil are active, those fractions from weathered oil would not be screened. An emphasis will be placed on studying the lower-molecular weight polar fractions from weathered oil which are most apt to contain biologically-active petroleum-degradation products.

Biological Studies

Introduction

At present, the Marine Research Laboratory (MRL) of Battelle, Pacific-Northwest Laboratories, Squim, Washington, is conducting four projects on the fate and effects of oil in marine organisms and the marine environment. Funding for these programs come from ERDA, EPA, and NOAA/BLM. They have emphasized the use of long-term flowing systems for laboratory research and field experiments to better evaluate the impact of hydrocarbons in the natural environment. Studies range from single species laboratory tests to field analyses of populations and communities. They are examining the uptake of specific oil components from water and sediment, as well as their effects on organisms of the Pacific Northwest. This background is noted to demonstrate an understanding of the best possible means of evaluating the impact of petroleum hydrocarbons on marine organisms and communities. This proposal involves only a small aspect of the problem, and our approach is restricted to some degree (at least in the early phases) by limitations on the volumes of hydrocarbon fractions. It is logical, however, to proceed from simple screening tests on numerous fractions to more comprehensive studies on the most significant hydrocarbons.

Test Materials

Battelle Northwest has on hand from other oil projects, a large supply (several barrels) of Prudhoe Bay Crude (PBC) oil, which can be shipped to Columbus. In addition, they will prepare a weathered PBC for similar fractionation and later bioassay tests. The facilities are ideal for the preparation of weathered product and all apparatus is presently available. They will use one or more (if necessary) 250 gal fiberglass tanks to expose an oil layer (about 6 cm thick) to air and sun, while water is constantly flowing beneath the slick at 5-10 gal/min. Seawater will be constantly sprayed over the surface, and outflow water will exit by the bottom, with a pipe extending from this point to the level of the surface and empyting into the waste treatment pond. The level will, therefore, be automatically maintained and the effluent readily detoxified in the system, as are other substances under investigation. Presumably, a period of 1 month will be adequate to realistically weather the oil, which will be drained into clean 5 gallon cans for shipment to Columbus.

Fractions prepared from these two different oils by methods described elsewhere, will then be transported by air to Squim for bioassay tests.

Organism Selection

There are numerous factors to consider in selection of suitable test species, but the nature of the toxicity testing has a significant influence on this process. It is planned that fractions will be continuously produced, and it will be necessary to rapidly utilize a large number of these in biological tests. The most important factors in species selection are, therefore, year-round availability and/or laboratory holding capability. Lifecycles in the cold waters of the Pacific Northwest are generally quite long, and in many species there is only one generation per year (Dungeness crab, benthic amphipods, polychaetes, etc.). We have had considerable experience with the mysid, *Neomysis awatschensis* and the benthic amphipod, *Anonyx laticoxae*. Both crustaceans have demonstrated high sensitivity to petroleum hydrocarbons, and we are aware of their availability, reproductive cycle, and requirements for laboratory maintenance. Amphipods are readily available from October through March, and the mysids are most easily collected during the remainder of the year. We have constantly maintained cultures of both species, such that field collections may be supplemented during periods of low availability. It will be possible to conduct tests on all fractions with at least one of these species from field collections, and adequate overlaps in toxicity data will be provided by careful selection of testing periods plus cultured organisms. To obtain additional comparative sensitivity data, we will subject other adult or larval crustaceans to the fractions shown to be most toxic. The shrimp, *Crago* and *Pandalus* and larvae of the Dungeness crab (*Cancer magister*) will be tested.

Experimentation

The primary emphasis in this testing will be to provide data on the relative toxicities of a large number of fractions from both fresh and weathered PBC oil. It is, therefore, best to utilize well-known and accepted bioassay techniques as described in Standard Methods (APHA, 1971). Care will be taken to check pH, dissolved oxygen, and weight to volume ratios in these tests. Water temperature will be controlled by placing the test aquaria in large water tables receiving flowing seawater by ambient temperature. Temperatures of our system range from approximately 8 to 13 C and vary by less than one degree per month, thus, assuring quite constant conditions during any given test. While reduction in temperature would be difficult, a heat-exchanger (available) can be used to regulate all tests to the same temperature (13 C). Probably little would be gained by conducting all tests at the same temperature, considering the relatively small natural range, and this procedure would require longer acclimation of organisms collected during the winter. The effects of this temperature alteration would probably be greater than any differences related to modification of toxicant effects by temperature.

During the first year of testing, only relatively small quantities of hydrocarbon fractions will be available for toxicity tests. Static bioassay systems must, therefore, be utilized to conduct the numerous screening experiments. While these conditions are not as acceptable as flow-through exposures, they have proven their worth in the past, particularly in regards to producing comparative data. It would, in fact, be a waste of time and effort to produce large volumes of fractions which may later be found to be harmless.

Fractions will be supplied in the solvent dimethyl sulfoxide (DMSO), which has been shown to have very low toxicity (37,000-72,000 ppm) for a variety of fish (EPA, 1971). Ten or more organisms will be placed in 6 liter aquaria containing 2 liters of seawater, and the fractions will be added to provide concentrations of 10, 1, 0.5, 0.1, and 0 ppm. The control series will contain the maximum amount of DMSO used in the contaminated aquaria. If the 96-hour LC_{50} value is found to be less than 1 ppm, a replicate bioassay utilizing additional low concentrations will be conducted.

While 96-hour static bioassays are in progress, frequent observation and recording of mortality will be supplemented with comments on gross behavioral abnormalities. The onset of adverse effects is often demonstrated by spiral swimming, hyper- or hypo-activity. In some cases, different specific hydrocarbons impact an organism at variable rates and produce diverse abnormalities. One may begin to correlate similar responses with a given class of hydrocarbons, and the effort in recording these observations is minimal.

It will be necessary to use calculated or nominal concentrations in the preparation of test solutions, but in the event the findings are particularly interesting, or perhaps difficult to explain, samples of the initial media will be taken and preserved. Final (96-hour) samples will be treated in the same manner, such that volatility calculations can later be made on fractions found to be significantly toxic. While space or time will not allow all tissue samples to be saved on termination of tests, living organisms from bioassays of significantly toxic fractions will be washed with distilled water, blotted and frozen for later analyses. In general terms, significantly toxic is defined as fractions which produce 50 percent or greater mortality at concentrations below 1 ppm. Of course, the lower the LC_{50} concentration, the greater will be our concern for water and tissue sampling.

The general approaches described above have proven to be very productive in early studies on the effects of four API reference oils (Anderson et al., 1974). Both Dr. Anderson and Dr. Warner collaborated in these studies to evaluate the comparative toxicities of the 4 oils and the comparative sensitivities of 3 fish and 3 crustaceans. Analyses of tissue samples from these early bioassay experiments provided evidence that naphthalenes were compounds accumulated to a high degree by all species. Follow-up studies using tissue accumulation as a clue showed that these compounds were very toxic to the marine organisms and were retained for a considerable period.

This investigation will also emphasize the study of compounds found to accumulate in tissues, since they are probably of greater significance than the numerous other compounds present in each fraction. One can not be expected to identify each and every hydrocarbon in even the most toxic fractions, but tissue analyses will provide a basis for comparisons between fractions and lead to tests with one or a few compounds. In later phases of the research, specific compounds or component classes implicated in bioassays can be used in long-term studies on growth and reproduction to determine threshold levels. While the extraction methods of this proposal differ from those in earlier hydrocarbon research, the biological approaches follow the same logical step-by-step procedure used successfully in studies on naphthalenes leading from acute toxicity to long-term uptake and release kinetics and effects on the growth and reproduction of several marine species (reviewed in Anderson, 1977).

Biological Screening

In vitro biological screening tests will be used to reconfirm the activity of toxic fractions before the fractions are tested on marine organisms. Our *in vitro* testing procedures are as follows.

Toxicity Screening

The Battelle Columbus Laboratory, Biomedical Sciences Section, has developed a rapid *in vitro* mammalian cell toxicity assay (prescreen confluency assay --PSC) using BAlB/C 3T3 fibroblasts. This assay allows for the rapid determination of toxicity of large numbers of materials in wide ranges of concentrations with great reproducibility. The assay is based upon the ability of cells treated with selected materials or concentration of an unknown toxicant to form a confluent monolayer in a tissue culture vessel in a selected period of time as compared to the degree of confluency achieved by control or untreated cells.

In essence, the assay is conducted by seeding BALB/C 3Tc cells into multiwell Falcon tissue culture plates (No. 3008). The plates have 24 cells measuring 16 mm in diameter and 10 mm in depth. Subconfluent monolayers of cells are established in the plate by seeding 5×10^3 cells per well and allowing them to grow for 24 hours. At this time, the growth medium is removed and replaced with fresh growth media containing a desired known concentration of the toxicant or unknown fraction applied as a DMSO solution. Six of the wells or one row are set aside as control wells and thus receive no toxicant in the replacement media. The duration of the treatment is 24 hours after which the toxicant is removed, the cells washed, refed with fresh media and re-incubated. When all monolayers in the control wells reach 90-100 percent confluency (approximately 6 days), all of the wells in the plate are fixed with methanol and the cells stained with giemsa stain. The plates are then scored on a basis of percentage of surface area covered by the cell monolayer. The toxicity is expressed as a function of the concentration of the test material which would yield 50 percent confluency as compared to the untreated control wells.

Each fraction to be screened will be assayed initially at the highest practical level. If it is inactive no further toxicity assays will be made. Active fractions will be rescreened at lower levels. Representative known petroleum toxicants, e.g. 2-methylnaphthalene, 2-methylphenanthrene, and 2,4-xylenol, will be screened concurrently for comparison.

Bacterial Mutagenesis Assay

It has recently been documented [McCann, Choi, Yamasaki, and Ames, Proc. Nat. Acad. Sci., Medical Sciences 72 5135 (1975)], that most mammalian carcinogens act as bacterial mutagens. The potential mutagens contained within each of the fractions studied will be detected by means of a special set of five Salmonella strains (TA-1535, TA-1537, TA-1538, TA-98, and TA-100) obtained from Dr. Bruce Ames (Biochemistry Department, University of California, Berkeley, California). The tester strains are histidine deficient and will be used for the purpose of detecting frameshift and base-pair substitution mutations as indicated by reversion to prototrophy. These systems have been selected for their sensitivity and specificity to be reverted back to the wild type by particular mutagens. The known carcinogens, 2-nitrosofluorene and benzo(a)pyrene-4,5-oxide, are highly active in this direct assay.

The assay has also been adapted for use in detecting compounds which may be potential mutagens. These are compounds which are not in themselves carcinogenic or mutagenic but are converted to active mutagens by mammalian metabolism especially by the TPNA-dependent microsomal enzymes of the liver. Since these specific bacteria do not have the mammalian microsomal enzyme system, mammalian liver homogenates are added to the system to activate the non-mutagenic parental compounds to possible mutagens. The activation system is derived from the rat liver. Benzo(a)pyrene, which is not active in the direct assay, is highly active in the microsome-activated assay. Compounds which are active in the direct assay are also active in the microsome-activated assay.

The experimental procedure to be used for detecting mutagens from various fractions will be a plate incorporation assay. Each sample will be tested against each of the five tester strains in the presence of the liver microsome activation system. The test is conducted by incorporating the bacterial tester strain, the liver microsome system, and a DMSO solution of the fraction being assayed into 2 ml of molten agar. The agar is then poured over the surface of a minimal agar medium and permitted to solidify. By adding the fraction to the agar while the agar is still molten, water-insoluble as well as water-soluble chemicals can be screened effectively. The plate is incubated for 48 hours and observed. Mutagenicity is indicated by mutagen-induced revertants. These will be evenly distributed throughout the plate and are counted. The test is semiquantitative and can be used to prepare a dose response curve.

All fractions will be evaluated in all bacterial indicator systems in the presence of the liver activating system. A preliminary assay will be conducted using 1, 10, and 100 μl of a 10% DMSO solution of each fraction if available. The results of the preliminary dose response will serve as a guide for any more detailed dose response determinations that may be needed. Controls will be included at all times consisting of a control for the spontaneous reversion rate for each tester strain where the potential mutagen is omitted, a sterility check of the potential mutagen and microsomal preparation, and positive controls consisting of known mutagens which do and do not require metabolic activation, e.g. benzo(a)pyrene and 2-nitrofluorene.

For the assay of subfractions, only the tester strain that was most responsive to the starting fraction need be used.

Characterization of Fractions

The methods used to characterize the most active fractions will depend to a large extent upon where they appear in the fractionation scheme. An indication of their molecule size, polarity, and solubility will be obtained from the various modes of fractionation. The detector responses will give some clues to their molecular structure.

Infrared (IR) analysis will be used as a general technique for getting additional clues to functional groups. Fourier-transform infrared (FT-IR) analysis will be used for sub-milligram sized samples. Gas chromatography combined with mass spectrometry (GC-MS) analysis, with and without derivatization, will be used for fractions having relatively low molecular weight or low polarity. Nuclear magnetic resonance (NMR) spectrometric analysis to determine the types of protons in the fractions will be used whenever appropriate. FT-NMR will be used for small samples.

In most cases it is expected that the active fractions will be comprised of various similar molecular species precluding single compound identification. Whenever practical, additional subfractionation will be carried out in an effort to identify the major individual components.

Literature Cited

(1) Anderson, J. W., Neff, J. M., Cox, B. A., Tatem, H. E., and Hightower, G. M., "Characteristics of Dispersion and Water-Soluble Extracts of Crude and Refined Oils and Their Toxicity on Estuarine Crustaceans and Fish", Mar. Biol., 27, 75-88 (1974).

(2) Anderson, J. W., "Responses to Sublethal Levels of Petroleum Hydrocarbons: Are They Sensitive Indicators and Do They Correlate With Tissue Contamination?" In "Fate and Effects of Petroleum in Marine Ecosystems and Organisms", Pergamon Press, New York, in press.

(3) Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington (1971), 874 pp.

(4) Water Quality Criteria Data Book, Vol. 3. Effects of Chemicals on Aquatic Life, Water Pollution Control Research Series, Environmental Protection Agency, 18050GWV05/71, 526 pp.

FUTURE RESEARCH

It is hoped that this work will lead to a better understanding of the potentially hazardous compounds in petroleum. Therefore, future research will build on the present studies in that once certain fractions have been identified as being toxic, both analytical and biological studies will be intensified on these fractions.

Analytical studies will emphasize the identification of semi-polar and polar compounds present in these toxic fractions. High performance liquid chromatographic techniques will be used to isolate the toxic compounds, and FT-IR, FT-NMR and mass spectrometry will be used for identification. Biological studies will be designed to study the long term effects of these selected fractions or individual compounds on both growth and reproduction of marine species.

ORGANIZATION AND PROGRAM DIRECTION

Battelle assumes corporate responsibility for all projects undertaken for its sponsors. This philosophy of corporate responsibility has been a key factor in Battelle's ability to manage projects and to bring them to a successful conclusion to the satisfaction of the sponsoring organization. The implementation of the program described in the proposal will require organized technical input as well as capable managerial skills. Battelle staff members regularly organize themselves into groups appropriate to the solution of a particular problem. There are no administrative barriers that prevent drawing upon the expertise necessary to bring this program to a successful conclusion.

The proposed program will be conducted by Battelle Columbus' Organic, Analytical, and Environmental Chemistry Section under Section Manager, Dr. Richard A. Nathan. Program organization is shown in Figure 4.

Dr. J. S. Warner, Senior Researcher in the Organic, Analytical, and Environmental Chemistry Section, will serve as Principal Investigator. He will be responsible for planning and technical direction of the program, work scheduling and coordination, and liaison and communication with the

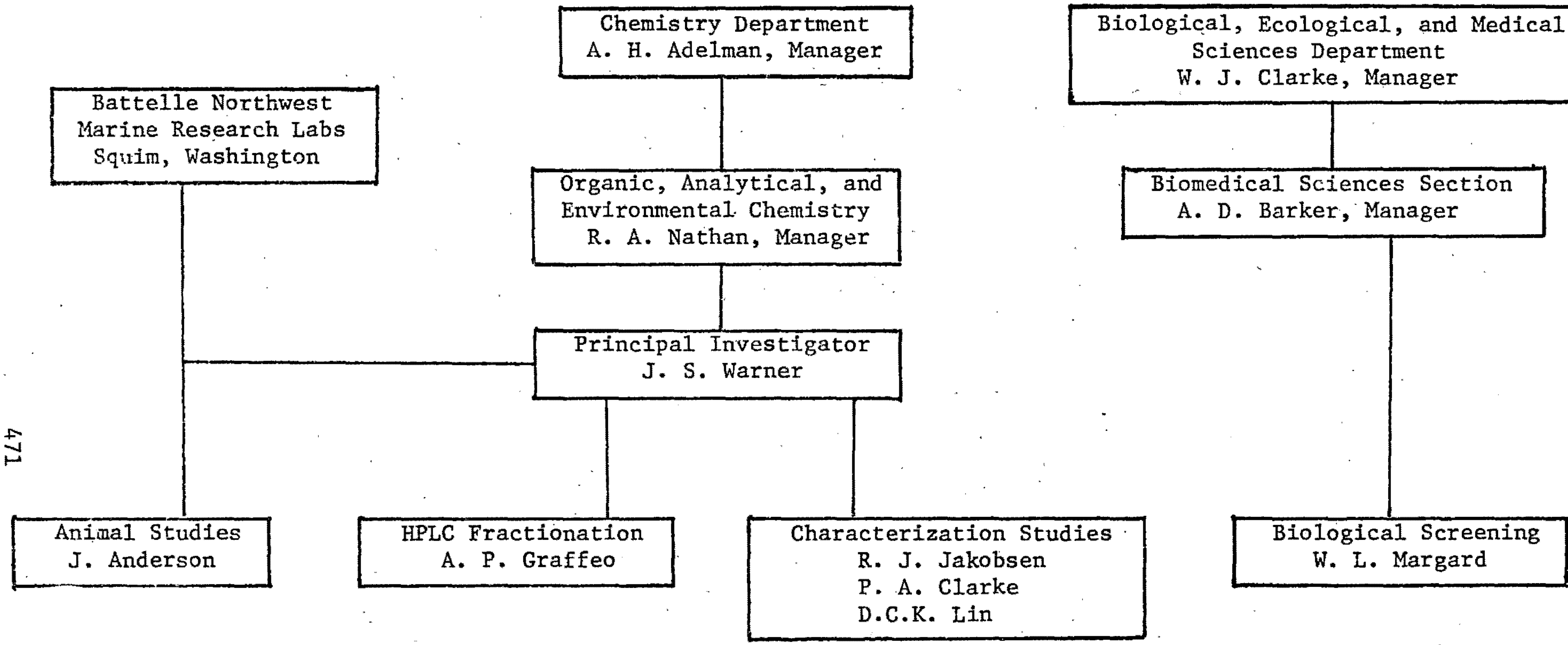


FIGURE 4. ORGANIZATION AND PROGRAM DIRECTION

NOAA Project Officer. Dr. Warner has specialized for the last eight years in the separation and identification of organic compounds using chromatographic and spectrometric techniques. He has had primary responsibility for numerous analytical programs including various programs involving the determination of trace petroleum components in marine samples. Through the latter programs, he has developed a national reputation and keen interest in advancing the state-of-the-art in evaluating the effects of petroleum components on the environment.

Dr. A. P. Graffeo, Research Chemist in the Organic, Analytical, and Environmental Chemistry Section, will be responsible for the required high pressure liquid chromatography which is his major area of expertise. Dr. Graffeo has been involved in developing HPLC methods for determining a wide variety of materials including aflatoxins, vitamins, analgesics, barbituates, sulfa drugs, amino acids, drug metabolites, munitions wastes, and aromatic hydrocarbons.

Mr. W. L. Margard, Staff Microbiologist in the Biomedical Sciences Section will be responsible for the biological screening required for the program. Mr. Wargard has worked with the various Salmonella tester strains during the past two years and has been successfully applying them for mutagenesis testing. He was also implemental in developing the rapid mammalian cell toxicity assay that will be used in the program.

For the characterization studies, Dr. Warner will be assisted by Mr. R. J. Jakobsen (IR and FT-IR), Dr. P. A. Clarke (NMR and FT-NMR), and Dr. D.C.K. Lin (MS and GC-MS), all of whom have had extensive experience in their respective areas of expertise.

The Biological Studies, which will be used extensively in this phase of the research, will be conducted by Dr. Jack Anderson at Battelle Northwest Marine Research Laboratory under a subcontract from Battelle Columbus Laboratories. The extensive experience of Dr. Anderson, with such studies and previous collaboration with our group, make this an ideal research situation.

REPORTS AND MEETINGS

The progress of the work will be reported in bimonthly letter reports and a comprehensive final report. We also recommend that a meeting with the Project Officer be held at Battelle at least once during the program.

The letter report will include a brief summary and discussion of the work accomplished during the period, a discussion of plans for the coming two months, and a cost summary. Four copies of the report will be mailed to the Project Officer and one copy to the Contracting Officer on or before the 15th of the month following the report period.

The final report will summarize all of the work performed under the entire contract and give interpretations and conclusions supplemented by appropriate chromatograms, spectra, and tabulations of data. Also included will be a discussion of how the results can benefit the Alaskan OCS program and what additional studies are recommended. Four copies of the final report will be mailed to the Project Officer and one copy to the Contracting Officer on or before the last day of the contract period.

Publications

Journal Articles:

Anderson, J. W., and D. J. Reish. 1967. The effects of varied dissolved oxygen concentrations and temperatures on the wood-boring isopod genus *Limnoria*. *Mar. Biol. 1:*56-59.

Anderson, J. W., and G. C. Stephens. 1969. Uptake of organic material by aquatic invertebrates. VI. Role of epiflora in the apparent uptake of glycine by marine crustaceans. *Mar. Biol. 4:*243-249.

Bedford, W. B., and J. W. Anderson. 1972. Physiological response of the estuarine clam, *Rangia cuneata,* to salinity. I. Osmoregulation. *Physiol. Zool. 45:*225-260.

Anderson, J. W., and W. B. Bedford. 1973. The physiological response of the estuarine clam, *Rangia cuneata,* to salinity. II. Uptake of glycine. *Biol. Bull. 144:*229-247.

Petrocelli, S. R., A. R. Hanks, and J. W. Anderson. 1973. Uptake and accumulation of an organochlorine insecticide (Dieldrin) by an estuarine mollusc, *Rangia cuneata. Bull. Environ. Contam. Toxicol. 10:*315-320.

Anderson, J. W., J. M. Neff, B. A. Cox, H. E. Tatem, and G. M. Hightower. 1974. Characteristics of dispersions and water-soluble extracts of crude and refined oils and their toxicity on estuarine crustaceans and fish. *Mar. Biol. 27:*75-88.

Petrocelli, S. R., A. Hanks, and J. W. Anderson. 1974. DDT and Dieldrin residues in selected biota from San Antonio Bay, Texas - 1972. *Pestic. Monit. J.*

Roesijadi, G., S. R. Petrocelli, J. W. Anderson, B. J. Presley, and R. Sims. 1974. Survival and chloride ion regulation of the porcelain crab *Petrolisthes armatus* exposed to mercury. *Mar. Biol. 27:*213-217.

Anderson, R. D., and J. W. Anderson. 1975. Effects of salinity and selected petroleum hydrocarbons on the osmotic and chloride regulation of the American oyster, *Crassostrea virginica. Physiol. Zool. 48:*420-430.

Neff, J. M., and J. W. Anderson. 1975. An ultraviolet spectrophotometric method for the determination of naphthalene and alkylnaphthalenes in the tissues of oil-contaminated marine animals. *Bull. Environ. Contam. Toxicol. 14:*122-128.

Petrocelli, S. R., J. W. Anderson, and A. R.Hanks. 1975. Controlled food chain transfer of Dieldrin residues from phytoplankters to clams. *Mar. Biol. 31:*215-218.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1975. Biomagnification of Dieldrin residues by food chain transfer from clams to blue crabs under controlled conditions. *Bull. Environ. Contam. Toxicol. 13:*108-116.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1975. Seasonal fluctuations of Dieldrin residues in the tissues of the marsh clam *Rangia cuneata* from a Texas estuary. *Texas J. Sci. 26:*443-448.

Green, F. A., Jr., J. W. Anderson, S. R. Petrocelli, B. J. Presley, and R. Sims. 1976. Effect of mercury on survival, respiration and growth of postlarval white shrimp *Penaeus setiferus*. *Mar. Biol. 37:*75-81.

Neff, J. M., D. Dixit, B. A. Cox, and J. W. Anderson. 1976. Accumulation and release of petroleum-derived aromatic hydrocarbons by four species of marine animals. *Mar. Biol. 38:*279

Roesijadi, G., J. W. Anderson, S. R. Petrocelli, and C. S. Giam. 1976. Osmoregulation of the grass shrimp *Palaemonetes pugio* exposed to polychlorinated biphenyls (PCBs). I. Effect on chloride and osmotic concentrations and chloride and water exchange kinetics. *Mar. Biol. 38:*343-355.

Roesijadi, G., J. W. Anderson, and C. S. Giam. 1976. Osmoregulation of the grass shrimp *Palaemonetes pugio* exposed to polychlorinated biphenyls (PCBs). II. Effect on free amino acids. *Mar. Biol. 38:*357-363.

Roesijadi, G., S. R. Petrocelli, J. W. Anderson, C. S. Giam, and G. E. Neff. 1976. Toxicity of polychlorinated biphenyls (Aroclor 1254) to adult, juvenile and larval stages of the shrimp *Palaemonetes pugio*. *Bull. Environ. Contam. Toxicol. 15:*297-304.

Rossi, S. S., J. W. Anderson, and G. S. Ward. 1976. Toxicity of water-soluble fractions of four test oils for the polychaetous annelids, *Neanthes arenaceodentata* and *Capitella capitata*. *Environ. Pollut. 10:*9-18.

Rossi, S. S., and J. W. Anderson. 1976. Toxicity of water-soluble fractions of No. 2 Fuel oil and South Louisiana Crude oil to selected stages in the life history of the polychaete, *Neanthes arenaceodentata*. *Bull. Environ. Contam. Toxicol. 16:*18-24.

Tatem, H. E., J. W. Anderson, and J. M. Neff. 1976. Seasonal and laboratory variations in the health of grass shrimp, *Palaemonetes pugio:* dodecyl sodium sulfate bioassay. *Bull. Environ. Contam. Toxicol. 16:*368-375.

Ernst, V., J. M. Neff, and J. W. Anderson. 1977. Effects of water-soluble fractions of No. 2 Fuel oil on the development of the fish *Fundulus similis*. *Environ. Pollut.* (In press)

Lee, R. F., and J. W. Anderson. 1977. Fate and effect of naphthalenes in controlled ecosystem enclosures. *Bull. Mar. Sci.* (In press)

Lucu, C., G. Roesijadi, and J. W. Anderson. 1977. Sodium kinetics in the shrimp *Palaemonetes pugio*. I. Steady state and non-steady state experiments. *J. Comp. Physiol.* (In press)

Rossi, S. S., and J. W. Anderson. 1977. Accumulation and release of fuel oil derived aromatic hydrocarbons by the polychaete, *Neanthes arenaceodentata* (Moore). *Mar. Biol. 39:*51-55.

Books:

Anderson, J. W. 1975. *Laboratory Studies on the Effects of Oil on Marine Organisms: An Overview.* API Publication No. 4249. American Petroleum Institute, Wash., D.C.

Petrocelli, S. R., and J. W. Anderson. 1976. Chapter 11: Distribution and translocation of residues of a chlorinated hydrocarbon insecticide, Dieldrin, among water, sediments and estuarine organisms from San Antonio Bay, Texas. pp. 185-218 in: *Shell Dredging and Its Influence on Gulf Coast Environments* (A. Bouma, ed.). Gulf Publishing Company, Houston, Texas.

Petrocelli, S. R., J. W. Anderson, and J. M. Neff. 1977. Chapter 20: Radiochemical Tracers in Marine Biology. pp. 921-968 in: *Radiotracer Techniques and Applications, Vol. II* (E.A. Evans & M. Muramatsu, ed.). Marcel Dekker, N.Y.

Technical Reports:

Anderson, J. W. 1973. *Uptake and Depuration of Specific Hydrocarbons from Oil by the Bivalves* Rangia cuneata *and* Crassostrea virginica. Background paper submitted to the National Academy of Science Workshop on Inputs, Fates and Effects of Petroleum in the Marine Environment, Airlie, Virginia, May 22-25, 1973.

Hopkins, S. H., J. W. Anderson, and K. Horvath. 1973. *The Brackish Water Clam* Rangia cuneata *as Indicator of Ecological Effects of Salinity Changes in Coastal Waters.* Contract Report H-73-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Petrocelli, S. R., and J. W. Anderson. 1973. Effects of shell dredging on the distribution and accumulation of chlorinated hydrocarbons in estuarine organisms, Vol. IV. In: *U.S. Army Corps of Engineers Environmental Impact Assessment of Shell Dredging in San Antonio Bay, Texas.*

Anderson, J. W., R. G. Riley, R. M. Bean, J. W. Blaylock, and S. L. Kiesser. 1977. *Laboratory and Field Studies on the Effects of Petroleum Hydrocarbons on Benthic Marine Invertebrates.* Progress Report to the U.S. Environmental Protection Agency, Energy Office, Wash., D.C.

Symposium Proceedings:

Anderson, J. W., J. M. Neff, and S. R. Petrocelli. 1974. Sublethal effects of oil, heavy metals, and PCBs on marine animals. pp. 83-121 in: *Survival in Toxic Environments* (M.A.Q. Khan and J. P. Bederka, Jr., ed.). Academic Press, New York.

Anderson, J. W., J. M. Neff, B. A. Cox, H. E. Tatem, and G. M. Hightower. 1974. The effects of oil on estuarine animals: Toxicity, uptake and depuration, respiration. pp. 285-310 in: *Pollution and Physiology of Marine Organisms* (F. J. and W. B. Vernberg, ed.). Academic Press, New York.

Anderson, J. W., R. Clark, and J. Stegeman. 1974. Petroleum hydrocarbons. pp. 36-75 in: *Marine Bioassays Workshop Proceedings* (API, EPA, MTS). Marine Technological Society, Wash., D.C.

Anderson, J. W. 1975. The uptake and incorporation of glycine by the gills of *Rangia cuneata* (Mollusca: Bivalvia) in response to variations in salinity and sodium. pp. 239-258 in: *Physiological Ecology of Estuarine Organisms* (F. J. Vernberg, ed.). University of South Carolina Press, Columbia, S.C.

Cox, B. A., J. W. Anderson, and J. C. Parker. 1975. An experimental oil spill: The distribution of aromatic hydrocarbons in the water, sediment and animal tissues within a shrimp pond. pp. 607-612 in: *Proceedings of 1975 Conference on Prevention and Control of Oil Pollution* (API, EPA, USCG). American Petroleum Institute, Wash., D.C.

Neff, J. M., and J. W. Anderson. 1975. Accumulation, release and distribution of benzo(a)pyrene-C^{14} in the clam *Rangia cuneata*. pp. 469-471 in: *Proceedings of 1975 Conference on Prevention and Control of Oil Pollution* (API, EPA, USCG). American Petroleum Institute Wash., D.C.

Anderson, J. W. 1976. Effects of petroleum hydrocarbons on the growth of marine organisms. pp. 157-165 in: *Petroleum Hydrocarbons in the Marine Environment* (A.D. McIntyre and K. Whittle, ed.). Rapp. P.-v. Reun. Cons. int. Explor. Mer, 171.

Anderson, J. W., and J. M. Neff. 1976. Accumulation and release of petroleum hydrocarbons by edible marine animals. pp. 1461-1469 in: *Proceedings International Symposium on Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Vol. III.* Commission European Communities, Luxembourg.

Anderson, R. D., and J. W. Anderson. 1976. Oil bioassays with the American oyster *Crassostrea virginica* (Gmelin). pp. 38-42 in: *Proceedings of the National Shellfisheries Association, Vol. 65.* Waverly Press, Easton, Md.

Neff, J. M., J. W. Anderson, B. A. Cox, R. B. Laughlin, Jr., S. S. Rossi and H. E. Tatem. 1976. Effects of petroleum on survival, respiration and growth of marine animals. pp. 515-539 in: *Sources, Effects & Sinks of Hydrocarbons in the Aquatic Environment.* American Institute of Biological Sciences, Arlington, Va.

Anderson, J. W. 1977. Responses to sublethal levels of petroleum hydrocarbons: Are they sensitive indicators and do they correlate with tissue contamination? pp. in: *Fate and Effects of Petroleum in Marine Ecosystems and Organisms* (D. Wolfe, ed.). Pergamon Press, New York. (In press)

Anderson, J. W., L. J. Moore, J. W. Blaylock, D. L. Woodruff, and S. L. Kiesser. 1977. Bioavailability of sediment-sorbed naphthalenes to the sipunculid worm, *Phascolosoma agassizii.* pp. in: *Fate and Effects of Petroleum in Marine Ecosystems and Organisms* (D. Wolfe, ed.). Pergamon Press, New York. (In press)

Anderson, J. W., D. B. Dixit, G. S. Ward and R. S. Foster. 1977. Effects of petroleum hydrocarbons on the rate of heart beat and hatching success of estuarine fish embryos. pp. 241-258 in: *Physiological Responses of Marine Biota to Pollutants* (F. J. and W. B. Vernberg, A. Calabrese and F. P. Thurberg, ed.). Academic Press, New York.

Dixit, D., and J. W. Anderson. 1977. Distribution of naphthalenes within exposed *Fundulus similus* and correlations with stress behavior. pp. 633-636 in: *Proceedings of 1977 Oil Spill Conference.* American Petroleum Institute, Wash., D.C.

Neff, J. M., and J. W. Anderson. 1977. The effects of copper (II) on molting and growth of juvenile and lesser blue crabs *Callinectes similis* Williams. pp. in: *Proceedings of NSF/IDOE Biological Effects Program Workshop* (Texas A&M University, May 16-19, 1976). In press.

"Gliotoxin, XI. A Related Antibiotic from Penicillium Terlikowski: Gliotoxin Monoacetate", Johnson, J. R., Kidwai, A. R., and Warner, J. S., J. Am. Chem. Soc., 75, 2110 (1953).

"Preparation and Characterization of 4,4'-Bis(dimethylamino)- and 4,4'-Bis(diethylamino)-benzophenone Oxime", R. D. Morin, J. S. Warner, and R. H. Poirier, J. Org. Chem., 21, 616 (1956).

"Sensitivity to Vaginal Jellies; Correlation Between Clinical Tests and Animal Tests", J. H. Holzaepfel, J. S. Warner, J. A. Buxton, and J. A. Howard, J. Am. Pharm. Assn., Sci. Ed., 47, 423 (1958).

"Sensitivity to Vaginal Jellies; A Note on the Therapeutic Index of Spermicides", J. H. Holzaepfel, J. S. Warner, J. A. Buxton, and J. A. Howard, J. Am. Pharm. Assn., Sci. Ed., 48, 486 (1959).

"Chemistry of Carbon Diselenide. I. Reactions with Primary Amines", J. S. Warner, J. Org. Chem., 28, 1642 (1963).

"Chemistry of Carbon Diselenide. II. Alkylation of Substituted Selenoureas", J. S. Warner and T. F. Page, Jr., J. Org. Chem., 31, 606 (1966).

"The Isolation of 4-Methylimidazole from Caramel Color and Its Determination by Thin-Layer and Gas Liquid Chromatography", R. A. Wilks, Jr., A. J. Shingler, L. S. Thurman, and J. S. Warner, J. Chromatogr., 87, 411 (1973).

"Quantitative Determination of Hydrocarbons in Marine Organisms", J. S. Warner, Presented at Marine Pollution Monitoring Symposium and Workshop held at NBS, Gaithersburg, Maryland, May 13-17, 1974. NBS Spec. Publ. 409, pp 195-196 (1974).

"Determination of Sulfur-Containing Petroleum Components in Marine Samples", J. S. Warner, Proc. of 1975 Joint Conference on Prevention and Control of Oil Spills, pp 97-101, American Petroleum Institute.

"Determination of Aromatic Hydrocarbons in Marine Samples", J. S. Warner, P. W. Jones, and P. A. Clarke, Presented at NBS' workshop on Standard Reference Materials for Offshore Drilling-Petroleum held at Santa Barbara, California, October 6-7, 1975.

"Determination of Aliphatic and Aromatic Hydrocarbons in Marine Organisms", J. S. Warner, Anal. Chem., 48, 578 (1976).

Abstracts:

Petrocelli, S. R., and J. W. Anderson. 1971. The uptake of Dieldrin by *Rangia cuneata*. *Amer. Zool. 11*:694.

Bedford, W. B., and J. W. Anderson. 1972. Adaptive mechanisms of the estuarine bivalve, *Rangia cuneata,* to a salinity stressed environment. *Amer. Zool. 12*:721.

Roesijadi, G., S. R. Petrocelli, and J. W. Anderson. 1973. The effects of mercuric chloride on the survival and chloride ion regulation of *Petrolisthes armatus* (Crustacea: Porcellanidae). *Amer. Zool. 13:*1307.

Tatem, H. E., and J. W. Anderson. 1973. The toxicity of four oils to *Palaemonetes pugio* (Holthuis) in relation to uptake and retention of specific petroleum hydrocarbons. *Amer. Zool. 13:*1307.

Cox, B. A., and J. W. Anderson. 1973. Some effects of #2 Fuel oil on the brown shrimp *Penaeus aztecus*. *Amer. Zool. 13:*1308.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1973. Interactions of dieldrin with sediments and biota of an estuarine system. *Amer. Zool. 13:*1326.

Young, L., and J. W. Anderson. 1974. Influence of salinity and temperature on the O_2 consumption of *Neanthes arenaceodentata* Moore. *Amer. Zool. 14:*1260.

Anderson, R. D., and J. W. Anderson. 1974. Physiological responses of the American oyster, *Crassostrea virginica* Gmelin, to salinity changes. *Proc. Natl Shellfisheries Assn. 64:*1.

Anderson, R. D., and J. W. Anderson. 1974. Uptake and depuration of petroleum hydrocarbons by the American oyster, *Crassostrea virginica* Gmelin. *Proc. Natl Shellfisheries Assn. 64:*1.

Hopkins, S. H., J. W. Anderson, and K. Horvath. 1974. Biology of the clam *Rangia cuneata:* What we now know and what it means. *Proc. Natl Shellfisheries Assn. 64:*4.

Neff, J. M., and J. W. Anderson. 1974. Uptake and depuration of petroleum hydrocarbons by the estuarine clam *Rangia cuneata*. *Proc. Natl Shellfisheries Assn. 64*:6.

Petrocelli, S. R., J. W. Anderson, and A. R. Hanks. 1974. Biological magnification of dieldrin in a two-part food chain. *Proc. Natl Shellfisheries Assn. 64*:7.

Young, L., and J. W. Anderson. 1976. Temperature, salinity and oil effects on the ingestion, egestion and growth of *Neanthes arenaceodentata* (Moore). *Amer. Zool. 16:*238.

- "High Performance Liquid Chromatographic Separation of Phenylthiohydantoin Derivatives of Amino Acids". A. P. Graffeo, A. Haag, and B. L. Karger, Anal. Lett., 6 (6), 505 (1973).

- Instrumentation in Amino Acid Sequencing, B. L. Karger and A. P. Graffeo, J. Bridgen and M. D. Waterfield, eds., Academic Press, Ltd., (1976).

- "Urinary Analysis of Indole Compounds by High Performance-Liquid Chromatography with Fluorescence Detection", A. P. Graffeo and B. L. Karger, Clin. Chem., 22 (1976), 184.

- "The Analysis of Benzoylecgonine in Urine by HPLC and GC/MS", A. P. Graffeo, D. C. K. Lin, and R. L. Foltz, J. Chromatog. 126, (1976), 717.

- "The Separation of Ionic Compounds by High Performance Reverse Phase Liquid Chromatography", A. P. Graffeo and B. L. Karger, Presented to the 1st Chemical Congress of the North American Continent, Mexico City, December, 1975.

- "The Quantitation of Drugs and Their Metabolites by HPLC and GC/MS", A. P. Graffeo, D. C. K. Lin, and R. L. Foltz, Presented at the 11th International Symposium on the Advances in Chromatography, Houston, Texas, November, 1976.

- "High Performance Liquid Chromatography", Short course presented to A.C.S., Cleveland Section, November, 1975.

- "Characterization of Off-Gases from Hot-Melt Adhesives", P. E. Strup, A. P. Graffeo, and P. W. Jones, Presented at the National ACS Meeting, San Francisco, Calif., Aug. 30, 1976.

- "The Composition of Certain Atmospheric Aerosols", G. D. Mendenhall, P. W. Jones, A. P. Graffeo, W. E. Schwartz, and W. E. Wilson, Presented at the ACS Bicentennial Meeting, New York, April 4-9, 1976.

Publications

(1) Porter, F. E., Crider, W. L., Mitchell, R. I., and Margard, W. L., "The Dynamic Behavior of Aerosols", Annals of the New York Acad. of Sciences, *105*, 45-87 (1963).

(2) Margard, W. L. and Litchfield, J. H., "Triple Sugar Iron-Urea Agar, A Differential Tube Medium for Confirming Salmonella in Mouse Fecal Samples", Bacteriol. Proc., *128*, (1961).

(3) Schmitt, J. A., Margard, W. L., and Meier, C. A., "Variation in Susceptibility to Experimental Dermatomycosis in Genetic Strains of Mice, I. Preliminary Studies", Mycopthol et Mycol Appl., *18*, 241-245 (1962).

(4) Margard, W. L. and Litchfield J. H., "Occurrence of Unusual Salmonellae in Laboratory Mice", J. Bacteriol., *85*, 1451-1452 (1963).

(5) Margard, W. L., Peters, A. C., Dorko, N., Litchfield, J. H., Davidson, R. S., and Rheins, M. S., "Salmonellosis in Mice - Diagnostic Procedures", Lab. Animal Care, *13* (2), 144-165 (1963).

(6) Margard, W. L. and Peters, A. C., "A Study of Gnotobiotic Mice Monocontaminated with *Salmonella Typhimurium*", Lab. Animal Care, *14* (3), 200-206 (1964).

(7) Margard, W. L. and Longsdon, R. F., "An Evaluation of the Bacterial Filtering Efficacy of Air Filters in the Removal and Destruction of Airborne Bacteria", ASHRAE Journal (May, 1965).

(8) Margard, W. L., "Salmonellosis in Mice - Influence of the Stresses Attendant with Shipping", Lab. Animal Care (1966).

(9) Margard, W. L., "Salmonellosis in Mice - Antagonistic Material Produced by *Aerobacter Cloacae*", Lab. Animal Care (1966).

(10) Margard, W. L. and Litchfield, J. H., "Problems in the Rapid Identification of Salmonella in Clinical Specimens and Foods", Proc. of the Conference on Rapid Identification of Biological Agents, April 12-14, 1966, I. Davis and R. Williams, eds., U.S.A.F. School of Aerospace Medicine, Brooks AFB, Texas (1967).

(11) Margard, W. L., Peters, A. C., Pesut, R. N., and Litchfield, J. H., "Chlortetroacycline Resistance in Enteric Microorganisms in Chickens and Swine", Developments in Ind. Microbiol., *12*, 376-392 (1971).

"Characteristic Infrared Frequencies of 3,3'-Diphenylphthalides in the Region of 200 to 330 cm-1:, R. J. Jakobsen and R. E. Wyant, Applied Spectroscopy, 14, 61 (1960).

"Vibrational Spectra of Benzene Derivatives. I. Parasubstituted Phenols", R. J. Jakobsen and E. J. Brewer, Applied Spectroscopy, 16, 32 (1962).

"Vibrational Spectra of Benzene Derivatives. II. Frequency Assignments in the CsBr Region", R. J. Jakobsen and F. F. Bentley, Applied Spectroscopy, 18, 88 (1964).

"The Use of a Polyethylene Matrix for Studying Dilution and Low Temperature Effects in the Far Infrared", J. W. Brasch and R. J. Jakobsen, Spectrochimica Acta, 22, 1644 (1964).

"Far Infrared Studies of Intermolecular Forces, Dipole-Dipole Complexes", R. J. Jakobsen, and J. W. Brasch, Journal of the American Chemical Society, 86, 3571 (1964).

"In Situ Monitoring of High Pressure Effects by Infrared Spectroscopic and Optical Microscopic Techniques", J. W. Brasch and R. J. Jakobsen, American Society of Mechanical Engineers Preprint, 64-WA/PT-26.

"The Vibrational Spectra of Benzonitrile-d_5", R. J. Jakobsen, Spectrochimica Acta, 21, 127 (1965).

"The Vibrational Spectra of p-Cresol", R. J. Jakobsen, Spectrochimica Acta, 21, 433, (1965).

"Far Infrared Spectra of the Hydrogen Bond of Phenols", R. J. Jakobsen and J. W. Brasch, Spectrochimica Acta, 21, 1753 (1965).

"Far Infrared Spectra of Mecuric Halides and Their Dioxane Complexes", Y. Mikawa, R. J. Jakobsen, and J. W. Brasch, Journal of Chemical Physics, 45, 4528 (1966).

"Infrared Evidence of Polymorphism in Formic Acid Crystals", Y. Mikawa, R. J. Jakobsen, and J. W. Brasch, Journal of Chemical Physics, 45, 4750 (1966).

"Far Infrared Studies of Hydrogen Bonding in Carboxylic Acids. I. Formic and Acetic Acids", R. J. Jakobsen, Y. Mikawa, and J. W. Brasch, Spectrochimica Acta, 23A, 2199 (1967).

"Infrared Spectra and Normal Coordinate Calculation of Crystalline Formic Acid", Y. Mikawa, J. W. Brasch, and R. J. Jakobsen, Journal of Molecular Spectroscopy, 24, 314 (1967).

"The Band Width of the OH Stretching Vibration in Solid Alcohols", R. J. Jakobsen, Y. Mikawa, and J. W. Brasch, Nature, 215, 1071 (1967).

"Chemical Far Infrared Spectroscopy", J. W. Brasch, Y. Mikawa, and R. J. Jakobsen, Applied Spectroscopy Reviews, 1, 187 (1968).

"Polarized Infrared Spectra of Single Crystals Using a Diamond Window High Pressure Cell", R. J. Jakobsen and J. W. Brasch, Spectroscopy Letters, 1, 61 (1968).

"The Effect of Hydrogen Bond Strength on the Frequency of a Hydrogen Bond Stretching Vibration", J. W. Brasch, R. J. Jakobsen, N. T. McDevitt, and W. G. Fateley, Spectrochimica Acta, 24A, 203 (1968).

"High Pressure Infrared Spectroscopy and Hydrogen Bonding", J. W. Brasch, Y. Mikawa, and R. J. Jakobsen, XIII. Colloquim Spectroscopicum Internationale, Ottawa, Hilger Ltd., London, 1968.

"Hydrogen Bonding in Solid Alcohols", R. J. Jakobsen, J. W. Brasch, and Y. Mikawa, Journal of Molecular Structure, 1, 309 (1968).

"The Infrared and Raman Spectra of Pentafluorobenzonitrile", H. F. Shurvell, A. S. Blair, and R. J. Jakobsen, Spectrochimica Acta, 24A, 1257 (1968).

"Past Results and Future Prospects of Far Infrared Studies of Hydrogen Bonding", R. J. Jakobsen, Y. Mikawa, and J. W. Brasch, Applied Spectroscopy, 22, 641 (1968).

"Far Infrared Studies of Hydrogen Bonding in Carboxylic Acids II. The n-Alkyl Acides Propanoic to Undecanoic", R. J. Jakobsen, Y. Mikawa, and J. W. Brasch, Spectrochimica Acta, 25A, 839 (1969).

"Polarized Infrared Spectra of Single Crystals of Propanoic Acid", Y. Mikawa, J. W. Brasch, and R. J. Jakobsen, Journal of Molecular Structure, 3, 103 (1969).

"Lattice Vibrations of Crystalline Formic Acid", Y. Mikawa, and R. J. Jakobsen, J. Mol. Spectroscopy, 33, 178 (1970).

"Infrared Spectroscopy at High Pressures. Polarized Spectra of Single Crystals of Acetonitrile", R. J. Jakobsen and Y. Mikawa, Applied Optics, 9, 17 (1970).

"High Pressure Spectroscopic Studies of Hydrogen Bonding", R. J. Jakobsen, Y. Mikawa, and J. W. Brasch, Applied Spec., 24, 333 (1970).

"Polywater: Proton Nuclear Magnetic Resonance Spectrum", T. F. Page, Jr., R. J. Jakobsen, and E. R. Lippincott, Science, 167, 51 (1970).

"Dynamics of Some Lattice Models of Polywater", J. R. Bates, E. R. Lippincott, Y. Mikawa, and R. J. Jakobsen, J. Chem. Phys., 52, 3731 (1970).

"Polarized Infrared Spectra of Single Crystals of Ethyl Alcohol", Y. Mikawa, J. W. Brasch, and R. J. Jakobsen, Spectrochim. Acta, 27A, 529 (1971).

"Some Evidence for the Existence of Water III", T. F. Page, Jr., and R. J. Jakobsen, J. Coll. and Interface Sci., 36, 427 (1971).

"Polymer Chemistry and Spectroscopy at High Pressures", R. J. Jakobsen, Polymer Characterizations: Interdisciplinary Approaches, Plenum Press, New York, 1971, C. Craver, ed.

"The Vibrational Spectra of Propanoic Acid", R. J. Jakobsen, Y. Mikawa, J. R. Allkins, and G. L. Carlson, J. Mol. Struc., 10, 300 (1971).

"The Use of Pressure in Infrared Spectroscopic Studies of Hydrogen Bonding", R. J. Jakobsen and J. E. Katon, Developments in Applied Spectroscopy, Volume 10, Plenum Press, New York, 1972, E. L. Grove and A. J. Perkins, eds.

"Far Infrared Studies of Hydrogen Bonding in Carboxylic Acids III Halogenated Acids", R. J. Jakobsen and J. E. Katon, Spectrochim. Acta, 29A, 1953 (1973).

"The Vibrational Spectra and Structure of α-Chloroacetic Acid", D. Sinha, J. E. Katon, and R. J. Jakobsen, J. Mol. Struc., 20, 381 (1974).

"The Vibrational Spectra and Structure of β- and α-Chloroacetic Acid", D. Sinha, J. E. Katon, and R. J. Jakobsen, J. Mol. Struc., 24, 279 (1975).

PAULINE A. CLARKE

"The Use of High Pressure Liquid Chromatography to Study Chemically Induced Alterations in the Pattern of Benzo[a]pyrene Metabolism", R. I. Freudenthal, A. P. Leber, D. Emmerling, and P. A. Clarke, Chem.-Biol. Interactions, 11, 449 (1975).

"Benzo[a]pyrene Metabolite Identification - An Example of NMR as an Analytical Technique", P. A. Clarke, presented at the Symposium on Polynuclear Aromatic Hydrocarbons, held at Battelle, October 15-17, 1975. The proceedings of this symposium are being published in book form titled "Polynuclear Aromatic Hydrocarbons".

"Determination of Aromatic Hydrocarbons in Marine Samples", J. S. Warner, P. W. Jones, and P. A. Clarke, presented by J.S.W. at NBS' Workshop on Standard Reference Materials for Offshore Drilling - Petroleum held at Santa Barbara, CA, October 6-7, 1975.

"Quantitative Analysis of Morphine in Urine by Gas Chromatography - Chemical Ionization Mass Spectrometry Using N-CD_3 Morphine as an Internal Standard", P. A. Clarke and R. L. Foltz, Clinical Chemistry, 20, 465 (1974).

"An NMR Study of Hydrogen Bonding in the Nitromethane - Methanol System", N. F. Hepfinger and P. A. Clarke, J. Org. Chem., 34, 2572 (1969).

"Intermolecular Hydrogen Bonding Between Nitriles and Methanol. A Nuclear Magnetic Resonance Study", P. A. Clarke and N. F. Hepfinger, J. Org. Chem., 35, 3249 (1970).

"A Three-Dimensional Model for Hydrogen Bonding Systems", P. A. Clarke and N. F. Hepfinger, J. Chem. Ed., 48, 193 (1971).

"A Mass Spectrometric Study of Some Diarylphosphinamides", P. Haake and P. A. Clarke (in preparation).

"A Mass Spectrometric Study of Some Guanidine Derivatives", P. Haake and P. A. Clarke (in preparation).

"An NMR Study of the Relative Hydrogen Bonding Abilities of Acetonitrile and Nitromethane", P. A. Clarke and N. F. Hepfinger (in preparation).

DENIS C. K. LIN

Alan K. Done, Regine Aronow, Joseph N. Miceli, and Denis C. K. Lin, "Pharmacokinetic Observations in the Treatment of Phencyclidene Poisoning", in 'The Management of Poisoned Patient', Science Press, Princeton, N. J. (in press).

Denis C. K. Lin, Rodger L. Foltz, Alan K. Done, Regine Aronow, Edjardo Arcinne, and Joseph N. Meceli, "Mass Spectrometric Analysis of Phencyclidine in Body Fluids of Intoxicated Patients", in 'Quantitative Mass Spectrometry in Life Science", p. 121, A. De Leenheer, Editor, Elsevier Scientific Publishing Company, Amsterdam, The Netherlands,(1977).

Anthony P. Graffeo, Denis C. K. Lin, and Rodger L. Foltz, "Analysis of Benzoylecgonine in Urine by High Performance Liquid Chromatography and Gas Chromatography Mass Spectrometry", J. Chromatography, Vol. 126, 717 (1976).

Rodger L. Foltz, David A. Knowlton, Denis C.K. Lin, and A. F. Fentiman, Jr., "Analysis of Abused Drugs by Selected Ion Monitoring: Quantitative Comparison of Electron Impact and Chemical Ionization", Proceedings of the Second International Conference on Stable Isotopes, p. 536, E. R. Klein and P. D. Klein, Editors. ERDA Conference 751027, National Technical Information Service, 1976.

Don C. DeJongh, Denis C.K. Lin, Pierre LeClair-Lanteigne, and Denis Gravel, "Mass Spectrometry of N-Benzoyl-2-hydroxyalkylamines. Role of the Hydroxylic Hydrogen in the Fragmentation Pattern", Can. J. Chem., Vol. 53, 3175 (1975).

D. C.K. Lin, A. F. Fentiman, Jr., R. L. Foltz, R. D. Forney, Jr., and I. Sunshine, "Quantification of Phencyclidine in Body Fluids by Gas Chromatography - Chemical Ionization Mass Spectrometry and Identification of Two Metabolites", Biomedical Mass Spectrometry, Vol. 2, 206 (1975).

Denis C.K. Lin, M. L. Thomson, and Don C. DeJongh, "Effect of the N-Phenyl Substituent on the Pyrolyses of 1-Phenyl-2-benzothiazolinethione and 1-Phenyl-2-benzothiazolinone", Can. J. Chem., Vol. 53, 2293 (1975).

Denis C.K. Lin and Don C. DeJongh, "The Pyrolysis and Mass Spectrum of 1-(2-Benzothiazole)benzotriazole", J. Org. Chem., Vol. 39, 1780 (1974).

D. C. DeJongh, D. C.K. Lin, and M. L. Thomson, Chapter 12 "Mass Spectra and Pyrolyses of Azoles", in 'Advances in Mass Spectrometry', Vol. 6, p. 99, A. R. West, Ed., Applied Science Publishers, Essex, England, 1974.

Denis C.K. Lin, M. L. Thomson, and Don C. DeJongh, "The Behavior of 1-Phenyl-2-benzimidazolinethione and 1-Phenyl-2-benzimidazolinone Upon Electron Impact and Pyrolysis", Can. J. Chem., Vol. 52, 2359 (1974).

DENIS C. K. LIN (Continued)

Denis C.K. Lin, L. Slotin, K. K. Ogilvie, and J. B. Westmore, "The Study and Characterization of Nucleonsides by Mass Spectrometry III, Comparison Between the Mass Spectra of Trimethylsilyl Derivatives of Purine 2'- and 3'-linked Anhydro, Thioanhydro and Aminoanhydro Nucleosides", J. Org. Chem., Vol. 38 (6) 1118 (1973).

Denis C.K. Lin and John B. Westmore, "Mass Spectral Studies of Binuclear Metal Complex: Copper(I) Carboxylates", Can. J. Chem., Vol. 51, 2999 (1973).

J. B. Westmore, Denis C.K. Lin, and K. K. Ogilvie, "The Study and Characterization of Nucleosides by Mass Spectrometry II. Comparisons Between the Mass Spectra of 3', 5'-substituted, Isomeric Paris of 2,2'-Anhydrouridines", Org. Mass. Spectro., Vol. 7 (3), 317 (1973).

K. K. Ogilvie, L. A. Slotin, J. B. Westmore, and D. Lin, "Synthesis of 8,3'-Thioanhydroguanosine", Can. J. Chem., Vol. 50 (20) 3276 (1972).

K. K. Ogilvie, D. Iwacha, H. Wayborn, G. E. Dunn, G. Taylor, J. B. Westmore, and D. Lin, "Thermal Rearrangement of Acyl Groups in Anhydronucleosides. A Convenient Synthesis of 5'-O-Acetylanhydrouridine", Can. J. Chem., Vol. 50 (14), 2365 (1972).

K. K. Ogilvie, L. Slotin, J. B. Westmore, and D. Lin, "A General Synthesis of 8,2'-Thioanhydropurine Nucleosides", Can. J. Chem., Vol. 50 (14), 2249 (1972).

J. B. Westmore, D. Lin, K. K. Ogilvie, H. Wayborn, and J. Berestiansky, "The Study and Characterization of Nucleosides by Mass Spectrometry I. The Mass Spectra of Pyrimidine 2,2'-Anhydronucleosides and Their Derivatives", Org. Mass Spectro., Vol. 6 (11), 1243 (1972).

K. K. Ogilvie, L. A. Slotin, J. B. Westmore, and D. Lin, "Synthesis of Purine 8,2'-Cyclonucleosides", J. Heterocyclic Chem., 9, 1179 (1972).

K. K. Ogilvie, L. Slotin, J. B. Westmore, and D. Lin, "Synthesis of 8,2'-Thoianhydroguanosine", Can. J. Chem., Vol. 50, 1100 (1972).

C. Reichert, D. Fung, D. Lin, and J. B. Westmore, "Thermal Decomposition of Copper(II) Carboxylates", Chem. Comm., p. 1094, 1968.

FORM CD-45
(REV. 3-76)

U. S. DEPARTMENT OF COMMERCE

SUPPLY, EQUIPMENT OR SERVICE ORDER

FOR: NOAA/ERL/OCSEAP

2. CHECK APPROPRIATE BLOCK

☒ PROCUREMENT ☐ OTHER *(Specify)*

Contract Modification

1. THE NUMBER SHOWN IN BLOCK 5 MUST APPEAR ON ALL SHIPMENTS AND/OR DOCUMENTS RELATING TO THIS ORDER

3. REQUISITIONER DOCUMENT NO.	4. BUREAU CONTROL NO.	5. PURCHASE ORDER NO.
RK-8-0018		

6. ISSUED TO:

Battelle Memorial Institute
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

7. DESTINATION — SHIP TO

OCS Program Office
NOAA/ERL, Rx4
Boulder, CO 80302

8. ACCOUNTING CODE	9. QUOTATION REF. OR CONTRACT NO.	10. DISCOUNT TERMS
RK0000 R7120815	03-7-022-35129	
11. DELIVERY F.O.B.	12. GOVT. B/L NO.	13. DELIVERY DATE

14. FUNDS AVAILABLE *(Budget Office)*	14a. STATION

15. LINE NO.	16. ITEM NUMBER DO NOT USE	17. DESCRIPTION	18. QUANTITY	19. UNIT	20. ESTIMATED TOTAL COST	21. ACTUAL UNIT PRICE	ACTUAL TOTAL COST
		Continuation of contract 03-7-022-35129, RU#500, work statement "Activity-Directed Fractionation of Petroleum Samples" plus letter of August 3, 1977 attached. (Also see copy of letter dated November 29, 1977 indicating the removal of the $3,760 sub-contract fee).					
		Please change the expiration date to 3-31-79 and change the CDM to Francesca M. Cava, NEGOA Project Office, P. O. Box 1808, Juneau, AK 99802					
		Total funded FY78 to date: $ -0-					
		AMOUNT OF THIS ACTION: $ 96,240			96,240		
		Total funded FY78 to date: $ 96,240					
		Total amount of contract $171,740					

APPROVED:

Director, ERL

22. SIGNATURE OF REQUISITIONER	DATE	23. SIGNATURE APPROVING OFFICER	DATE
TITLE		TITLE	

24. ☐ ACCOUNTABLE PROPERTY	INITIALS	25. ☐ NOT AVAILABLE-BUREAU STOCK/EXCESS	INITIALS	26. SIGNATURE-BUREAU CONTROL OFFICER	27. ☐ NOT AVAILABLE-DEPARTMENT STOCK/EXCESS	INITIALS

28. APPROVAL	DATE	29. PURCHASING AGENT	DATE

30. RECEIPT ACTION - Quantities shown in Column 18 above have been received and accepted, except as follows: *(If additional space is needed, use reverse side.)*

31. SIGNATURE-RECEIVING OFFICER	DATE	32. PROPERTY CONTROL NO.	☐ TRADE-IN ☐ RECEIVING REPORT

33. SEND INVOICES IN DUPLICATE TO:

RESEARCH PROPOSAL

TITLE: TRACE METAL BASELINE STUDIES AT THE ALEUTIAN, KODIAK AND ST. GEORGE BASIN OUTER CONTINENTAL SHELF (OCS) SITES OCSEAP RESEARCH UNIT 506
2311103260 Revision 1

PRINCIPAL INVESTIGATORS: David E. Robertson
Keith H. Abel

TOTAL COST OF PROPOSAL: $28,000

TO: National Oceanic and Atmospheric Administration
Outer Continental Shelf Environmental Assessment Program
Bering Sea-Gulf of Alaska Project Office
P. O. Box 1808
Juneau, Alaska 99802
(907) 586-7432

FROM: Battelle, Pacific Northwest Laboratories
Physical Sciences Department
P. O. Box 999
Richland, Washington 99352

DATE: December 5, 1977

SIGNATURES:	David E. Robertson Principal Investigator	(509) 942-5664 Telephone	11/7/77 Date
	[illegible] Required Organization Approval	(509) 946-2305 Telephone	12/5/77 Date
	for M A Williams Organization Financial Officer	(509) 946-2212 Telephone	12/7/77 Date

I. TITLE: TRACE METAL BASELINE STUDIES AT THE ALEUTIAN, KODIAK AND ST. GEORGE BASIN OUTER CONTINENTAL SHELF (OCS) SITES

RESEARCH UNIT NUMBER: 506

CONTRACT NUMBER: 03-5-022-56

PROPOSED DATES OF CONTRACT: October 1, 1977 to September 30, 1978

II. PRINCIPAL INVESTIGATORS: David E. Robertson
Keith H. Abel

III. COST OF PROPOSAL (By Federal Fiscal Year)

Total - $28,000

Distribution of Efforts by Lease Areas:

Cook Inlet	90%
Beaufort/Simpson Basin	10%

IV. BACKGROUND

During the past two years we have been engaged in studies of the natural trace metal distributions in Alaskan OCS proposed lease areas. These studies were designed to provide accurate and precise baseline data for trace metals in seawater (soluble and particulate phases), sediments and biota collected over rather vast expanses of the continental shelf of the Bering Sea, the Eastern GOA and the Western GOA. Such data are necessary to characterize the natural levels and distributions of trace metals in the marine environment prior to offshore exploration, drilling and oil extraction activities which could result in perturbation or contamination of the coastal marine environment.

During the course of these studies we have identified significant regional variations in the distribution of trace metals in sediments and in the suspended phases in seawater. This observed variability emphasizes the importance of understanding the natural processes which can create fluctuations in the trace element distributions. Only after these natural variations are understood can we expect to detect any man-made perturbations of the system. The first two years of the program have provided a broad-brush picture of the natural concentrations and distributions of trace metals in the Alaskan shelf environment. During the upcoming interdisciplinary study in FY 1978 a more concentrated effort will be made to understand in much greater detail the baseline environmental parameters for both trace metals and hydrocarbons within the Cook Inlet area.

V. OBJECTIVES:

The immediate objective of this study is to determine environmental baseline concentrations and distribution of selected trace metals and hydrocarbons in the Cook Inlet study areas and determine the presence or absence of perturbation caused by hydrocarbon development in Upper Cook Inlet. The trace metal phase of this program is being coordinated between ourselves, Dr. R. Feely - PMEL (Ru 152) and Dr. D. Burrell - UAK (Ru 162). Below are listed the elements each investigator will determine in the various environmental sample types.

PRINCIPAL INVESTIGATORS RESPONSIBLE FOR ANALYSIS OF VARIOUS METALS IN VARIOUS SAMPLE TYPES

Metal	Sediment	Biota	Water	Filt Part	Settled Partic
V	R	R	R	R	R
Fe	R,B	-	-	F	F
Al	-	-	-	F	F
Mn	R,B	R	R	F	F
Cr	R	R	-	F	F
Cu	B	B	B	F	F
Cd	B	B	B	B	F or B
Hg	B	-	B	-	-
Pb	B	B	-	F	F
Ni	B	B	-	F	F
Zn	B	B	-	F	F

B = Burrell

F = Feely

R = Robertson

- = Not scientifically significant or not technically feasible

A secondary objective is to participate in an intercalibration and quality control program with the other investigators (Burrell - Ru 162, Feely - Ru 152) using Cook Inlet sediment supplied from this year's field efforts. The ultimate objective of these tasks is to provide BLM, NOAA, and other concerned groups with a high quality data base describing the material trace metal economy of offshore OCS lease areas. A reliable set of data such as this can then be used for evaluating any possible future perturbations of the marine environment from oil extraction activities.

VI. GENERAL STRATEGY AND APPROACH

Whereas the first two years of our participation in the Alaskan OCS program were designed to provide a broad overview of the trace metal concentrations and distributions in the Alaskan offshore environment, we now recognize the need to conduct more detailed surveys at quite specific areas where oil exploration, drilling and extraction are now or will likely occur. Not only is it important to establish the local trace metal distributions and natural variations over rather small areas, but it is very important to characterize the processes which can control the trace metal economy or that can modify the trace metal distributions and behavior. Therefore, during FY 1978 we will be concentrating our efforts on much smaller, specific sites for establishing trace metal baseline parameters in seawater, sediments, and biota. Then during succeeding years we feel that it will be absolutely essential to perform rather extensive studies of ocean processes to characterize the temporal influences (i.e. river runoff, storms, primary productivity, current variations, etc.) and natural parameters which create or modify the existing trace metal distributions and behaviors.

Within the Cook Inlet study areas a joint sampling grid will be constructed in cooperation with Dr. D. Burrell - Ru 162 and Dr. R. Feely - Ru 152. This grid will be the focus of seasonal sampling beginning November 1977 and continuing to May and August 1978.

VII. SAMPLING METHODS

Sampling programs for water, biota and sediments will be coordinated with the schedules and sampling grids of Dr. D. Burrell and Dr. R. Feely and with the ongoing physical and biological oceanographic studies in the Cook Inlet study area.

A. Water

Seawater samples will be collected with all plastic GoFlo® Niskin sampling bottles and immediately filtered to separate the suspended matter for trace metal analysis. The filtered seawater is acidified to pH 1.5 with high purity HCl and stored in carefully precleaned polyethylene bottles. Seawater samples will be collected at standard physical oceanographic stations extending from the coasts to open ocean waters.

B. Biota Sampling

Several midwater and benthic "indicator" organisms will be collected in conjunction with ongoing biological programs. Major emphasis will be placed on obtaining commercially important nonmigratory species such as crab, flatfish and various macrozooplankton. Examination will also include intertidal biota--specifically fucus and mytilus. The samples will be immediately frozen and transported to our laboratory for dissection and analyses. Both muscle and liver tissues will be analyzed when possible. Approximately 25 samples from each study area will be analyzed.

C. Sediments

Continental shelf sediment cores will be collected when possible with a HAPS corer to obtain relatively undisturbed cores to a depth of 20 cm. The cores will be sectioned into 2-4 cm segments, frozen and transported to the laboratory for analysis. In areas of sandy or coarse sediments, grab samples will be collected for analysis.

VIII. ANALYTICAL METHODS

Water samples, biota and sediments will be analyzed for selected heavy metals primarily by instrumental neutron activation analysis (see Appendix). When necessary, preconcentration and/or radiochemical separations will be performed to measure those elements needing further purification from the major matrix constituents. The instrumentation and capabilities at Battelle-Northwest for performing multielement trace metals analysis of marine environmental samples are second to none and are in place and available for immediate utilization.

Sediment and suspended particulates will be analyzed by a selected leaching method jointly worked out with Dr. D. Burrell and Dr. R. Feely.

IX. ANTICIPATED PROBLEMS

The data submission schedule attached anticipates collection and completion of field sampling throughout the fiscal year. This schedule is dependent upon availability of NOAA vessels during the time periods which are uncertain at the present time.

X. DELIVERABLE PRODUCTS

During the 12-month study period we expect to continue to provide a large data base describing the concentrations and distributions of heavy metals in the Alaskan coastal marine environment, in dissolved and suspended seawater constituents, in selected "indicator" biota and in whole sediments. This information will provide important baseline data from which to evaluate potential environmental impacts from offshore petroleum recovery operations. Data will be submitted on magnetic tape in OCSEAP format 061 and will be reported in quarterly documents to the sponsor.

A. Digital Data

Parameters which will be collected and submitted are listed below:

File Type 061 - Trace Elements

Common to all records
- File type
- File identifier
- Record type
- Station number

Record Type "1" - Station Header
- Sample date/time
- Latitude/longitude
- Bottom depth
- Sequence number

Record Type "3" - Data Record
- Sphere
- Material analyzed
- Taxonomic code
- Depth of sample
- Weight
- Method of analysis
- Filter
- Element
- Concentration

Unit code
Detection code
Limit concentration
Sample composition
Sequence number

Record Type "4" - Text Record
Text
Sequence number

B. Narrative Reports

At this time it is anticipated that a journal article describing vanadium distribution in the Alaskan shelf waters, sediments and biota will be produced and one other scientific report describing the elemental composition of Alaskan shelf sediments.

C. Visual Data

None other than that included in reports.

D. Other Nondigital Data

None.

E. Data Submission Schedule

See attached data products schedule.

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

Other than the routine data required during shipboard sampling, the major data exchange will involve sampling information and identification of marine organisms collected by the biological oceanographers. Contact will be made with NOAA personnel and the biologists involved in sampling these areas to coordinate the sampling program and assure that biological samples will be available for trace metal analyses. Other important data exchanges will involve the work being done at the University of Alaska under the direction of David Burrell and at NOAA-PMEL under Richard Feely. Contacts with these individuals have already been initiated.

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Intertidal organisms	Tape	20 samples	061	Yes	October 77 - September 78	June 78, Oct 78, Dec 78
Benthic organisms	Tape	10 samples	061	Yes		August 78
Sediments	Tape	30 samples	061	Yes		February 78
Suspended particulate	Tape	30 samples	061	Yes		April 78
Soluble species	Tape	30 samples	061	Yes		September 78

XII. QUALITY ASSURANCE PLANS

Battelle-Northwest has its own internal quality assurance program which requires continual calibration of instrumentation and procedures. In addition, we have, and will be participating in interlaboratory intercomparisons of major and trace element concentrations in sediments with other investigators in this program and continually analyze National Bureau of Standards SRM's or USGS standard rocks to insure quality of the data produced.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLAN

Samples obtained during this study will be archived at Battelle-Northwest in Richland, Washington. Sediment and biota samples will be stored frozen except for small subsamples utilized for analysis. We presently have numerous other samples stored from previous research programs and the cost for these few additional samples will be negligible. Acidified seawater samples will be stored in the same facility that presently houses our GEOSECS archive samples and again cost will be negligible. These samples will be retained throughout our research program with OCSEAP for future reference.

XIV. LOGISTIC REQUIREMENTS

The areas of sampling during the field efforts of the Cook Inlet study will be determined by discussion with other investigators, scientists at BLM and NOAA, and potential leasors. It is presently anticipated that sampling will be conducted seasonally beginning in November 1977 and in May and August, 1978. Sampling conducted will include water sampling at near surface and near bottom depths using the ship's rosette and sampling bottles, preferably GoFlo® Niskin bottles, and coring of surficial sediments using a HAPS corer. Where coring is not possible, samples will be obtained by bottom dredge.

XV. MANAGEMENT PLAN

Planned personnel who will be active in the program effort and their proposed time commitments are listed below:

For OCSEAP use only.
RU # ______
Discipline ______
Area of Operation ______

LOGISTICS REQUIREMENTS

Please fill in all spaces or indicate not applicable (N/A). Use additional sheets as necessary. Budget line items concerning logistics should be keyed to the relevant item described on these forms.

INSTITUTION Battelle-Northwest PRINCIPAL INVESTIGATOR D. E. Robertson

SHIP SUPPORT

1. Delineate proposed tracks and/or sampling grids, by leg, on a chart of the area. Include a list of proposed station geographic positions. Tracks in conjunction with those of Dr. Burrell and Dr. Feely

2. Describe types of observations to be made on tracks and/or at each grid station. Include a description of shipboard sampling operations. Be as specific and comprehensive as possible.
   A. Water sampling at surface and near bottom
   B. Sediment sampling using HAPS corer

3. What is the optimum time chronology of observations on a leg and seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification.)

   Nov., 1977; May 1, 1978; August 15, 1978

4. How many sea days are required for each leg? (Assume vessel cruising speed of 14 knots for NOAA vessels. Do not include running time from port to beginning point and from end point to port and do not include a weather factor.)
   Leg #1 - 8 days; Leg #2 - 8 days; Leg #3 - 8 days

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback? We could piggyback.

   Approximately how many vessel hours per day will be required for your observations and must these hours be during daylight? Include an estimate of sampling-time on station and sample processing time between stations.
   Estimate 1 hour station time with sample processing completed during steaming time to next station.

6. What equipment and personnel would you expect the ship to provide?

   Laboratory space and rosette with sampling bottles

7. What is the approximate weight and volume of equipment you will bring? 1500#

8. Will your data or equipment require special handling? No If yes, please describe:

9. Will you require any gasses and/or chemicals? Yes If yes, they should be on board the ship prior to departure from Seattle or time allowed for shipment by barge. Two N_2 cylinders on board prior to departure from Seattle.

10. Do you have a ship preference, either NOAA or non-NOAA? If "yes" please name the vessell and give the reason for so specifying. No

11. If you recommend the use of a non-NOAA vessel, what is the per sea day charter cost and have you verified its availability?

12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals.

    K. H. Abel or D. A. Cochran

D. E. Robertson, Principal Investigator Senior Research Scientist	0.5 months
K. H. Abel, Research Scientist	1.2 months
D. A. Cochran, Chemical Technician	1.0 months
E. F. Briggs, Chemical Technician	1.0 months

XVI. OUTLOOK

Baseline research will be necessary in other lease areas not examined to date, even if completion of the baseline research outlined in this document for the Cook Inlet areas is reached on schedule. We would anticipate funding levels and periods of effort scaled to the size of these other leasing areas.

However, even before completion of this baseline research other areas need investigation. Below we have listed some potential trace element concerns which need evaluation.

A. Field Study Around Platform Site(s) to Examine Impact Upon Local Trace Element Chemistry

A long-term study should be initiated at one or two specific sites to examine the effect drilling platforms have on local trace element chemistry. This would entail establishing more detailed, pre-drilling baseline data for major and trace elements in seawater, suspended particulates, sediments and biota. This should involve sampling in the vicinity of proposed platforms on a seasonal basis to establish natural fluctuations of trace element levels and distributions. These studies should proceed through the platform construction, drilling and post-drilling phases to determine the possible impact of the platform structure and operations during its use. Specific size ranges of sediments and two or three indicator organisms would be used for the analyses.

B. Detailed Examination of Suspended Particulate Matter

It might be anticipated that perturbations of trace element chemistry in suspended particulates in the water column might be more significant during OCS development than those produced in either sedimentary or soluble trace element concentrations. Factors of importance would be not only the increased levels of suspended sediments from development activities, but also introduction of particulates with different chemistries from drilling muds, corrosion of platforms or other metallic materials, and, finally, coating of suspended particles with hydrocarbons released inadvertently.

Studies should be initiated to measure the flux of particulate matter from surface waters to the seafloor and resuspension of sediments in bottom waters. This could be accomplished by using particle traps to catch sinking particulates. These traps could be suspended at several depths at upcurrent and downcurrent locations relative to drilling platforms. The collected particulates would be analyzed on a seasonal basis for total suspended particulate levels, total elemental levels, organic carbon content, and the forms in which the elements are present (e.g. organically or mineralogically bound).

Large volume seawater filtration would also be conducted on a seasonal basis to collect suspended particulate material for the above analyses.

C. Studies Of The Interactions Of Suspended Particulate Matter And Sediments With Crude Oil

The physicochemical processes that occur when suspended particles and sediments come in contact with crude oil should be characterized to help evaluate the fate of spilled oil in the Alaskan marine environment. Freshly collected particulate matter and sediments would be contacted with various levels of seawater-crude oil mixtures to determine adsorption capacities and mechanisms, release rates from the particles, and physicochemical changes in the crude oil and particles that occur after attachment to the particles.

D. Forms And Speciation Of Trace Elements

The chemical form(s) of toxic trace elements are known to significantly affect toxicity and biological interactions or availability in aquatic systems. However, very little is known concerning chemical forms of trace elements in seawater. If the impact of potential trace element pollution from OCS development is to be evaluated, it is necessary to understand the speciation naturally present in seawater and that of the introduced trace elements. Only then can the significance of the elements and forms which are being introduced by development be evaluated.

XVII. MANAGEMENT DATA

1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements.

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U. S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

<u>MILESTONE CHART</u>

RU # 506 PI Robertson/Abel

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Field sampling - Cook Inlet		—	Δ					—Δ			—Δ				
Sediment analyses and data generation (∿30 samples)		—	—	—	—Δ			—	—	—Δ					
Suspended particulate analyses and data generation (∿30 samples)			—	—	—	—	—	—	—	—	—	—	—	Δ	
Obtain biota - intertidal, benthic, finfish (∿40 samples)			Δ					Δ			Δ				
Analyze biota and data generation			—	—	—	—	—	—	—	—	—	—	—	Δ	
Soluble seawater analysis (30 samples)								—	—	—	—	—	—	Δ	
Reports - Quarterly and annual to Sponsor			—Δ			—Δ			—Δ			—Δ			
Technical documents publication schedule							—Δ					—Δ			

504

APPENDIX

ANALYTICAL TECHNOLOGY

ANALYTICAL TECHNOLOGY

The analytical technology for performing all of the proposed measurements in this study is well developed and in place for immediate employment. Instrumental neutron activation analysis (INAA) will be used for measuring the majority of the elements. Details of the INAA techniques used at our laboratory have been recently published in the following document:

> D. E. Robertson and R. Carpenter, "Neutron Activation Techniques for the Measurement of Trace Metals in Environmental Samples," NAS-NS-3114, National Academy of Sciences, National Research Council, USAEC Technical Information Center, Oak Ridge, Tennessee, Jan., 1974.

This document contains detailed descriptions of the INAA methods used at our laboratory for trace metal measurements in fresh and saline waters, biological materials, sediments and soils, and atmospheric aerosols. It would be redundant to repeat these details here; however, a summary of the methodology used in these analyses is provided.

NATURAL WATER ANALYSIS

Because of short-lived interferences from Na, Cl and Br neutron activation products, the INAA of natural waters is generally restricted to those trace elements which possess relatively long-lived neutron activation products. However, by employing the simple, rapid separation procedures outlined in the above reference, all of the trace metals of interest can be readily measured in natural waters by neutron activation analysis. Table 1 illustrates the detection limits for the measurement of various trace elements in nonsaline waters by NAA. Tables 2 and 3 illustrate the detection limits for measuring various trace elements in saline waters of high salt content. Notable exceptions are Pb and Cd which are rather insensitive to neutron activation analysis. We have developed extremely sensitive atomic absorption spectrophotometric (AAS) techniques for

TABLE 1

APPROXIMATE LIMITS OF DETECTION OF VARIOUS TRACE METALS IN RIVER WATER BY NEUTRON ACTIVATION AND GROUP SEPARATIONS

Element	Approx. Estimate of Conc. in River Waters (μg/ℓ)	Detection Limits by NAA After Group Separation (μg/ℓ)	Allowable Limits (μg/ℓ)
Ag*	0.3	0.01	50
As	2	0.1	50
Ba	10	5	1000
Br*	20	0.01	
Cd	--	50	10
Cl*	7800	100	
Co*	0.2	0.01	
Cr*	1	0.1	50 (Cr^{+6})
Cs*	0.02	0.01	
Cu	7	0.1	1000
Fe*	--	10	300
Hg	0.07	0.1	(10)
K*	2300	10	
Mn*	7	0.01	50
Na*	6300	10	
Rb*	1	0.1	
Sb*	0.3	0.01	
Sc*	0.004	0.001	
Se*	0.2	0.1	10
Zn*	20	1	5000

*Elements normally detected and measured by INAA

TABLE 2

ESTIMATED DETECTION LIMITS FOR INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF SALINE WATERS

Element	Typical Seawater Concentration (μg/l)**	Detection Limit (μg/l)
Sr	8000	100
Rb	120	5
Fe	1-20(5)	1
Zn	0.5-10 (3)	0.2
U	3.3	0.1
Cs	0.3	0.003
Sb	0.2	0.005
Hg	0.01-0.3(?)	0.05
Co	0.001-0.1 (0.03)	0.001
Sc	$1\text{-}20 \times 10^{-4}$	1×10^{-4}

* 25 ml seawater; 24-hour irradiation at 10^{13} n/cm^2/sec; 40 days decay; 1000 minute count on 20 cc Ge(Li) diode detector.

** Estimated average concentrations in parentheses.

TABLE 3

ESTIMATED MINIMUM DETECTABLE CONCENTRATIONS OF HEAVY METALS IN SALINE WATERS BY INAA AND BY NAA WITH SEPARATIONS

Trace Element	Typical Reported Concentrations in Seawater (Micrograms/Liter)	Minimum Detectable Concentrations (in micrograms/liter)	
		INAA*	NAA with Separations**
Hg	0.02-0.2	0.05	0.001
Cd	0.06-0.7	16,000	0.001
Ag	0.002-0.05	1.0	0.003
As	2-3	Not Possible	0.0001
Cu	0.5-2	Not Possible	0.002
Cr	0.02-0.6	0.3	0.003
Zn	0.5-10	0.2	0.01
Sn	0.02	Not Possible	9
Se	0.08	0.2	0.02
Sb	0.2	0.02	0.00003

* 25 ml seawater; 24 hour irradiation at 10^{13} n/cm^2/sec; 40 days decay; 1000 minute count on 20 cc Ge(Li) diode detector; based on 3α above Bkg-Compton contribution in peak areas.

**500 ml seawater; elements chemically separated; 24 hour irradiation at 10^{13} n/cm^2/sec 3 days decay; 500 minute count on a 20 cc Ge(Li) diode detector; based on twice Bkg contribution in peak areas.

measuring Hg, Pb and Cd in natural waters. The Hg procedure involves a modified cold vapor AAS technique which can detect 0.001 μg/ℓ Hg in only 100 ml of fresh or saline water. The Pb and Cd procedures involve a solvent extraction separation from 100 ml of water, followed by heated graphite atomization--AAS detection.

BIOLOGICAL MATERIALS

INAA is particularly applicable for the measurement of trace metals in biological materials. Approximately 18 trace elements can be measured in most biological materials by INAA, including the heavy metals Hg, Ag, As, Sb, Zn and Se (see TAble 4). Cadmium and Cr are present in many biological materials at concentrations just under their INAA detection limits, but can be measured in some specimens when their concentrations exceed about 1 and 0.1 μg/gm dry weight, respectively. When required, the separation procedures outlined in the above document can be easily employed for the measurement of Cd, Cr and Cu. Lead will be measured by atomic absorption spectrophotometry.

SEDIMENTS AND SOILS

Of the various analytical methods available for the determination of elemental concentrations in geological materials, neutron activation analysis is one of the most sensitive, selective and reliable. INAA, utilizing high resolution Ge(Li) detectors, permits the nondestructive measurement of 25 to 30 elemental constituents in geological materials, including marine and freshwater sediments (see Table 5). Frequently, however, separations are necessary to permit the measurement of Hg, Cd, Se and Zn. These separation techniques are discussed in the above reference. Lead will be measured by atomic absorption spectrophotometry.

TABLE 4

ESTIMATED DETECTION LIMITS OF INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF BIOLOGICAL MATERIAL (μg/g DRY TISSUE)

ELEMENT	TYPICAL CONCENTRATION IN BIOLOGICAL TISSUE	DETECTION LIMIT*
Na	500-1500	0.05
K	1000-30,000	20
Rb	0.5-8	1
Cs	0.02-0.4	0.0001†
Fe	1-500	2
Zn	10-200	0.5
Br	10-200	0.05
As	<1-50	0.3
Cd	<0.1-10	1
Ag	<0.001-5	0.001†
Co	0.001-0.5	0.001†
Cr	<0.02-1	0.02
Hg	0.05-5	0.02
Se	0.5-50	0.05
Sb	0.0001-0.05	0.0001†
Sc	0.00001-0.002	0.00005†

* 300 mg of freeze-dried tissue; integral thermal neutron exposure of 3×10^{17} n/cm^2; 20 min. and 1000 min. counts after decay periods of 3 to 5 days and 20 to 30 days, respectively; 20 to 40 cc Ge(Li) diode detection, except where specified.

† Detection limits obtained by dual, coincidence NaI(Tl) spectrometry. Detection limits obtained by Ge(Li) spectrometry for these five elements are approximately 5- to 10-fold higher.

TABLE 5

ESTIMATED DETECTION LIMITS FOR THE INAA OF TRACE ELEMENTS IN SEDIMENTS AND SOILS

Element	Typical Concentration Ranges in Sediments (μg/gm)	INAA Sensitivity (μg/gm)
Ag	0.01-0.5	0.1
Al	10,000-90,000	10
As	2-20	1
Ba	60-8100	100
Ce	40-70	5
Cd	1	10
Co	1-200	0.1
Cr	10-200	0.8
Cs	0.3-15	0.2
Cu	10-700	1
Dy	0.2	0.1
Eu	0.2-10	0.05
Fe	20,000-60,000	200
Hf	0.1-18	0.1
Hg	0.05-3	0.5
K	3000-30,000	5000
La	2-60	2
Lu	0.2	0.1
Mn	100-10,000	10
Na	2000-40,000	100
Pb	10-200	---
Rb	1-100	1**
Sb	0.5-15	0.1
Sc	0.2-30	0.02
Se	0.1-1	2
Sm	0.5-30	0.3
Sn	0.5-15	500
Sr	200-2000	100**
Ta	0.03-3	0.01
Tb	0.1-7	0.1
Th	0.3-10	0.08
V	10-500	10
Yb	1	0.3
Zn	5-4000	5**
Zr	100-400	70

* 100 to 800 mg of dried sediment; samples irradiated at optimum intervals ranging from 1 minute to 6 hours in a flux of 10^{11} to 10^{13} $n/cm^2/sec$ and counted at optimum intervals after the irradiation for 1 minute to 200 minutes; Ge(Li) diode detectors, 20 cc to 60 cc volumes.

** Determined by counting on a coincidence-anticoincidence shielded Ge(Li) gamma-ray spectrometer (Cooper and Perkins, 1972).

Seasonal Composition and Food Web Relationships

of Marine Organisms in the Nearshore Waters

of Lower Cook Inlet - Including Fishes and Benthic Epifauna

R.U. 512

Principal Investigators

James E. Blackburn - Alaska Department of Fish and Game

Peter B. Jackson - Alaska Department of Fish and Game

Cost of Proposal

FY 1978 $165,000

Date of Submission - June , 1977

Required Signatures

James E. Blackburn - Principal Investigator

Peter B. Jackson - Principal Investigator

for Commissioner, Alaska Department of Fish & Game

John Stewart, Finance Officer

Technical Proposal

I. Title: Seasonal Composition and Food Web Relationships of Marine Organisms in the Nearshore Waters of Lower Cook Inlet - Including Fishes and Benthic Epifauna

Research Unit Number: 512
Contract Number: 03-5-022-69
Proposed Dates of Contract: October 1, 1977 - September 30, 1978

II. Principal Investigators:
James E. Blackburn
Peter B. Jackson

III. Cost of Proposal:

C. Total: $165,000
D. Distribution of Effort by Lease Area: Lower Cook Inlet - 100%

IV. Background:

The body of available information on various species of marine organisms, especially commercially important finfish and shellfish species, in lower Cook Inlet is considerable. The majority of these studies have been conducted by the Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service (NMFS) in the course of ongoing fisheries management and stock assessment programs. While these studies have, by necessity, been species specific in nature, the ADF&G Division of Habitat Protection as well as the OCSEAP in FY 75 began a series of studies designed to investigate and classify the biological sensitivities of lower Cook Inlet. These studies addressed classification of species assemblages, their spatial and temporal distribution, and how these parameters were influenced by changing physical and environmental factors. These initial studies, while yielding some essential baseline data on marine species assemblages, were not of sufficient intensity or scope to yield data on the more critical indicators of biological sensitivity - those concerning trophic relationships and other biological interdependancies among and between these marine communities. The imminent development of oil and gas resources in lower Cook Inlet dictate that studies designed to determine these relationships be conducted immediately in order that the full extent of their potential impact can be more fully realized.

The study proposed here is only one of six, each designed to study specific portions of this question. The ultimate outcome of this intergrated effort will be an investigation of sufficient intensity and scope so as to document and quantify the biological sensitivity of the study area and permit more in-depth evaluation of potential impact from oil and gas development in this area.

V. Objectives:

The objectives of this study are designed to develop an understanding of seasonal changes in composition and feeding habits of dominant marine organisms. Specifically, these objectives are:

1. Determine feeding habits of principal life stages of dominant marine organisms and provide an initial description of the food web.
2. Describe the temporal dynamics of marine organisms at specific sites.
3. Evaluate the timing and use of specific areas by critical life stages of marine organisms.

VI. General Strategy and Approach:

Two areas in lower Cook Inlet have been identified which will be studied intensively. These are the Jakalof Bay - Tutka Bay area of Kachemak Bay and the northern portion of Kamishak Bay. Greater effort will be expended in the Kamishak Bay area.

In each area several devices and survey techniques will be employed to study the pelagic and nearshore demersal communities. Effort will be seasonally stratified to investigate each component of the marine community during the time each is most active, while simultaneously maintaining attention upon all components. Periodic sampling in locations peripheral to the main study areas will provide comparative data.

Specific sampling sites and schedules will be worked out when information is available on the field facilities. Frequencies and locations will be chosen to adequately delineate the compositional and distributional changes in the nearshore finfish communities.

VII. Sampling Methods:

The sampling tools that will be employed include hand purse seine, beach seine, gill net, trammel net, and bottom trawl. The specific bottom trawl utilized will be chosen to fit the use and sampling platform. In addition, SCUBA surveys will most likely be conducted and the use of underwater television will be evaluated.

Two areas will be sampled: the Tutka Bay - Jakalof Bay area of Kachemak Bay and northern Kamishak Bay. Effort will be most intense in Kamishak Bay.

The choice of study areas is based on evidence that these two areas are biologically very active. The decision to place most effort in Kamishak Bay is based on the generally lower level of knowledge than is available for Kachemak Bay and the known surface drift to the west, and hence, vulnerability of Kamishak Bay to oil impacts.

Sampling will be most intense during the prime periods of biological activity. Sampling will be conducted continuously from October through December, and repeated on a regularly scheduled basis from April through late summer (August or September).

The planned October through December 1977 sampling in Kamishak Bay is absolutely contingent upon the presence of suitable OCSEAP supplied field facilities. Without them, sampling would necessarily be limited to the Kachemak Bay area. If the field facilities are not in place by early April, the sampling plan for summer work will necessarily be completely revised.

VIII. Analytical Methods:

Analysis of samples will include identification to species when possible and by life history stage for selected species. All taxa caught will be enumerated and weighed. Stomach samples, length frequencies and structures for age determination will be taken from selected taxa. Seasonal analysis of maturity state will be conducted for selected taxa.

Data will be interpreted by comparing these data among sites sampled, between surveys, with previous work and by intercomparison of results with investigators of other ongoing OCSEAP studies in the study area.

IX. Problems:

1. The NODC format does not accomodate all the information requested of the investigator by OCSEAP. At this time we anticipate that we need approval for use of the following changes and additions to File Type 23:

Suggested Column	Record Type	Identification	Attributes	Format	Suggested Codes
60	4	Life history stage	I1	X	1 egg 2 larvae 3 juvenile 4 adult
61-64	4	Subsample %	I4.1	XXX.X	N/A
33	5,6	Sex	I1	X	add code undetermined = 0
43-44	5	Size of length class in mm	I2	XX	N/A
52-57	6	Small fish weight in grams	I5.1	XXXX.X	N/A

In addition, in Record Type 1, Time Fished in hours to nearest tenth (columns 56-58, XX.X) is not useful to us. There is no place to add time fished in minutes in Record Type 1. We need time fished in minutes. Can this be arranged?

We need to know what flexibility exists in the data format. It is likely that we will need to add new parameters to existing record types. If we knew the flexibility allowed the investigator, our work would be greatly facilitated.

2. There is an apparent conflict between the requested objectives of this project and that of Howard Feder's (R.U. 5). Both projects are requested to determine food habits of fishes. Hopefully, the P.I.'s will be able to determine an acceptable division of the effort.
3. Weather may preclude completion of planned work at any time during the study, however, during the summer months this should be minimal. During October through December, and perhaps in April, there may be few workable hours.
4. Timely submission of quarterly reports with significant data content due July 1 and October 1 will be difficult due to intensive field activities.
5. The execution of the project as currently planned depends upon the timely placement of field facilities. The details of the equipment planned to be located at the field location determine how sampling plans develop. We need to know what will be at the field location and where it will be before we can plan the details of the study.
6. Timely receipt of OCSEAP funding upon submission of this proposal. Receipt of funding by no later than August 1 is essential for State administrative approval to expend funds, for purchasing of supplies and for hiring of personnel.
7. As field work is planned through the end of the contract period, additional funding of project extension must be insured beginning October 1, 1978 in order that a comprehensive report of the first year's studies can be prepared.
8. The details of sampling in the Jakalof Bay - Tutka Bay area of Kachemak Bay have not been worked out to our satisfaction. Whatever the plan, it will require periodic interruption of the main effort in Kamishak Bay as funds are insufficient to hire separate crews for each area. The result will be fairly intensive sampling in Kamishak Bay with interruptions of data continuity and monthly samples in the Kachemak Bay area. The anticipated results in Kachemak Bay do not appear to be as intensive as were obtained during FY 76, however, more gear types will be employed. In addition, duplicate sampling platforms and gear must be obtained for each area. The crew will be shuffled back and forth periodically, each time "mothballing" the operation that is being left and dusting off the one being begun. Chance for

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Pelagic and Demersal rshore Finfish	Disketts	1500-105 byte ADP Listings	File Type 23	Yes	10/77 thru 12/77	3/78
"	"	5000-105 byte ADP Listings	"	"	4/78 thru 6/78	9/78
"	"	"	"	"	7/78 thru 9/78	12/78

vandelism and storm damage or loss seems increased and there will be a fair amount of time lost in shifting between areas.

Perhaps the work in Kachemak Bay should be eliminated. It is possible that when details of the logistical support are known to us that more flexibility will be possible.

9. Conflicting demands upon the principal investigator's time, generated by requests from OCSEAP, NODC, NOAA and Boulder for such items as special reports, generation of information for synthesis meetings, and review of synthesis documents, detract from the ability to satisfy the contracted objectives. We recognize that the various demands satisfy a unique and special purpose and enhance the ability of NOAA/OCSEAP to satisfy the needs of BLM. We enjoy the opportunity to contribute to these special needs, however, it is especially difficult to plan for them. Consequently, our schedule for completion of contracted work is always being delayed. We request that OCSEAP offer as much advance notice of activities and description of needs as possible. This will help us plan how much time to devote to non-contract needs.

X. Deliverable Products:

A. Digital Data

1. Attached (Table 1) is a listing of the File Type 23 (Fish Resource) Format Parameters to be submitted with expected ranges for each.
2. List of digital products - see Data Products Schedule, attached.

B. Narrative Reports

Other than required quarterly and annual reports, preparation of additional narrative reports is not anticipated at this time. In the event special reports are required by OCSEAP, as was the case in FY 76, they will be complied with. In the event special reports of this nature are required, however, it would be appreciated if lead time of at least six weeks is given. The only other narrative reports possibly resulting from this proposed work would be formally published papers of an opportunistic nature depending on findings (species range extensions, newly developed sampling methodology, etc.). In these cases all stipulations in Parts 9 and 10 of Section XVII (Standard Statements) will be adhered to.

C. Visual Data

All visual data products produced in conducting studies proposed here will be incorporated in quarterly or annual reports. These visual data would include maps showing spatial and and temporal distribution of principal species in various life stages and distribution of sampling sites in the study areas in respect to available habitat types. Photos of the study areas may be included to show the various habitat types, various phases of sampling activity and methodologies utilized. Data on life history parameters (i.e. spawning areas, growth rates, age class composition, mortality rate, etc.) will be depicted by graphic methods in addition to narrative discussion. Depending on results, other data parameters and their comparisons may be presented through graphic, tabular or pictoral means.

D. Other Non-Digital Data

No other forms of non-digital data are anticipated for submission.

E. Data Submission Schedule

See attached Data Products Schedule.

XI. Information Required from Other Investigators:

Data on bottom type, current patterns and salmon spawning areas will be required. This information should be available through OCSEAP quarterly reports and direct contact with other principal investigators. Establishment of the base camp facilities in Kamashak Bay by NOAA/OCSEAP as described in the Logistics section of this proposal where scientists from several OCSEAP projects would be conducting studies simultaneously would provide an outstanding medium for exchange of data and ideas as well as the ability to integrate and coordinate field activities.

XII. Quality Assurance Plans:

Uniformity of techniques and analytical results will be assured by, first, devising detailed operational plans for all field sampling and laboratory procedures for collection, recording, and analysis of data, and, second, to insure that these procedures are adhered to through close supervision and double-checking of data. Calibration of instruments utilized for sampling and laboratory analysis will be calibrated immediately prior to and at frequent intervals during each period of use as per manufacturers recommended procedures.

XIII. Special Sample and Voucher Specimen Archival Plans:

A reference collection of all pelagic and demersal finfish species encountered by OCSEAP fish resource surveys was initiated in FY 76 during lower Cook Inlet and Kodiak studies. Any new species found will be added to this collection, and a species list for this area updated. Further, the principal investigators will insure that voucher specimens are preserved for archival as per plans formulated by the OCSEAP Project Office in Juneau. These specimens will be retained by the principal investigator throughout the contract period unless OCSEAP requests an early transfer to a permanent archive.

XIV. Logistics Requirements:

Due to the specialized and unique nature of logistics requirements, the forms supplied are not applicable. Consequently, the nature of support needed and justifications are included in the following narrative.

NOAA will supply a base camp to support field activity in northern Kamishak Bay. This facility will include sleeping quarters, kitchen, sanitary facilities, laboratory space, food, minimal electric power, two-way radio, boats with permanent or dead weight anchorage, fuel, skiff for transit between anchorage and shore and periodic (weekly) air flights to and from Homer. We strongly suggest that a winch be placed ashore to pull small boats above the influence of tidal activity to increase security during periods of inactivity.

The project proposed here will need facilities for four people during October through mid December 1977 and mid April through about mid September 1978. In addition, other investigators will be using this facility, although the exact number of personnel involved and their dates of utilization is not presently known to us.

We need three boats, one Boston Whaler, one open skiff 22 feet long and a salmon seiner. The open skiff will be used continuously and the seiner and Whaler used about fifty percent of the time, alternately.

In Kachemak Bay we need a salmon seiner (another possiblity would be the PUFFIN, an ADF&G owned vessel based in Homer) and a Whaler or skiff, each to be used simultaneously about twenty-five percent of the time. If facilities were available at the NMFS Kasitsna Bay facility, this would considerably enhance logistics for the Kachemak Bay effort. Establishment of a Kamishak Bay field lab will enable the most intensive sampling effort of any alternative and it will allow the most efficient use of research funds and personnel.

XV. Management Plan

The study proposed here will be managed by the two principal investigators named, with Mr. Blackburn being primarily in charge of study execution. Field studies will be conducted by a biologist staff of four. One field supervisor will be designated and the data collection responsibilities will be specifically assigned.

XVI. Outlook:

The broad and highly comprehensive nature of the study proposed here obviously precludes completion of all objectives in a single year; furthermore, NOAA/OCSEAP policy dictates that studies of this nature extend for more than one year so as to enable evalutation of between season fluctuations in abundance, reproductive potential, and other critical life history parameters. Consequently, it is planned to accomplish the major objectives proposed here in a stepwise manner by emphasizing data collection and analysis of a subset of closely related biological parameters in successive years, while simultaneously obtaining data on all parameters every year. This would ultimately result in a comprehensive and relatively long-term study of all desired objectives. Primary among the biological parameters necessary to accomplish this work are:

a. Species composition
b. Distribution by season
c. Relative abundance by season
d. Food habits by season
e. Food habits by life stage
f. Migration routes and timing
g. Growth and mortality rates (age class composition)
h. Spawning times and spawning areas
i. Foraging areas
j. Primary predators

The above table represents only one side of a matrix crossed with species. There are scores of species in the study area and completion of some objectives for some species in each year is all that can be done. With one years data collection completed we have information on a, and some information on b, c, d, f and g (growth only). In FY 78, emphasis will be placed upon food habits and seasonal distribution and abundance: elements b, c, d and e above. Information on f may be obtained from this effort by inference and information on i and j will come from food habits work.

In FY 79, objectives will be reevaluted according to OCSEAP guidance and with FY 78 results in hand and the emphasis of the study adjusted to obtain maximum understanding of the system. Some of the previous objectives will be continued to fill in the number of species encompassed. Sampling areas, times and gears may be adjusted. Information on age class composition and mortality cannot be reliably done before FY 78, but due to variability of age class success and other factors, a long time series of information is necessary to study these parameters meaningfully.

In FY 1980, objectives will again be reevaluated according to OCSEAP guidance and with data results in hand.

XVII. Standard Agreements:

1. Updated Activity/Milestone/Data Mangement Charts will be submitted quarterly.
2. Quarterly reports will be submitted in sufficient time during

the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.
4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and perdiem for these trips will be borne by the Project Office.
5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).
6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).
7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.
8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.
9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.
10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgement is standard.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

MILESTONE CHART

RU #: 512 PI: Jim Blackburn, Peter Jackson

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978														
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D			
Arrange and Let Contract for Food Habits	X		X															
Plan Field Effort (September, 1977)																		
Field Sampling	X	X	X				X	X	X	X	X	X						
Submission of ROSCOP Forms		X	X	X				X	X	X	X	X	X					
Laboratory Sample Analysis	X	X	X	X	X		X	X	X	X	X	X	X	X				
Processing of Digital Data preparation punch proof	X	X	X	X	X	•	X	X	X	X	X	X	X	X				
Submission of Digital Data						X						X			X			
Preparation of Quarterly Reports			X						X			X						
Preparation of Annual Report			X	X	X													
Review of Annual Report Prior to Submission						X												
Preparation of FY 79 Work Statements											X	X						
Preparation of Final Report (due April, 1979)												X	X	X	X			

Table 1
Definition of File Type 23 Digital Data Parameters
Utilized in Proposed Work for R.U.   in FY 78

Record Type Headers - All Record Types

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
1-3	File Type	I3	XXX	023
4-9	File Identification	I6	XXXXXX	070177-113078
10	Record Type	I1	X	1-8

Record Type 1 - Haul Record

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-12	Agency Code	I2	XX	21
13-14	Vessel Code	A2	XX	02-30: A-X
15-16	Cruise Number	A2	AX	N/A
17-19	Haul or Set Number	I3	XXX	0-999
29-35	Latitude	A7	XX.XX.XXA	59° 00'00'N-60° 50'00
36-43	Longitude	A8	XXX.XX.XXA	151° 00'00"W-154° 20'0
44-49	Date (GMT)	I6	XXXXXX	771001-780930
50-53	Time (GMT)	I4	XXXX	0-2400
54-55	Gear Type Code	I2	XX	10-92
56-58	Duration of Fishing	I3	XX.X Hrs.	00.1-36.0
59-61	Distance Fished	I3	XX.X Km.	00.0-[illegible]
62	Direction of Tow	I1	X	1-9
63	Performance Code	I1	X	0-8
70-73	Mean Bottom Depth	I4	XXXX M	0-275
76	Sounding Record	I1	X (Blank)	1-3
77-78	Bottom Trawl Type	I2	XX	00-40
79-80	Bottom Trawl Accessories	I2	XX	00-32
81-84	Scope or Warp Used	I4	XXXX M	0-1225

Record Type 1 - Haul Record (cont.)

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
89	Present Weather	I1	X	0-9
90	Cloud Amount	I1	X	0-9
91	Sea State	I1	X	0-9
100-104	Sequence Number	5	XXXXX	N/A

Record Type 2 - Trawl Gear Record

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-12	Agency Code	I2	XX	21
13-14	Vessel Code	A2	XX	02-24: A-X
15-16	Cruise Number	A2	XX	N/A
17-19	Haul or Set Number	I3	XXX	0-999
20-21	Gear Type Code	I2	XX	10-92
22-24	Opening Height - Trawl	I3	XX.X M	00.5-03.0
25-27	Opening Width of Trawl	I3	XX.X M	00.5-11.0
28-30	Overall Trawl Length	I3	XXX M	01.0-15.0
31-32	Codend Length	I2	XX M	01.0-5.0
33-34	Footrope Length	I2	XX M	00.0-25.0
35-36	Headrope Length	I2	XX M	00.0-25.0
37	Gear Material Code	I1	X	0-2
38	Opening Mesh	A1	X	0-9: [illegible]
39	Average Body Mesh	I1	X	0-9
40	Codend Mesh	I1	X	0-9
41	Codend Liner	I1	X	0-9
42-43	Number of Floats	I2	XX	05-50
44-45	Float Diameter	I2	XX Cm.	10-25
46	Tickler	I1	X	0-1
47	Roller Gear	I1	X	0-1
48-50	Length of Bridles	I3	XXX M	001-037
51-52	Length of Doors	I2	X.X M	0.5-3.0
53-54	Width of Doors	I2	X.X M	0.3-1.5
55-58	Warp Length	I4	XXXX M	0005-0823
59-62	Depth of Gear	I4	XXXX M	0005-0275
100-104	Sequence Number	I5	XXXXX	N/A

Record Type 3 - Miscellaneous Gear Record

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-12	Agency Code	I2	XX	21
13-14	Vessel Code	A2	XX	02-24: A-X
15-16	Cruise Number	A2	XX	N/A
17-19	Haul or Set Number	I3	XXX	000-999
20-21	Gear Type Code	I2	XX	10-92
26-27	Net Depth	I2	XX M	0-19
34	Gear Material Code	I1	X	0-2
39	Seine - Average Body Mesh	I1	X	0-9
40	Seine - Bunt Mesh	I1	X	0-9
41-42	Gillnet, No. of Shackles	I2	XX	1-20
43	Gillnet, Material	I1	X	0-2
44	Mesh	A1	A	0-9: A-D
65-68	Depth of Gear	I4	XXXX M	0-183
100-104	Sequence Number	I5	XXXXX	N/A

Record Type 4 - Species Catch Record

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-12	Agency Code	I2	XX	21
13-14	Vessel Code	A2	XX	02-24: A-X
15-16	Cruise Number	A2	XX	N/A
17-19	Haul or Set Number	I3	XXX	0-999
24-33	Taxonomic Code	I10	XXXXXXXXX	1/
34-41	Total Weight by Species	I8	XXXXXX.XX kg.	2/
42	Weight Determination	I1	X	1-2
43-48	Total Number by Species	I6	XXXXXX	N/A
49	Number Determination	I1	X	1-3
50-59	Total Weight by Species	I10	XXXXXX.XXXX	2/
100-104	Sequence Number	I5	XXXXX	N/A

1/ NODC Taxonomic Codes - March, 1977.

2/ Total Weight of species recorded in Columns 34-41 for large trawl hauls where .01 kg accuracy is acceptable. In catches by smaller gear types where single fish are frequent and more decimal places are necessary, the total weight by species will be recorded in columns 50-59.

Record Type 5 - Length Frequency Record

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
1-32	The same as in the Species Catch Record - (Record Type 4)			
33	Sex	I1	X	0, 1, 2[1]
34-37	Length of Class in mm	I4	XXXX	0-2000
38-41	Length Frequency	I4	XXXX	0-200
42	Length Sample	I1	X	2, 4
43-44[1]	Size of Length Class in mm	I2	XX	1-50
100-104	Sequence Number	I5	XXXXX	N/A

[1] Requires Approval

Record Type 6 - Individual Biological Record

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
1-32	The same as in the Species Catch Records - (Record Type 4)			
33	Sex	I1	X	0, 1, 2[1]
34	Maturity	I1	X	1-5
35-38	Length	I4	XXXX	1-2000
39-44	Weight	I5	XXXXXX	0-100,000
45	Weight Determination	I1	X	1, 2
46-47	Age	I2	XX	0-40
48	Age Structure	I1	X	1, 2, 3
49	Age Determination	I1	X	1, 2
50	Sample Type	I1	X	1, 2, 3
51	Data Type	A1	X	1-9, A-F
52-57[1]	Small Fish Weight	I5.1	XXXX.X	0-500.0
100-104	Sequence Number	I5	XXXXX	N/A

[1] Requires Approval

Record Type 8 - Comments

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
1-19	The same as in the Species Catch Record - (Record Type 4)			
20-99	Comments	A80	XX etc.	N/A
101-104	Sequence Number	I5	XXXXX	N/A

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Boulder, Colorado 80302

October 4, 1977

Mr. Peter B. Jackson
Alaska Dept. of Fish and Game
P. O. Box 686
Kodiak, AK 99615

Subject: Contract 03-5-022-69, T. O. #13, RU#512

Dear Mr. Jackson:

I am pleased to notify you that your FY78 proposal, as revised, entitled, "Seasonal Composition and Food Web Relationships" has been recommended to me for funding in the amount of $155,000. Our Contracting Clerk, Kay Jentsch, will initiate contracting procedures as soon as possible. We are also notifying the Juneau Project Office and your institution business office by copy of this letter. The contract period will be from October 1, 1977 through September 30, 1978. If you have any funding questions, please call Kay Jentsch, 499-1000, x6562, FTS 323-6562. Technical or scientific questions should be referred to your project office.

I thank you for your contributions to the OCSEA Program and look forward to another year of cooperative effort.

Sincerely,

David J. Norris

for Rudolf J. Engelmann, Director
Outer Continental Shelf Environmental
Assessment Program Office

cc: James E. Blackburn
John Stewart
Juneau

bcc: RU512
contract file
Jentsch
Read file

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

JAY S. HAMMOND, GOVERNOR

P. O. Box 686
Kodiak, Alaska 99615

August 2, 1977

Dr. Herbert Bruce, Project Manager
NOAA/OCSEAP Project Office
P. O. Box 1808
Juneau, Alaska 99802

We have received your letter of July 27, 1977 which lists required revisions in our FY 78 work statement for Research Unit 512. We agree to the revisions included in Points 1 through 8 of this letter. The elaboration required for Points 9, 10 and 11 of this letter are as follow:

9. Analytical Methods: Sampling of pelagic and demersal fish species from the two study areas (Kamishak Bay and Jakalof/Tutka Bay) will be conducted on a regular monthly basis beginning in March 1978 and continued throughout the contract period, as described in our original work statement under Sampling Methods. The various gear types described in this work statement will be utilized at individual sampling stations in a manner that most efficiently and representatively samples the species shown by FY 76 studies to be dominant: Dolly Varden, pink salmon, chum salmon fry, sand lance, herring and perhaps juvenile flounder. Data from all hauls will be recorded on the File Type 023 Format as described in Section X of this work statement. All catches will be identified by species, counted, weighed in significant figures, sampled for length measurement and representative samples of foreguts taken. The number of foreguts analyzed for each species is dictated by their relative abundances as shown by FY 76 studies and available funding. Based on these parameters, an estimate of the extent of foregut analyses for this study are as follow:

Species	No. Foreguts Analyzed
Dolly Varden	150
Pink salmon fry	150
Chum salmon fry	150
Chinook salmon smolts and juveniles	50
Red salmon smolts	50
Coho salmon smolts	40
Sand lance	100

Species	No. Foreguts Analyzed
Herring	150
Whitespotted greenling juveniles	50
Masked greenling juveniles	50
Smelt species	50
Starry flounder	25
Rock sole	25
Great sculpin	25
Staghorn sculpin	25
Snake prickleback	15
Tubenose Poacher	15
Total:	1120

While the number of foreguts of each species sampled during each monthly sampling period will be dependent upon temporal abundance, all attempts will be made to analyze the total number of foreguts for each species shown above. The total number of stomachs analyzed is based on an estimate of $10 per stomach for analysis.

Foreguts sampled will be individually examined and the condition factor subjectively judged by the degree of distention of the stomach and rated on a relative scale of fullness. The stomachs shall be opened, the contents removed, and the degree of digestion subjectively judged and rated on a relative index scale. The contents will then be air dried or blotted dry in a uniform manner and weighed to the nearest 0.01 gm. Contents will be identified to the lowest possible taxonomic level and each group shall be counted and weighed to the nearest 0.01 gm. The resulting information shall be placed on the appropriate EDP medium and summarized by species in a standardized format.

10. The SCUBA surveys planned in connection with this work will function as a supplemental sampling tool to aid in studying the composition, relative abundance and trophic relationships of that portion of the nearshore fish assemblage in the Iniskin and Jakalof Bay study areas available to divers (out to 60 ft. - 18.23 M). These surveys will be conducted by a team of two experienced biologist-divers swimming depth stratified transects of a consistent width. The abundance of all species encountered will be recorded on the appropriate data format. In addition, specimens of various species sighted will be captured and utilized for foregut analyses to supplement samples obtained by other gear types. This work differs from that in R.U. 417 in that it addresses finfish specifically, whereas R.U. 417 addresses demersal invertebrate epifauna specifically and treats any abundant finfish species encountered incidentaly.

11. Quality Assurance: To ensure the quality of data, we employ qualified personnel to conduct the field work, backed by a series of check procedures. All data are recorded directly on EDP forms to ensure accuracy and completeness. Personnel are familiarized with the

species they will encounter as well as data recording procedures and are closely supervised on initial sampling efforts. Unidentified specimens are preserved and identified onshore by the field personnel with the appropriate keys (Wilimovsky, 1958, Provisional Keys to the Fishes of Alaska; Trautman, Milton B. 1973, A Guide to the Collection and Identification of Presmolt Pacific Salmon in Alaska with an Illustrated Key; Andriyashev, 1964, Fishes of the Northern Seas of the USSR; Hart, J.L., 1973, Pacific Fishes of Canada, and others). The species identities are then double-checked by the Principal Investigator. Reference specimens are collected routinely for confirming identifications.

All instruments employed to obtain and quantify data are checked, serviced and calibrated immediately prior to and when necessary during each field season according to manufacturers specifications.

All data sheets are proofed by the Principal Investigator, keypunched and verified. Then 10% of the data are randomly selected and proofed for keypunch errors. An error rate in excess of 1% in this, plus a second identical subsample, necessitates reverification of all data keypunched.

We recognize and agree to the fact that some of the research strategy and methodology proposed is subject to change as a result of the intensive research planning and organization meetings held prior to initiation of field studies.

Herb, I hope this satisfies the additional information and agreements required in your letter of July 27, 1977. Please contact Jim Blackburn or myself immediately if further clarification is necessary as expedient initiation of this project will be to both our benefits.

Cordially,

Peter B. Jackson

Peter B. Jackson
OCS Coordinator

11. Include a paragraph on quality assurance procedures during data collection, processing and analysis. This may be accomplished either through appropriate references (OCSEAP progress reports) or by detailing them in the revised proposal.

If you have questions concerning any of the above guidance, please phone the Juneau Project Office, (907) 586-7432.

Your letter agreeing to these changes, or a revised work statement, must be sent to and received in the Juneau Project Office, with a copy to Boulder no later than August 5, 1977. If there are extenuating circumstances which prevent you from meeting this schedule, please phone the Project Office. The short deadline is required to ensure continuous funding of your project in FY 78.

Upon receipt of your work statement, revised in accordance with the above guidelines, we will initiate contracting procedures for FY 78. I look forward to your continued involvement in our program.

Sincerely,

Original signed by
Herbert E. Bruce

Herbert E. Bruce, Ph.D.
Bering Sea-Gulf of Alaska Project Manager

cc: Program Office

Please be advised that the final funding commitment and level are contingent on the approval of the FY 78 OCSEAP budget by BLM.

Original signed by
Herbert E. Bruce

Herbert E. Bruce

RFx41-512-551

27 JUL 1977

Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P. O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

Mr. James E. Blackburn
Mr. Peter B. Jackson
Alaska Department of Fish and Game
Commercial Fish Division
P.O. Box 686
Kodiak, Alaska 99615

Re: Research Unit # 512

Dear Mr. Blackburn and Mr. Jackson:

Your FY78 renewal proposal, entitled "Seasonal Composition and Food Web Relationships of Marine Organisms in the Nearshore Waters of Lower Cook Inlet--Including Fishes and Benthic Epifauna," has been reviewed by the Juneau Project Office. The following revisions are required before the work statement can be sent to our Contracting Office for funding:

1. The funding level should be reduced to $155,000, of which $150,000 is for science and $5,000 is for logistics. These departures from your proposed funding level and distribution are explained in the following paragraphs.

2. Your proposal should show the start of field operations in March 1978, not October 1977. We feel it inadvisable to begin field work in October 1977 because of the limited time available to plan and organize the integrated nearshore study. Overall experimental design, coordination between investigators, provision of logistic support, definition of integrated research products and the means to attain integration must be carefully developed to assure a smooth-running and fruitful research program. This required planning is necessarily a lengthy process.

3. The General Strategy and Approach section of your proposal should state that a series of intensive research planning and organization meetings will be convened by the Juneau Project Office with the attendance of the Principal Investigators. These meetings will be conducted during the period preceding the initiation of spring field operations. As a result of these meetings, some of your proposed research may be modified; however, such changes will not adversely impact your research funding level or radically alter the basic objectives of the studies.

4. Please reduce your budget for personnel salaries of temporary biologist I's by 9 man/months, or $15,670. This decrease is requested as a consequence of the delayed need for these personnel

resulting from the elimination of Autumn 1977 field work.

5. Please reallocate $5,670 of the funds deleted from salaries in paragraph 4 to travel and per diem for planning meetings and additional foregut analyses. We estimate that three meetings totaling approximately 7 days will be required.

6. Please add $5,000 to your budget under CPF-6 (Direct Costs). This increase is intended to cover per diem and food costs for personnel at the Kamishak Bay Camp. OCSEAP will not provide food services. However, the camp will be equipped with cooking facilities, refrigerator, and other amenities such as sleeping quarters, heating and a chemical toilet. Scientific and technical personnel will be expected to purchase and prepare their own food.

7. It is clear that considerable time must be spent on the clarification of digital data products to be produced by R.U. 512. The list of File Type 023 parameters to be used for the proposed work does not include Record Type 7 (Prey Record), which would appear indispensible in view of the emphasis on food habits investigations. Also, the listing of Record Type 6 does not include the "gut collected" field (byte 55). The need for this particular field is debateable, as indicated by your suggested replacement of bytes 52/57 with a "small fish weight" field. These two examples do not comprise an exhaustive list of such questions or conflicts regarding your digital data products. Therefore, you must include a statement in the proposal that digital data formats and expected data products will be finalized during negotiations between the Juneau Project Office and the Principal Investigators.

8. Paragraph 6 of Section XVII (Standard Agreements) should be revised by placing the words "to the Juneau Project Office" immediately after "submitted".

9. The Analytical Methods section should be amplified to give additional information. This may be done by furnishing appropriate references or by describing the methods to be used. As an example of the information we require, consider the following questions: What types and level of analyses will be performed on foregut contents? (We assume the suite of data from this work would include, at a minimum, (1) weight of total contents, (2) enumeration of individuals comprising each prey category, and (3) the weight of each prey category.) What species do you plan to perform foregut analyses on? How will the foregut sampling be stratified with respect to time, location, etc?

10. Please state the intended objectives of the SCUBA surveys. This information is necessary to evaluate possible duplication of effort by this research unit and RU 417.

CU Proposal No. 0677.9.394B
State ID No. 77-270210-394

Research Unit #516

A Proposal to the

National Oceanic and Atmospheric Administration

for support of

A GEOGRAPHIC-BASED INFORMATION MANAGEMENT SYSTEM

FOR PERMAFROST IN THE BEAUFORT AND CHUKCHI SEAS

Name and Address of Institution:	The Regents of the University of Colorado Boulder, Colorado 80309
Desired Starting Date:	1 October 1977
Amount Requested from NOAA:	$40,000
Time Period for Which Support is Requested:	One Year
Principal Investigator:	Michael Vigdorchik, Research Assoc. Institute for Arctic and Alpine Research University of Colorado Boulder, Colorado 80309 303-492-6387

M. Vigdorchik
Michael Vigdorchik
Principal Investigator

Roger G. Barry
Roger G. Barry
Acting Director, INSTAAR

Milton E. Lipetz
Vice Chancellor for Research and
Dean of the Graduate School

TECHNICAL PROPOSAL

I. Title: A geographic-based information management system for permafrost in the Beaufort and Chukchi seas (Alaskan coast).
Research Unit number - 516
Contract number - 3-7-022-35127
Proposed date of Contract - October 1977 - September 1978

II. Principal Investigator: Michael Vigdorchik

III. Cost of Proposal: $40,000 (Lease area)

IV. Background: A broad range of earth-science studies have been supported by OCSEAP in the Beaufort and Chukchi Sea areas. Some of the studies, such as the examination of seismicity in northeastern Alaska, the offshore permafrost studies, the survey of ice-gouging on the sea bottom, and the estimates of rates of shoreline retreat, were conceived as studies of obvious geologic hazards to drill rigs, producing platforms, pipelines, and supporting facilities. Other studies, such as the analysis of the distribution of bottom sediments, and of rates and mechanisms of dispersal of sediments were originally conceived as supportive of the biological investigations. The Barrow Synthesis meeting made obvious the interdependence of biological, physical oceanographic, and geological investigations, demonstrated that such investigations can contribute in many ways to minimize enviromental damage and to optimize the use of scarce resources during the future exploitation of the petroleum resources of the continental shelves of arctic Alaska.

Knowledge of the distribution, state, and water or ice content of offshore permafrost is critical for planning petroleum exploration and production structures, buried pipelines, and developmental tunnels beneath the sea bed. Knowledge of sea-bed temperatures is also needed in order to recognize potential sites of accumulation of gas hydrates and to predict areas in which ground water under artesian pressure is likely to be encountered. More detailed and site-specific information about the distribution, thickness, state, and ice content of subsea permafrost will be greatly needed as petroleum exploration and development progress.

Subsea permafrost has been studied by means of boreholes and seismic-refraction lines off the Mackenzie River delta in Canada and off Prudhoe Bay and in the Elson Lagoon area near Point Barrow. Local Canadian borehole seismic-refraction studies have been augmented by a regional analysis of commercial multichannel seismic-reflection records, making it possible to map the distribution of ice-bonded permafrost over a large segment of the Canadian shelf (Hunter and others, 1976). Studies on the Alaskan shelf of the Beaufort Sea have been essentially confined to the two profiles in the Elson Lagoon and Prudhoe Bay areas (Lewellen, 1976; Osterkamp and Harrison, 1976; Quarterly reports to NOAA for R.U. 194, 205, and 271). Harrison and Osterkamp (4th quaterly report, 1976) have developed a very simple but crude thermal model for subsea permafrost and have discussed its assumptions and application in the Chukchi Sea. It is based on the sea level history curve of Hopkins, sea bed temperature data for the Chukchi Sea, and thermal parameters obtained from Gold and Lachenbruch (1973). The problems of subsea permafrost were summarized during the Barrow Synthesis meeting attended by the following geologists: D.M. Hopkins, P.W. Barnes, Niren Biswas, Jan Cannon, Edward Chamberlain, Joe Dygas, Will Harrison, A.S. Naidu, Dag Nummedal, James Rogers, Paul Sellmann, Michael Vigdorchik, William Wiseman, and Tom Osterkamp.

The report on this meeting also contains data contributed by Gary Boucher, Edward Chamberlain, Alex Delancy, Steve Eittreim, S. Estes, L. Gedney, A. H. Grantz, M.O. Hayes, R.E. Lewellen, J.L. Morack, Thomas Osterkamp, C. Pearson, Erk Reimnitz, and C.H. Ruby. This summary focuses chiefly upon studies of the continental shelf of the Beaufort Sea and gives only peripheral consideration to the Chukchi Sea area. In the annual report of the research units 253, 255, 256, (April 1, 1976 - March 31, 1977), W. Harrison and T. Osterkamp determine the distribution and properties of subsea permafrost in the Chukchi Sea. Their program includes an effort to understand the basic physical processes responsible for the subsea regime as a basis for predictive models.

Experience obtained in the terrestrial environment has indicated the necessity for careful consideration of permafrost during OCS oil and gas development activitities. The consequences of error in planning or design of facilities are greater in the complicated offshore conditions than on land in terms of loss of human life, time environmental damage, and costs.

It is understandable that site-specific information on offshore permafrost from the seismic or drilling methods cannot be obtained for all locations on the continental shelf. In order to meet the need for predictive information on the potential distribution and characteristics of offshore permafrost, a different kind of modeling approach must be used, drawing on all existing data. The proposal "A Geographic-based information management system for permafrost in the Beaufort and Chukchi Sea" is the continuation of just such a kind of modeling approach we had already begun at the end of 1976.

V. Objectives: The first principal objective of this work is to continue to develop a computerized system which will aid in predicting the distribution and characteristics of offshore permafrost. A special computerized system will divide the offshore territory into areas which are suitable or unsuitable for relict permafrost. Computer-based mapping of the distribution, thickness and character in modern offshore conditions will be the main part of the program.

The approach to solving this problem involves the gathering and study of all the source data about direct and idirect indicators of permafrost in the given area (depth, temperature and salinity of water, topography, bottom deposits, ice conditions, etc.).

According to this objective all existing data on depth, temperature and salinity of the Beaufort and Chukchi Seas shelf have been gathered. Some of this data is on magnetic tapes which makes it possible to compile the source data maps as a second step of Data Management System development. Their compiling in computerized form is processing now and will be finished in August - September 1977.

The second objective of work is to continue to undertake a comprehensive review and analysis of past and current Soviet literature on subsea permafrost and related coastal processes, and, where appropriate, translate selected materials for general dissemination. The availble materials relate to problems of submarine permafrost orgin and development such as Quaternary Arctic history; especially Quaternary transgressions and regressions in Eurasiatic arctic shelf should be summarized and evaluated with respect to their significance.

The first results are summarized and will be summarized in our annual report (October 1976 - March 1977) and two quarterly reports (April - June 1977 and July - September 1977).

According to the second objective of the work, an in-depth search of the Soviet literature has been performed and the bibliography has been compiled. We have included this biblography and the primary part of analysis of the Soviet data and results in subsea permafrost study in the annual and quaterly reports.

The bibliography includes 413 publications connected with research on the theory of submarine permafrost and the practical applications of the results of the study of the properties of the frozen deposits. Environmental aspects of submarine permafrost is an important part of this kind of "analysis". The primary part of the "analysis" consists of about 220 pages and about 110 schemes, figures and tables. This is about one half of the full "Analysis of Submarine permafrost on the Arctic shelf of Eurasia." The compiling of its second half (in the same volume) is included in this proposal for 1977-1978.

The Barrow Synthesis meeting has made possible the further development of the Data Management system not only for submarine permafrost prediction but as the basic approach and tool that can be utilized on any project which requires the analysis of different types of geographical data as a basis for developing a shelf use plan or evaluation. A great many maps were generated at the Barrow meeting by different groups of scientists in biglogical, physical oceanoceanographic and geological source materials for our system. From another side the scientists at Barrow have identified the salient issues related to the various physical conditions, social concerns, economic factors and legalities affecting the shelf use plan and evaluation. These issues were to be determined at the meeting and some of them are related to engineering feasibility and construction costs, losses and so on, while others pertain to the concerns of public safety and environmental impact.

Having the source maps and "issues of concern", we can take the next step in the "Data Management system" display by structuring the information needs of each discipline in a clear, integrated and efficient manner and then generating computerized environmental composite and candidate area maps. Logically it is the third main objective of our proposal. This can be realized after recieving the full results of the Barrow meeting, especially the maps, and will be continued during the 1978-1979 y.y.

VI. General Strategy and Approach: This proposal represents the continuation of our efforts to use computer techniques for managing large amounts of geographically based data. These techniques could be used in many different types of planning projects including site selection studies; highway and pipeline route selection; resource management plans; environmental impact assessments and so on. Indeed the basic approach of this proposal can be utilized on any project which requires the analysis of different types of geographical data as a basis for organizing shelf use plan or evaluation.

On this paticular project the computer is utilized in performing a comprehensive shelf study to identify the most suitable candidate areas for offshore permafrost.

We hope to continue developing a system which will aid in predicting the distribution and characteristics of offshore relict permafrost by obtaining information on the conditions, the history and the development of the paleogeographical conditions in this area.

A special computerized system will divide the offshore territory into areas which are suitable or unsuitable for relict permafrost. Computer-based mapping of the distribution, thickness and character in modern offshore conditions will be the main part of the program.

To approach a solution involves the study of all the data about direct and indirect indicators of permafrost in the given area, using cartographic methods and also the investigations of the shelf and coastal shorelines. The computer provides us with a tool for managing all of the spatialy disposed data and decision logic used to assess the most suitable area for permafrost. In addition to providing a tool for storing and retrieving geographically based data, the system is used to produce derivative maps showing the new aspects of the conditions for the submarine permafrost extension and its possible character. If the work continues during 1978-1979 , it will be possible to generate composite maps of the shelf area using suitable and environmental sensitivity.

VII. Sampling Methods: Not applicable.

VIII. Analytical methods: The continuation of the Offshore Permafrost Geographic Based Information Management System (OPGIMS) development.

Our data management system is designed to provide a comprehensive framework for recording, storing, manipulating and displaying mappable information used in preparing planning studies. This program entails the use of electronic data processing and computer graphics to organize and present a variety of complex data in an orderly and systemic manner. Data is stored on magnetic discs allowing retrieval, analysis, and display of the data in the form of computer-generated maps. Techniques and facilities available via NGSDC in Boulder are of considerable assistance in these respects (especially the data files at NGSDC/EDS on bathymetry, etc. and their facilities for digitilizing map data). The program gives a dynamic base that can be readily updated, and it allows the evaluation of many alternatives. The system can automatically generate a great deal of secondary data, saving time and money during the collection phase of the project. During the data analysis phase, it is possible to aggregate a number of subjective judgements into an integrated set of evaluations. This set of evaluations has to identify the most suitable candidate offshore area for permafrost, based on a multiplicity of geomorphological, geological, cartometerical, geophysical, and oceanographic factors. The system provides a complete trace of the decision-making process as well as an up-to-date base which can be used for future siting and routing and environmental studies of this territory.

Using the computer-oriented approach, a team of investigators is able to coordinate the flow of information for projects analysis, to control the selection and format of the data used, and to establish their value. The Data Structure Diagram (Fig. 1) represents and organizes data requirements, the stages of mapping, and the production of information resulting from the study. This Diagram differs from the Data Structure Diagram of the first proposal in that some changes were made after studying the available source data in this area, including such parameters as:

Sea bottom temperatures and salinities,
Air temperatures (incl. paleo-temperature record),
Thickness of Holocene sediments,
Bathymetry,
Sea level history,
Thermal characteristics of subsea sediments.

This data Structure Diagram illustrates the relationships among the data information used in the study, and it can be viewed as describing the flow of mappable information. The layout and content of the diagram is developed in response to the relevant issues (the distribution and the thickness of the permafrost in the Alaskan northern coast. The diagram is organized both horizontally and vertically, with the vertical organization arranged by the type of map analysis. The source data column contains "nonvalue-oriented" data from maps. The next two columns, for "derived data maps," contain the results of cartometrical and other ways of the first usage of the data management. Then the interpretive data maps and issue maps display information developed from source data and derived data maps. These maps are defined by disciplinary knowledge and the relationships between source data topics. They serve as the basis to further, more experimental and subjective analysis.

We will use computer methods as the mechanisms for identifying and organizing the multiplicity of the values of the data into a form useful in the composite analysis stages. The composite mapping records and illustrates the geologist's opinion about the major problem--the area suitable for existence of permafrost in the Beaufort Sea offshore. The last map gives the final variant of the location, character and thickness of the permafrost in this area. The Data Structure Diagram clearly serves as a useful vehicle for initially organizing the project and efficiently moving toward the stated goals of the study. Different types of data are needed in order to determine the most suitable location of the offshore permafrost in the Beaufort Sea. Using a modified cost/benefit analysis, each potential source data type can be evaluated as to its costs of acquisition relative to its degree of importance in the overall decision-making process.

At the begining of 1977 two base maps had been prepared: A Geographic Base Map as a basis for mapping all source data at the same scale and in a common format (each data category can be mapped onto a separate copy of the GBM) and A Grid Base Map in order to facilitate the referencing of mappable data for computer processing. It is used as an overlay for encoding the data. The individual cells on the Grid Base Map serve to represent discrete geographic areas which act as depositories for data. Each grid cell is indexed by its row and column number to provide a discrete address identifying a specific location.

Both kinds of maps have been prepared in two scales: 1:50,000 and 1:1,000,000 (in the same coordinates system). The first scale is directly connected with submarine permafrost investigations in nearshore areas with a higher desnity of data; the second one is oriented on the maps generated at the Point Barrow meeting. The size of the grid cell is determined by several factors: The overall goals of the study; the character and density of the data; and the size of the study area. A grid cell size is 2.5 minutes by 2.5 minutes for the scale 1:50,000 and 30 minutes by 30 minutes for the scale 1:1,000,000. Identifying the particular data characteristics for each grid cell, the computer is able to record the type, location, and extent of all mappable data within the study area.

The Universal Transverse Mercator (UTM) coordinate system was selected because it is the contiguous coordinate system throughout the entire study area. In order to prepare a source data map for imput to the computer, the map must first be convered into a computer-readable form. This is referred to as "the process of encoding data." Encoding of a specific source data map is done by aligning a transparent copy of the Grid Base Map over the respective source data map. The data is encoded by writing into each grid cell on the transparent grid map the appropriate data label number, that is, the number used to represent a particular data characteristic. Specific techniques are used for manipulating the data.

The four basic techniques that are used for interpreting and analyzing the data are: (1) the Translation technique for converting a single source data map into a secondary data map; (2) the Comparison technique for comparing two or more maps in order to produce a third derivative map showing the results of the comparison; (3) the Overlay technique for combining two or more maps in order to produce a composite map showing the results of the overlay process; and (4) the Distance technique which is used for calculating the distance of all geographical areas from a given point, line, or area.

The computer technique and such statistical methods as factor analysis and cluster routines are used also for "controlling" the computerized division of the territory and for comparing the results of these two methods of offshore area division. The comparison of the two methods is important also in the methodological sense for evaluating the time and the cost of such different approaches for further investigations.

IX Anticipated problems connected with physical field mapping.

There is very often the need to map certain physical fields (salinity, temperature, ocean depths) over some limited area. But usually we have observations (ships, satellites) only in a very limited number of points, and the real problem is to cover the whole region with some reasonable data. The data assimilation problem is the problem of creating an equal-distance network of grid points from very sparsely distributed observation stations. In our Quarterly report we describe the simplest approach to this problem dividing our region (Alaskan shelf) into generally small rectangular areas. Some of them include shorelines and others are totally in the ocean. We have produced some preliminary contour maps on CDC-7600 (water salinity, sampling depth and temperature); we have also made half-tone intensity maps of these characteristics. These maps have also been produced on the printer without using the plotting machine. The main problem is that this area has a very poor observational network, so in our work we have to rely a very low density of observations.

At the beginning of our research we have used three different approaches to the data assimilation problem, but all of them have the same main goal: to build the grid point network of data by mathematical and statistical means, very densely and equally spaced (from 2' to 5') in latitudinal and longitudinal directions. Sometimes this procedure of data assimilation is called "objective analysis". The preliminary results of these approaches have been described in our Quarterly report (July 1, 1977).

X Deliverable Products:

A. Digital data The following source parameters averaged for a thirteen minute grid covering the continental shelf in the scale of 1:1,000.000 and five minute grid in the scale 1:50,000: Oceanographic (bathymetry, temperature and salinity of water). Lithological (character and thickness of the bottom recent Holocene and Pleistocene deposits, base and subsurface bedrock), tectonical(structural and linear features), Arctic coastal geomorphological (shoal location, ice type, major ice lineations, gouge directions); indicators of the shorelines, paleotemperature records, direct drilling, geophysic and geopmorphic data on permafrost.

B. Visual data Computer generated sources and derived data maps, including the maps of the parameters listed above, the maps of the thermal characteristics and poroisity of the deposits, static and dynamic tectonics, density of seasonal ice, density of the different indicators of the submarine permafrost, rate of shoreline changes, duration of the shoreline changes, density of the bottom contours.

Complex of Interpretive and Specific Parameters Maps includes:
Surface factors affecting permafrost distribution,
Paleogeographical (historical and paleoclimatic) factors affecting permafrost distribution,
Areas of ice and bottom interaction,
Local uplift and subsidence areas,
Permafrost thickness,
Types of submarine permafrost environments.

Composite Maps:
Suitability for relict permafrost.
Unsuitability for relict permafrost.

Candidate Area Map:
Offshore permafrost distribution, character and thickness.

C. Narrative Report The final report will also include 200 pages, 30 pictures and numerical models cluster and factors analysis diagrams, block schemes and so on. The expected information products will also include the analysis of the data and ideas of the Russian literature on submarine permafrost, with the following content:

Submarine Permafrost on Arctic Shelf of Eurasia (Data and Ideas Analysis and Bibliography)
Bibliography*

A. Introduction *

B. Division of the bibliography according to the different aspects of submarine permafrost study *

C. Submarine permafrost regional distribution, composition, composition and structure *

1. Thickness of the rock zone with subzero temperature on the Eurasia Arctic coast *

2. Data on submarine permafrost extension in Laptev East Siberian and Kara Seas *

3. Depth and thickness, cryogenic structures and their formation **

4. Thermal regime and genesis ***

D. History of development, paleogeograhical conditions (changing of the sea level, regressions and transgressions, Pleistocene and recent tectonics, paleoclimatic data) ****

E. Geological and geomorphological environments, thermal erosion, coastal dynamics, arctic shoreline processes, shelf bottom relief and deposits, the ice processes in the coastal zone connected with the bottom freezing ****

F. Hydrological peculiarities (influence of the river flow, thermal and chemical characteristics of the sea water, currents) ****

G. Physics, physical chemistry, mechanics, thermal processes and methods of their study, including mathematical simulation ****

H. Engineering geology and the principles of construction****

I. Surveying and predicting ****

J. General problems connected with submarine permafrost development in the polar regions ****

We see that the main result of the proposal will be the creation of a system to organize the multiplicity of data values into a form useful in the composite analysis stages. The recorded and illustrated composite mapping will solve the major problem of how to show areas suitable for permafrost existence in the Beaufort and Chukchi Seas. The last map gives the final variant of the location, character and thickness of the permafrost in this area, solving the principal problem of this work. While the system may not be able by itself to actually predict the extent of subsea permafrost everywhere on the shelf, it will aid in such predictions by other OCSEAP research projects on subsea permafrost (see R.U. 105).

* Chapters included in Annual Report (October 1976 - April 1977)

** Chapters included in Quarterly Report (April - June 1977)

*** Chapters to be included in Quarterly Reprot (July - September 1977)

**** Chapter to be written during 1977 - 1978

E. Data Submission Schedule This proposal is a continuation of the work begun in 1976-1977. That is why we may consider the submission of all source data by the beginning of September 1977. It gives us the possibility to concentrate our efforts in recording, storing, manipulating and displaying mappable information used in preparing planning studies, in electronic data processing and computer graphics to organize and present a variety of complex data in an orderly and systemic manner. Data is stored on magnetic discs allowing retrieval, analysis, and display of the data in the form of computer-generated maps. The OPGIMS can automatically generate a great deal of secondary data, saving time and money during the collection phase of the project. During the data analysis phase, it is possible to aggregate a number of subjective judgements into an integrated set of evaluations. The OPGIMS provides a complete trace of the decision-making process as well as an up-to-date base which can be used for future siting and routing studies of this territorry.

Using the computer-oriented approach, the study team is able to coordinate the flow of information for projects analysis, to control the selection and format of the data used, and to establish their value.

The dates data will be submitted to the project offices for inclusion in the data base according to the attached "Data Products Schedule".

XI. Information Required from other Investigators.

During the 1976-1977 year the arrangements and proposal contacts were made on the Beaufort and Chukchi Seas submarine permafrost and other geological and related problems. I hope to continue these contacts, especially with David M. Hopkins (Shoreline History of the Chukchi Sea as an Aid to Predicting Offshore Permafrost Condition along the Northern Alaskan Coast), Robert Lewellen (Coastal Erosion, Erosional and Depositional Rates, and Patterns of Sediments Along the Alaskan Sea Coasts), Peter Barnes and Eric Reimnitz (Offshore Permafrost, Lateral Extent and Continuity of Permeable Layers), T.E. Osterkamp and W.D. Harrison (Drilling Properties, Processess and Models), James C. Rogers (Acoustic studies, the Shape of the Permafrost Boundary, Thermal Models, Comparison with Bottom Temperatures along the Coast), R. Berg et al. (Engineering Characteristics), Jerry Brown and P. Sellman, (CRREL and other scientists of OCSEAP). Their data are and will be a very important part of the OPGIMS. I can underline the importance of the Point Barrow meeting in organizing of such kinds of contacts, for instance, the example of the sucessful experience of the common work.

XII, XIII, & XIV, XV We do not propose to use quality assurance plans, special sample and Voucher specimen Archival Plans, logistics requirements and Management Plans. (Note: This proposal itself is a "management system".)

XVI. Outlook

Assuming that the research proposal for FY 1978 is successfully carried out and reaches the first major plateau of accomplishment, we can outline the following:

A computer-based system for systematic collection, storage and display of the environmental parameters of importance for predicting not only the extent of subsea permafrost but as an aid to an environmental assessment of the seashore continental shelf.

For incorporation in Impact Assessment considerations, it is anticipated that the research should be continued through FY79 for the whole Beaufort and Chukchi Seas shelf area, and also that the environmental impact of oil exploration in the offshore permafrost environment be studied. Issues of concern are ecological sensitivity, water and ice contamination, coastal and bottom deposits stability, social sensitivity, public hazards, and wildlife hazards. These aspects would be under consideration and would be reflected in the Data Structure Diagram and computer-based value setting for composite mapping analysis into separate districts relating to the areas of sensitivity to these factors. Maps generated at the Point Barrow meeting are a good base for such work. We consider these maps as a source data maps. That is why in 1979 we can begin from derived maps, generating them for reaching the main goal of the work: The compiling of The Composite map of the Beaufort and Chuckchi Seas Shelf Environmental Division.

In addition some special environmental maps could be done, such as A Computer generated Map of Water and Ice Contamination Sensitivity of the Alaskan Shelf and so on.

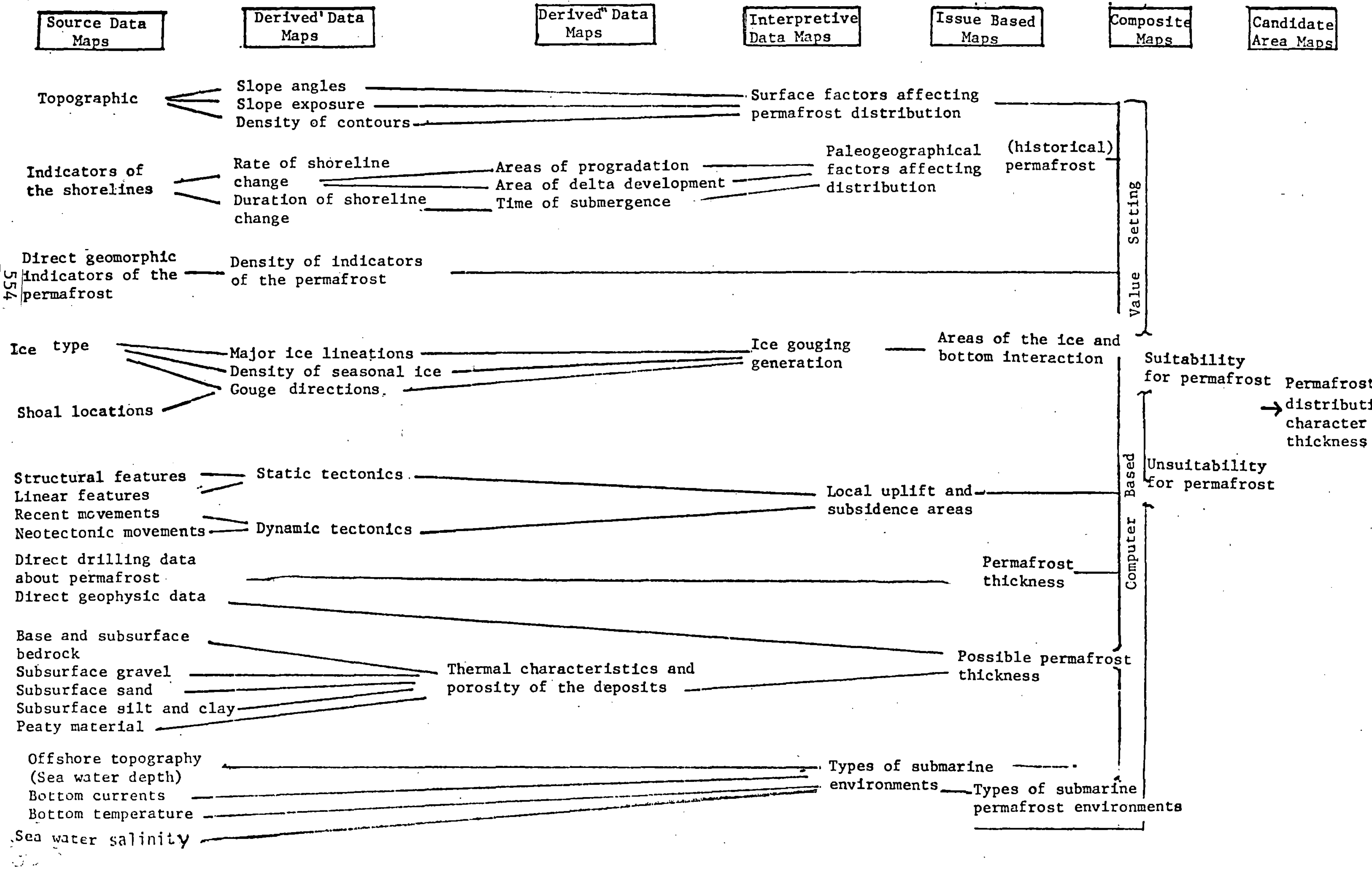
The cost of this work will be approximately $40-60K which is on the same level of the current work. We do not need additional major equipment nor special field efforts and with logistic requirements. Of course, we consider this work as a collective effort of the OCSEAP participants and hope to share our authorship with the representatives of the different scientific fields.

Data Products Schedule

Data Type (ie, Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disc)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by P.I. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Source data	Maps	12	Scale: 1:50,000			
		12	1:1,000,000	Yes	October 1977	November 1977
	Coding sheets	12		Yes	Oct.- Dec. 1977	January 1978
	Punch cards	6.10^5		Yes	Oct.- Dec. 1977	January 1978
	Magnetic tapes	10		Yes	Oct.- Dec. 1977	January 1978
Derived data	Maps	10	1:50,000			
		10	1:1,000,000	Yes	Oct. - Dec. 1977	January 1978
	magnetic tapes	8		Yes		
Interpretive data	Maps	5	1:50,000	Yes	Jan. - March 1978	April 1978
		5	1:1,000,000			
	magnetic tapes	4		Yes	Jan. - March 1978	April 1978
	Issue based	5	1:50,000			
	Maps	5	1:1,000,000	Yes	April-June 1978	July 1978
	Composite map	1	1:50,000	Yes	July-Sept. 1978	October 1978
		1	1:1,000,000			
	Candidate Area	1	1:50,000			
	Map	1	1:1,000,000	Yes	July-Sept. 1978	October 1978
	Magnetic tapes	2		Yes	July-Sept. 1978	October 1978

Data Structure Diagram

Figure 1



MILESTONE CHART

RU #: 516 PI: M. Vigdorchik

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978								
Data Management System (Continuation)	O	N	D	J	F	M	A	M	J	J	A	S
Source Data Maps	+	+	+									
Derived Data Maps	+	+	+									
Quarterly Report	+	+	+									
Interpretive Data Maps				+	+	+						
Annual and Quarterly Report				+	+	+						
Issue Based Maps							+	+	+			
Quarterly Report							+	+	+			
Composite Maps										+	+	+
Candidate Area Map										+	+	+
Quarterly and Final Report										+	+	+
Submarine Permafrost on Arctic Shelf of Eurasia (Analysis continuation)												
Chapter D	+	+	+									
Chapter E				+	+	+						
Chapter F							+	+	+			
Chapter G							+	+	+			
Chapter H										+	+	+
Chapter I										+	+	+
Chapter J										+	+	+

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

TO:	OCSEAP, Arctic Project Office Elvey Bldg, Geophysical Institute University of Alaska Fairbanks, Alaska 99701
TYPE OF SUPPORT REQUESTED:	Contract
TITLE OF PROJECT:	Characterization of the Nearshore Hydrodynamics of an Arctic Barrier Lagoon System; Meteorological Input, Research Unit 519
PRINCIPAL INVESTIGATOR:	F. D. Carsey, Research Scientist Division of Marine Resources University of Washington Seattle, Washington 98195 Telephone: area code 206, 543-1234
AMOUNT REQUESTED:	$51,914
DESIRED PERIOD:	October 1, 1977 - September 30, 1978
UNIVERSITY OFFICE TO BE CONTACTED REGARDING GRANT OR CONTRACT NEGOTIATION:	Grant and Contract Services 201 Administration Building, AG-50 University of Washington Seattle, Washington 98195 Telephone: area code 206, 543-4043

DATE: ______________________

Frank Carsey
PRINCIPAL INVESTIGATOR F. D. CARSEY

Stanley R. Murphy
Stanley R. Murphy
Director, Division of Marine Resources

N. Untersteiner
Norbert Untersteiner
Project Director, AIDJEX

OFFICIAL AUTHORIZED TO GIVE UNIVERSITY APPROVAL:

D R Baldwin
Donald R. Baldwin, Director
Grant and Contract Services
201 Administration Building, AG-50

7-15-77

C. Technical Proposal:

I. Title: Characterization of the Nearshore Hydrodynamics of an Arctic Barrier-Lagoon System: Meteorological Input

Research Unit Number: 519

Contract Number: 03-5-022-67

Proposed Dates of Contract: 1 October 1977 - 30 September 1978

II. Principal Investigator: F. D. Carsey

III. Cost of Proposal

Total $ 51,914

Distribution of Effort by Lease Area: Beaufort Sea, 100%

IV. Background

Work proposed here supplements the effort of Matthews and coworkers by providing large scale and mesoscale meteorological input for nearshore current and sea level height and tilt modeling. This work extends current efforts in measurement and modeling of sea-breeze and mountain effect winds and Beaufort Gyre tides begun under RU519. Examination of data taken during RU519 shows the growth seaward of a sea breeze cell during the summer day and the tides thereby created. Cell dimension and strength are to be further studied in summer, 1977 and are clearly important in both magnitude and time dependence in the establishment of lagoon currents, sea level tilt and the ultimate trajectory and surface borne contaminants. The same situation exists for mountain effect winds and Beaufort Gyre tides for which processes preliminary data has been gathered (in early summer, 1977) but not yet analyzed.

V. Objectives

The objectives of this program are to measure and model mesoscale processes in the surface winds of the Beaufort Sea Coast to make possible accurate calculated trajectories of suspended and floating pollutants. Also, it is important to examine the access to historical estimates of these winds from archived data. Spatial and temporal variation of surface currents driven

V. Objectives: continued

by surface winds and ice motion will determine the probability that oil-related accidents will have impact on identified biological populations at the continental shelf edge and shore regions. Spatial variations due to orographic and thermal effects can help identify regions of high environmental impact hazard.

VI. General Strategy and Approach

The strategy proposed is to examine actual surface winds in comparison with carefully taken large scale pressure distributions and to model the differences as mesoscale contributions. Winds are measured at 3-5 locations along the Beaufort coast on points and islands with roughly 50 km spacing and pressures are recorded at 4-6 locations defining a grid of some 100 km spacing between Barrow, Barter Island, Narwhal Island and Umiat. Instruments and measurement spacing and data intervals are chosen to balance precision and ruggedness.

VII. Sampling Methods

Sampling is done continuously and is analyzed into 3-hourly averages to conform with atmospheric transient response and for comparison with archived data. Sampling periods are usually one month in duration to provide a period long compared to synoptic change and still within budget limitations. The sampling period will be chosen to coincide with that of J. B. Matthews who will be measuring oceanographic variables.

VIII. Analytical Methods

Pressure fields are analyzed to produce geostrophic wind fields after Brown et al (1974) and surface wind fields after Carsey and Leavitt (1977). Sea-breeze modeling is not a well understood process; recent theory is due to Walsh (1974). We will attempt to extend and particularize this model. Mountain effect winds have been discussed by Schwertfeger (1974,1975) and Dickey (1960). These include both barrier flow and orographic baroclimicity. It is likely that a combination of at least these two processes will be necessary to account for the actual measured wind field. Beaufort Gyre tides will be examined by comparing ADRAM's buoy movements (Coon,1977) with data taken as part of OCSEAP (Aagaard,1977).

IX. Anticipated Problems

The modeling of the sea-breeze is the most significant anticipated problem. We will first compare the model of Walsh (1974) to our data. The basic results of Walsh demonstrate the importance of sea-breeze modeling for oil spill trajectory modeling in the strong time and space dependence of the winds. The primary purpose of this work is not to forecast the sea-breeze but simply to estimate reasonable scale and magnitude for the cells under the conditions of the region.

X. Deliverable Products

A. Digital data, placed in OCSEAP format by investigator

1. Wind speed and direction at four coastal sites in the barrier islands region

2. Atmospheric pressures at 4-6 sites in Northern Alaska.

B. C. & D. other data: none anticipated

E. Data Submission Schedule: see attachment

XI. Information required from other Investigators: none anticipated

XII. Quality assurance plans:

Anemometer winds are annually compared to factory calibration in wind tunnel tests.

Microbarographs are compared to transfer standards on a weekly basis and are intercompared at least twice annually. Instrument temperatures are recorded in the field for calibration purposes.

XIII. Special Sample and Specimen Archival Plans: none anticipated

XIV. Logistics Requirements: see attachment

XV. Management Plan: see attachment

XVI. Outlook

It seems unlikely that this work will proceed past data presentation for the field season of 1978.

C. AIRCRAFT SUPPORT - HELICOPTER

1. Delineate proposed transects and/or station scheme on a chart of the area. (Note: If flights are for transport of personnel or equipment only from base camps to field camps and visa versa, chart submission is not necessary but origin and destination points should be listed) Flights are for transport

Deadhorse to Cottle Island
Deadhorse to Narwhal Island
Deadhorse to Tolaktavut Point
2 trips each site

2. Describe types of observations to be made.

NONE

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

Late July and early September

4. How many days of helicopter operations are required and how many flight hours per day? At least 2, perhaps 4

Total flight hours? 5

5. How many people are required on board for each flight (exclusive of the pilot)?

2

6. What are the weights and dimensions of equipment or supplies to be transport ?

Approximately 100 lbs, 2'x2'x3'

7. What type of helicopter do you recommend for your operations and why?

No recommendation

8. Do you recommend a particular source for the helicopter? If "yes" please name the source and the reason for your recommendation.

No

9. What is the per hour charter cost of the helicopter?

Approximately $450.00

10. Where do you recommend that flights be staged from?

Deadhorse

11. Will special navigation and communications be required?

No

AIRCRAFT SUPPORT

Fixed Wing or Helicopter

1. Proposed transects:

   Pingok to Umiat to Happy Valley to Deadhorse to Pingok

2. Observations: none

3. Optimum time chronology:

   Once per week - late July to early September

4. How many days of flights: 7

   How many hours: 14

5. How many people: 1

6. Equipment: 100 lbs., 2'x2'x2'

7. Recommended aircraft: no recommendation

8. Recommended source: no recommendation

9. Cost per hour: $150.00

10. Staging point: Pingok or Oliktuk

11. Special navigation equipment: none

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

a) Pingok Is., about 40 days
   Deadhorse, about 5 days
b) Late July to early September
c) 2 persons for 14 days
   1 person for 20 days

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

No

3. What is your estimated per man day cost for this support at each location?
a) $90/day Deadhorse
b) $40/day Pingok

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

a) Deadhorse estimate from past costs
b) Pingok estimate from NARL experience

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by P.I. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Wind speed and direction, 4 locations	tape	2560 entries	101	yes	approx. 20 July-10 September	Nov. 1978
Atmospheric Pressure, 4 locations	tape	~2560 entries	101	yes	" " " " "	" "

XVII. The following provisions are recognized:

1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the P.I. is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of accruing or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following standard acknowledgement is acceptable.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

MILESTONE CHART

RU #: 526 PI: F. D. Carsey

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Data submission: 1977 field work			X												
Data submission: 1978 field work														X	
Report: Impact of Seabreeze												X			
Field Season: 1978										X	X	X			
Report: Geographical extent of barrier winds												X			
Quarterly Reports			X						X			X			
Annual Report						X									

Frank D. Carsey - Publications

1970

(with M. Levy, R. Kagiwada, I. Rudnick) Regular flux jumps in the mixed state of niobium. *Physics Review 4B*, p. 2804.

(with M. Levy) Apparent superconducting energy gaps in pure niobium and tantalum, *Proceedings of the Twelfth International Conference on Low Temperature Physics.* Tokyo: Keigaku Publishing Company, p.273.

1971

(with R. Kagiwada, M. Levy, and K. Maki) Apparent two energy gaps in pure niobium, *Phys. Rev. 4B*, 854.

(with M. Levy) Mixed state ultrasonic attenuation in clean niobium near H_c2: field dependence $\vec{q}||\vec{H}$, *Phys. Rev. Lett. 27*, 853.

1972

(with M. Levy) Temperature dependence of ultrasonic attenuation in the mixed state of pure niobium. *Proceedings of the 13th International Conference on Low Temperature Physics* (to be published).

1973

(with M. Levy) Anomalous ultrasonic attenuation in pure superconducting Nb. *Physics Review 7B.*

A linear zipper array acoustic antenna for probing the wind and structure profile of the lower atmosphere. *J.A.S.A.* (Symposium on Atmospheric Acoustics and Noise Propagation, September 1972)(in process).

(with M. Levy) Mixed state ultrasonic attenuation in pure niobium near the superconducting transition (in process).

1974

(with D. W. Beran, B. C. Willmarth, F. F. Hall, Jr.) An acoustic doppler wind measuring system. *J.A.S.A. 55*, p. 334-339.

1975

(with A. H. Vanderpol, D. S. Covert, R. J. Charlson and A. P. Waggoner) Aerosol Chemical Parameters and Air Mass Character in the St. Louis Region, *Science 190*, p. 570.

1976

"The AIDJEX acoustic sounder system with some preliminary results. *AIDJEX Bulletin No. 31*

1977

(with Eric Leavitt). "Pibal/Acoustic Radar Data in Measurement and Computation of Air Stress over Pack Ice." *AIDJEX Bulletin No. 36*, May, 1977; pp. 87-128.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Boulder, Colorado 80302
OCS Arctic Project Office
506 Elvey - Geophysical Inst.
University of Alaska
Fairbanks, AK 99701

January 10, 1978

MEMO

TO: Frank Carsey - RU 519 (526 B)

FROM: Gunter Weller, Project Manager

SUBJECT: Change of Principal Investigator on RU 519

In response to your letter of December 21, I accept your resignation as Principal Investigator on "Characterization of the Nearshore Hydrodynamics of an Arctic Barrier Lagoon System: Meteorological Input," Research Unit 519 (526 B). I approve the appointment of Dr. Eric Leavitt of the Polar Research Center, University of Washington, and look forward to meeting with him at the Beaufort Synthesis Meeting in Barrow later this month. Please be sure that he has all the information he needs regarding OCSEAP policies and procedures.

We are sorry to lose your participation in OCSEAP, but look forward to continued contact. I wish you every success in your new position, wherever it may be.

THJ

cc: Roy Overstreet

aidjex
ARCTIC ICE DYNAMICS JOINT EXPERIMENT

December 21, 1977

Dr. Gunter Weller
Arctic Project Office
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

Dear Gunter:

I am writing to inform you that I am resigning my duties as Principal Investigator on "Characterization of the Nearshore Hydrodynamics of an Arctic Barrier Lagoon System: Meteorological Input, Research Unit 519
Other personnel in the project will not be changed.

I do this with considerable regret since I remain strongly interested in the physical phenomena of the region and strongly sympathetic with the goals of the OCSEAP study. Subject to your approval, I have asked Dr. Eric Leavitt of the Polar Research Center of U.W. to become PI for this project. Eric has considerable experience in arctic atmospheric boundary layer studies, and can easily perform the requisite duties. It is very likely you will meet him in January in Barrow. Eric will be informally assisted by Dr. Miles McPhee, also of the PRC, who can contribute considerably to our project and to general OCSEAP progress through his familiarity with the dynamics of the oceanic mixed layer driven by wind or ice-movement. This is a study area which I feel is yet under-examined in the problem of coastal processes in the Arctic.

I expect to remain active in polar sciences and I am certain that I will remain interested in the physics and the fate of the arctic coast. In this regard, please consider me available for any such tasks as proposal review or recommendation which you feel I could give assistance with.

Best regards,

Frank Carsey

FC:jt

cc: Roy Overstreet

UNIVERSITY OF WASHINGTON DIVISION OF MARINE RESOURCES / 4059 Roosevelt Way N.E. Seattle, Washington 98105 Telephone (206) 543-6613 SCAN 323-6613

PROPOSAL TO

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

FOR

CHARACTERIZATION OF THE NEARSHORE HYDRODYNAMICS OF AN ARCTIC BARRIER ISLAND - LAGOON SYSTEM

OCSEAP RESEARCH UNIT NO.:	526A
PRINCIPAL INVESTIGATOR:	J. B. Matthews
TOTAL COST OF PROPOSAL:	$151,942
PERIOD OF WORK:	October 1, 1977 to September 30, 1978
INSTITUTION AND DEPARTMENT:	University of Alaska Geophysical Institute Fairbanks, Alaska 99701

June 20, 1977

J B Matthews WJS Date 6/28/77
J. B. Matthews
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7477

Date 6/28/77
Neta J. Stilkey, Business Manager
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7644

T Neil Davis Date 6/28/77
T. Neil Davis, Acting Director
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7393

Keith B. Mather /ajs Date 6/29/77
Keith B. Mather, Vice Chancellor for Research and Advanced Study
University of Alaska
Fairbanks, Alaska 99701
Telephone Number: (907) 479-7282

C. TECHNICAL PROPOSAL

I. A. Title: Characterization of the nearshore hydrodynamics of an arctic barrier island - lagoon system

B. Research Unit Number: R.U. 526

C. Contract Number: Mod. No. 9, NOAA Task Order Contract No. 03-5-022-55

D. Proposed Dates of Contract: October 1, 1977 to September 30, 1978

II. Principal Investigator(s)

A. J. B. Matthews, Associate Professor of Marine Science
Geophysical Institue, University of Alaska, Fairbanks, Alaska 99701

B.

C.

III. Cost of Proposal Federal Fiscal year 1978

Total: $151,942

Distribution of effort by lease area

1. Aleutians
2. Beaufort Sea - 100%
3. Bristol Bay
4. Chukchi Sea
5. Kodiak
6. Lower Cook Inlet
7. NEGOA
8. Norton Sound
9. St. George Basin
10. Non-lease-area laboratory or management

IV. Background: The objectives and background of the proposed work were set out in the original proposal; little change in research direction has been encountered. The background and objectives are repeated here for completeness.

In order to assess the probable impacts on the nearshore environment associated with the oil and gas developments in the Alaskan Arctic, it is necessary to understand the nearshore water mass dynamics. This is true whether the developments are from onshore or offshore wells because the coastal waters are used as transportation routes in either case and will be affected by the construction of docks and wharfs as well as by oil spills and blowouts. Even if oil development occurs in deep water off the shelf region, the interaction of water masses will ensure that nearshore regions will be adversely influenced by offshore oil spills and related activity.

The coast of the Alaskan Arctic is characterized by a shallow shelf region with offshore barrier islands forming characteristic shallow lagoons. The shelf waters are believed to interact with lagoon waters which derive some of their water from coastal rivers. In winter the lagoons are frozen, almost completely. In summer they are ice-free and protected from pack ice by the barrier islands. Because of the interaction of the shelf and lagoon waters and because the lagoons are little understood and very productive regions, it is important to characterize their circulation and flushing patterns.

Simpson Lagoon has been chosen as a fairly typical system to be studied in detail. The proposed effort is directed towards understanding the hydrodynamics; other related work will study meteorological and biological aspects as well as sediment dynamics. Some previous work with drifters and very short current meter records has been done in Simpson Lagoon (Kinney et. al., 1972) and a few drogue tracks seaward of the Jones Islands have been reported (Wiseman et. al., 1973), but these are very cursory studies. Moreover the coastal systems are subject to storm surges much larger than the tides (Matthews, 1970) and wind stress is known to be important in the ice-free season (Matthews, 1971, Wiseman et. al., 1975). The response of a lagoon system and the dispersive characteristics are still unknown.

V. Objectives

It is proposed to determine, over a three-year period, the circulation patterns within a characteristic lagoon system, to estimate flushing times and dispersion characteristics and to attempt to determine the interaction of lagoon waters with the offshore waters especially with respect to longshore flow and flow between the barrier islands.

VI. General Strategy and Approach:

The program is ambitious for so short a period given the problems of working in the Arctic. However, a several pronged attack will be mounted and use will be made of the concurrent work of other investigators to look at several facets simultaneously. Also because we shall be primarily concerned with the summer ice-free season, it was agreed that it was imperative to make good use of the first field season so that the second major field season could be carried out fully and the project completed on schedule. However because of the late approval to proceed the initial pre-field-season modeling was not carried out as scheduled and the field season was not as complete as had originally been planned. The first field season has been redesigned to test the very preliminary ideas and techniques so that a more complete model verification can be successfully attempted in the second year.

It is proposed to carry out a detailed literature search on the arctic coastal dynamics and estuarine lagoon systems in general. It was originally hoped to perform this survey concurrently with the development and adaptation of numerical models of the circulation of the barrier island-lagoon system. It will now be carried out after the first field season. The work of Kinney et al., (1972) and Wiseman et al., (1975) as well as the principal investigator's work on arctic storm surge dynamics (Matthews, 1970, 1971 and unpublished manuscript) will serve as a basis for the historical study and determination of model parameters. The modeling work will start with some simple two-dimensional tidal models using continuity and depth-mean current assumptions. We have already developed several different hydrodynamical numerical models (Matthews and Mungall, 1972, Matthews, 1972, Mungall and Matthews, 1973, Matthews and Laevastu, 1975) which could be adapted for studying the lagoon system and have several other available to us. For the models, detailed bathymetry will be required especially since the bathymetry and current regime form a dynamically balanced system. At first we intend to use the standard oceanographic charts of the region with refinements as they become available from other works in the field (the work of Naidu and Cannon is anticipated to be particularly useful).

The modeling program will be carried out sumultaneously at the University of Alaska under Matthews' direction and at Texas A & M University under Mungall's direction. The expertise of both groups will be fully utilized and be complementary to each other. Dr. Mungall's work on wind stress-induced mixing in the lagoon and the wave and trajectory modeling is described in a separate proposal. The modeling in the present proposal is concerned with wind-induced currents, storm surge and tidal pumping effects on the lagoon-barrier island system. One of the several numerical models available to us has the possiblity of adaptation to allow overtopping of the offshore barrier islands during large storm surges. It is proposed to modify the model and run some experiments to examine the importance of overtopping.

The University of Alaska is well-equipped to carry out the proposed effort with its unique Honewell 66/20 statewide time-sharing computer sytem. The uniqueness of the system lies in the extreme distances it spans and the equality with which users are treated via the mini-computer 'nodes'. Since its installation in early 1976, the system has surpassed all expectations and the development plan has been moved up one full year. The computer was up-graded to a 66/40 in Februdary 1977; a second 66/40 is scheduled to be installed in August 1977. We anticipate using all available features including the distant nodes and advanced graphics package. It should be possible to input data directly from the field via the node at Barrow (originally planned for July 1977 but now postponed). Dr. Matthews has had much experience with time-sharing systems during his fellowship year at IBM and has already developed models, bibliographic programs and displays for such systems. We have, through the timely assistance of Dr. Weller of the Arctic Project Office, implemented an optimised version of the Laevastu-Hansen model as used by Callaway (R.U. 335). This model will be used to provide large scale modeling, information on multilevel flows, storm surge overtopping and input data for detailed small scale models. Models will be refined and developed throughout the proposed program as new information from the field becomes available and our understanding of the system increases. Though it was not possible to provide data for use in the detailed planning of the first field season, some useful data were culled from the model results of R. F. Henry (Henry, 1975) and R. J. Callaway (Callaway, 1976) (R. U. 335) both of which use Matthews' unpublished data as primary input. It is hoped to use the data obtained during the first field season and from the N.O.S. tide gague to refine the models to give estimates of flushing associated with storm surges, considerable effort will be made to present the results in compact and clear form using the techniques of computer graphics.

Wind stress is known to dominate the circulation of the lagoon system; hence it is important to know local winds in detail. We anticipate incorporating geostrophic winds into the models to simulate specific events for which we already have some data. However we shall need local wind data at the same time that the current meters and tide gauges are in operation in the field seasons. We have coordinated our efforts with those of Dr. Carsey's meteorological study (R. U. 519). We plan to continue to cooperate with Dr. Carsey to place other instruments at appropriate locations for our mutual benefit. The meteorological program is designed to produce geostrophic wind charts of much greater accuracy than the ones provided by the National Weather Service. By using actual pressure and wind records from the Simpson Lagoon we expect to be able to model the results of real storm surges in the Lagoon. Results to date show that there is a significant sea breeze regime during the summer months. The use of the real data in the model should allow the importance of the sea breeze to nearshore water movements to be assessed.

Tidal or sea level data are essential for any nearshore studies and this is especially true for the very shallow wind-driven waters on the Simpson Lagoon. It was originally intended to install one conventional bubbler tide gauge and one submerged Aanderaa gauge. However problems with the bubbler gauge prevented its renovation in the short time period available before the first field season. At this writing the Aanderaa gauge will be placed in the Lagoon for the first summer season. An N.O.S. bubbler gauge will operate in Prudhoe Bay. More detailed data on sea surface slope is needed to model the surging in the Lagoon. It is proposed to install 4 instruments during the second field season. This will give a minimal data return on the sea surface slope in the modeled area but still not provide redundancy. The meters will be placed to give both longshore and offshore sea-surface slopes along the modeled area boundaries.

Current measurements in the gaps between the islands are essential to our understanding of the circulation and flushing regimes. In the first season we shall attempt to place three bottom-mounted instruments. Aanderaa current meters have been chosen because of their small size, ability to operate under arctic conditions and compatiblity with existing data processing systems. In the second season five meters will be installed to attempt to measure the flow through all the major entrances and exits to the lagoon. This number of meters is small and has no redundancy to allow for losses and failures. Eight current meters is considered to be the minimum to allow for monitoring the inputs and outflows from the seward part of the lagoon. Dr. Mungall at Texas A & M will request 3 meters to be used in conjunction with the wave program and with the present proposed work. This is the best possible array under budget constraints and should provide sufficient data to verify the models. Attempts to borrow additional instruments from the OSC pool have been unsuccessful to date.

Concurrent with the current, sea level and wind measurements we shall be taking a few stations with a temperature-salinity profiler. Because the lagoon is shallow we expect its waters to be well mixed. However, in response to river input, wind stress and storm surges the temperature and salinity will vary and may lead to temporary stratification (Wiseman et al., 1975). Rather than using the expensive, highly accurate deep-sea systems, we hope to use a simpler instrument giving accuracies of 0.1°C and 0.1% which are adequate for our purposes. The problem arises in finding a suitable instrument with digital readout capable of operation under a wide range of salinity and below 0.°C temperatures. For the 1977 field season we have been able to borrow an instrument from the Institute of Marince Science with manual deck readout. The instrument may be recalled at any time and in any case does not have recording capability. We intend to obtain a temperature salinity depth sensor and recorder suitable for shallow water use for the second field season if a suitable instrument can be located. It is expected that we shall be able to use the oceanographic barge for our instrument emplacement offshore of the barrier island. However it is not suitable for use in the lagoon and either float planes or helicopters will be used. Dr. Mungall will also be taking a number of the temperature-salinity and current depth profiles and all data will be available to all investigators. Run-off data will be taken from the study by Dr. Carlson, and we expect to be able to obtain the actual gauge data from the Kuparuk River which is the only gauged river in the area of Simpson Lagoon.

To examine the surface currents upon which oil spills are likely to move we propose to make surface drifter drops from helicopters using available expertise (Paskausky et al., 1974, Murphy et al., 1975, Paskausky and Murphy, 1976). Dr. Paskausky of the Office of Naval Research will be available at no cost to the project to supervise and carry out the drifter program during the first field season. We anticipate several drops of four or five clumps of drifters into the lagoon with fixing by photography and photogrametry. By carrying out a preliminary experiment in the first field season we hope to be able to have a full drifter program ready for the second field season.

This project is being coordinated with the ecological study of the Barrier Island-Lagoon ecosystem under the direction of LGL Limited. The water movement data produced by the models and verified in the field programs will be given to the ecological group at the U.B.C. under Dr. C. Walter's direction. We have discussed, in group meetings, the type and format of data requirements and anticipate changes to our modeling and field programs as the ecosystem analysis progresses. Our initial work on the wind-driven lagoon models has already had an impact on the field season program for 1977 and it is expected that further changes will be requested in the first part of the new contract period so that we might better provide data useful to the aquatic biologists, modelers, nutrient chemists and sedimentologists. Travel funds to allow our attendance at the workshops as well as communications funds for coordination with LGL and the other investigators (particularly Dr. Carsey and Dr. Mungall) have been included in the budget proposal.

VII. Sampling Methods:

Sea level will be sampled hourly with in situ instruments recording on magnetic tape. The tape, (and instrument) must be recovered to extract the sample data.

Current speed and velocity and water conducting and temperature will be sampled by in situ digital recording meters. The instruments record on several magnetic tapes and must be recovered to obtain the sampled data at the end of a sample period. The accuracy of savronius rotor and vane type sensors may be impaired if the samples are taken where there is appreciable wave action. The anticipated problems will be minimized by sampling in the deepest parts of the passes and lagoon. If the problem is serious we expect to test the feasibility of using ducted orthogonal sensors coupled to the same digital recorders.

VIII. Analytical Methods

Aanderaa current and sea level data will be converted to computer-compatible digital format. Existing computer programs and plotting routines will be used to extract information from the data. A harmonic analysis will be run on the sea level data and the data corrected for tidal and inverted barometer effects to leave the storm surge record. The storm surge records will be examined for correlation with the wind components recorded by Dr. Carsey and with the current components.

The raw and refined sea level and wind speed data recovered by the above-mentioned procedures will be used to drive the numerical models which are being developed as part of the work. The current meter observations will be used as verification data for the models. The numerical models will then be refined and used to assess the physical locations where more verification data is needed so that the next field season may be planned efficiently.

IX. Anticipated Problems:

Problems are anticipated in the field program because of the great difficulties in recovering data from in situ instruments in a partially ice-covered environment. The experiences of the Canadian Beaufort Sea Project suggest that considerable redundancy be built into the field program so that when instruments are lost, data from others may be used in substitution. We have at the present level of funding, built no redundancy into our field program and could be unfortunate enough to have no useful data at the end of a field season. There may be the possibility that the meters chosen to record in situ current will be aliased by surface waves. Only the analysis of the field data will reveal the extent of the problem. A possible solution may lie in the use of ducted current meter sensors. Dr. Mungall will use ducted meters (not digitally recording). Should the experiment be successful we may convert the Aanderaa sensors to the ducted type.

We anticipate navigation problems in locating our sample stations. From the R. V. Alumiak or a float plane we should have reasonable navigation available but from small boats in the lagoon station location will be very difficult. The topography is very low affording no good land marks and in any event the summer haze and fogs are extremely common. Some form of radio beacon array and portable RDF and echo (depth) sounder may be the solution to the problem.

X. Deliverable Products:

A. Digital Data:

1. Recorded Parameters:

   Sea level
   Current speed and direction

2. List of Digital Products:

   Sea level
   Current speed and direction

B. Narrative Reports:

Historical review of Lagoon hydrodynamics.
Summary of present knowledge of arctic lagoon hydrodynamics with specific analysis of Simpson Lagoon.
Report of results of numerical model runs on Simpson Lagoon.

C. Visual Data:

Depth mean current plots under typical selected conditions derived from numerical models.
Comparative plots of time-series of current speed and direction, sea level, barometric pressure and wind components from actual field observations (if any).

D. Other Non-Digital Data:

Estimates of flow rates in inter-island gaps.
Estimates of flushing times under various typical conditions in Simpson Lagoon.
Discussion of longshore circulation and its effect on the flow through the barrier islands.
Discussion of water quality within the lagoon and its dependence on longshore currents, wind stress and river runoff.

E. Data Submission Schedule:

Digital current and sea level data will be submitted within 90 days of recovery of the instruments.

Data Products Schedule Attached

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by P.I. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Sea level	tape	750 samples	015	Yes	8/1/77 - 8/30/77	1/78
Current speed & direction	tape	2250 samples	015	Yes	8/1/77 - 8/30/77	1/78
Sea level	tape	3000 samples	015	Yes	8/1/78 - 8/30/78	1/79
Current speed & direction	tape	3750 sampels	015	Yes	8/1/78 - 8/30/78	1/79

XI. Information Required from other Investigators:

Wind speed and direction
Barometric pressure at stations along the Alaskan Beaufort Sea from Dr. Carsey.
River runoff data from Dr. Robert Carlson.
Temperature salinity and current profiles in Simpson Lagoon from Dr. Mungall (if any).
Sea level records from the Alaskan Beaufort Sea from National Ocean Survey.
Bathymetry updates and coastline changes for Simpson Lagoon and surrounding area from Drs. Barnes and Hopkins (U.S.G.S.) and Drs. Naidu and Cannon (if any).
Current and temperature salinity data off shore of the Simpson Lagoon from Dr. Aagard.

XII. Quality Assurance Plans

The numerical models generated under this task order will be verified as far as possible with field observations. Any model output will be released with a statement as to whether or not it is verified and to what the results of such verification imply about the accuracy of modeled output.

Field observations will be carried out as far as possible with calibrated instruments and the known accuracies will be given with the data.

XIII. Logistics Requirements. (See attached form)

Float plane used for setting current meters and in situ tide guages in Simpson Lagoon for 3 days at the beginning and end of each field season, July and end of August.

Float plane one day per week during August to take a station array within the Simpson Lagoon.

Boston Whaler with windshield and spray cover daily during the month of August at the ARCO dock for daily sampling with hand held profilers.

Alumiak at the beginning and end of August to run a sampling grid outside the lagoon to the ice edge.

STATION LOCATIONS

Code		N. Latitude	W. Longitude	Depth Feet	Depth Meters
PRB 13	B	70° 22.0'	148° 8.2'	3	0.91
	C	70° 22.6'	148° 7.6'	7	2.13
	D	70° 23.3'	148° 7.1'	13	3.96
	E	70° 24.0'	148° 6.5'	15	4.57
	F	70° 24.7'	148° 5.2'	16	4.88
	G	70° 25.3	148° 5.2'	20	6.10
	H	70° 26.0'	148° 4.5'	20	6.10
	I	70° 26.6'	148° 4.0'	23	7.01
	J	70° 27.9'	148° 3.4'	23	7.01
	K	70° 27.9'	148° 2.8'	18	5.49
	L	70° 28.6'	148° 2.1'	20	6.10
	M	70° 29.2'	148° 1.6'	26	7.92
	N	70° 29.9'	148° 0.9'	33	10.06
	O	70° 30.5'	148° 0.3'	43	13.11
	P	70° 31.2'	147° 59.7'	50	15.24
	Q	70° 31.9'	147° 59.0'	50	15.24
	R	70° 32.4'	147° 58.3'		
	S	70° 33.1'	147° 57.7'		
PRB 28	A	70° 18.8'	148° 24.6'	2	.61
	B	70° 19.5'	148° 24.1'	7	2.13
	C	70° 20.1'	148° 23.5'	7	2.13
	D	70° 20.7'	148° 23.0'	7	2.13
	E	70° 21.4'	148° 22.5'	4	1.22
	F	70° 22.0'	148° 21.9'	3	.91
	G	70° 22.7'	148° 21.2'	4	1.22
	H	70° 23.4'	148° 20.5'	5	1.52
	I	70° 24.0'	148° 19.7'	8	2.44
	J	70° 24.7'	148° 19.1'	12	3.66
	K	70° 26.0'	148° 18.1'	22	6.71
	M	70° 26.6'	148° 17.5	24	7.32
	N	70° 27.2	148° 16.9'	24	7.32
	O	70° 27.9'	148° 16.2'	17	5.18
	P	70° 28.6'	148° 15.5'	15	4.57
	Q	70° 29.2'	148° 14.8'	25	8.62
	R	70° 29.9'	148° 14.2'	39	9.14
	S	70° 29.5'	148° 13.6'	38	11.58
	T	70° 31.2	148° 13.0'	46	14.02
	U	70° 31.9'	148° 12.4'	48	14.63
	V	70° 32.4'	148° 11.8'	55	16.76
SIM 10	C	70° 24.0'	148° 32.0'	9	2.44
SIM 11	C	70° 24.0'	148° 32.6'	8	2.44
	D	70° 24.7'	148° 32.9'	13	3.96
	E	70° 25.3'	148° 31.4'	18	5.49
	F	70° 26.0'	148° 30.7'	21	6.40
	G	70° 26.6'	148° 30.1'	24	7.32
	H	70° 27.2'	148° 29.4'	26	7.92
	I	70° 27.9	148° 28.8'	28	8.53
	J	70° 28.6	148° 28.2'	27	8.23
	K	70° 29.2'	148° 27.6'	19	5.79
	L	70° 29.9'	148° 27.0'	26	7.92
	M	70° 39.5'	148° 26.4'	37	11.28
	N	70° 31.1'	148° 35.8'	42	12.80

STATION LOCATIONS

Code		N. Latitude	W. Longitude	Depth Feet	Depth Meters
SIM 11	O	70° 31.8'	148° 25.2'	50	15.24
	P	70° 32.5'	148° 24.6'	54	16.46
	Q	70° 33.2'	148° 24.0'	61	18.59
SIM 12	C	70° 24.0'	148° 33.2'	5	1.52
SIM 13	B	70° 23.9'	148° 34.3'	3	0.91
SIM 29	A	70° 25.2'	148° 47.0'	3	0.91
	B	70° 25.9'	148° 46.3'	5	1.52
	C	70° 26.6'	148° 45.6'	9	2.74
	D	70° 27.2'	148° 45.0'	11	3.35
	E	70° 28.0'	148° 44.4'	14	4.27
	F	70° 28.6'	148° 43.7'	19	5.79
	G	70° 29.2'	148° 43.1'	31	9.45
	H	70° 29.8'	148° 42.5'	39	11.89
	I	70° 30.6'	148° 41.9'	44	13.41
	J	70° 31.2'	148° 41.2'	44	13.41
	K	70° 31.8'	148° 40.7'	38	11.58
	L	70° 32.4'	148° 40.1'	50	15.24
	M	70° 33.0'	148° 39.5'	57	17.37
SIM 52	A	70° 28.2'	149° 3.9'	5	1.52
	B	70° 28.5'	149° 3.6'	6	1.83
	C	70° 28.8'	149° 3.3'	8	2.44
	D	70° 29.5'	149° 2.7'	3	0.91
	E	70° 30.1'	149° 2.0'	23	7.01
	F	70° 30.7'	149° 1.4'	30	9.14
	G	70° 31.4'	149° 0.8'	34	10.36
	H	70° 32.1'	149° -.2'	38	11.58
	I	70° 32.8'	148° 59.8'	42	12.80
	J	70° 33.4'	148° 59.0'	43	13.11
	K	70° 34.0'	148° 58.4'	50	15.24
	L	70° 34.7'	148° 57.8'	54	16.46
	M	70° 35.3'	148° 57.1'	53	16.15
	N	70° 36.0'	148° 56.4'	32	9.75
	O	70° 36.6'	148° 55.7	45	13.72
SIM 67	A	70° 29.8'	149° 15.1'	3	.91
	B	70° 30.3'	149° 14.7'	7	2.13
	C	70° 30.8'	149° 14.2'	7	2.13
	D	70° 31.3'	149° 13.7'	3	.91
	E	70° 31.8'	149° 13.2'	15	4.57
	F	70° 32.4'	149° 12.6'	15	4.57
	G	70° 33.1'	149° 12.0'	36	10.97
	H	70° 33.8'	149° 11.5'	31	9.45
	I	70° 34.4'	149° 10.8'	36	10.97
	J	70° 35.1'	149° 10.2'	39	11.89
	K	70° 35.8'	149° 9.5'	51	15.54
	L	70° 36.4	149° 9.0'	60	18.29
	M	70° 37.0'	149° 8.2'	56	17.07
SIM 67	N	70° 37.6'	149° 7.7'	44	13.41
	O	70° 38.3'	149° 7.2'	50	15.24
	P	70° 38.9'	149° 6.5'	58	17.68
SIM 83	A	70° 31.4'	149° 27.2'	6	1.83
	B	70° 31.8'	149° 26.7'	7	2.13
	C	70° 32.3'	149° 26.2'	9	2.74

STATION LOCATIONS

Code	N. Latitude	W. Longitude	Depth Feet	Depth Meters
C	70° 32.3'	149° 26.2'	9	2.74
E	70° 33.4'	149° 25.1'	22	6.71
F	70° 34.1'	149° 24.5'	32	9.75
G	70° 34.7'	149° 23.9'	38	11.58
H	70° 35.3'	149° 23.3'	42	12.80
I	70° 36.0'	149° 22.6'	45	13.72
J	70° 36.7'	149° 22.0'	50	15.24
K	70° 37.4'	149° 21.3'	55	16.76
L	70° 38.0'	149° 20.7'	55	16.76
M	70° 38.7'	149° 20.1'	56	17.07
N	70° 39.2'	149° 19.6'	59	17.98
O	70° 39.9'	149° 18.9'	60	18.29
SIM 97 A	70° 30.8'	149° 39.0'	4	1.22
B	70° 31.5'	149° 38.3'	6	1.83
C	70° 32.1'	149° 37.7'	7	2.13
D	70° 32.8'	149° 37.0'	6	1.83
E	70° 33.5'	149° 36.4'	5	1.52
G	70° 34.2'	149° 35.8'	21	6.40
H	70° 34.9'	149° 35.1'	35	10.67
I	70° 35.6'	149° 34.4'	44	13.41
J	70° 31.1'	149° 33.9'	46	14.02
K	70° 31.8'	149° 33.2'	46	14.02
L	70° 32.4'	149° 32.6'	47	14.33
M	70° 33.2'	149° 32.0'	51	15.54
N	70° 33.8'	149° 31.3'	55	16.76
O	70° 34.6'	149° 30.6'	56	17.07
SIM 105A	70° 29.8'	149° 48.4'	3	.91
B	70° 30.5'	149° 47.8'	6	1.83
C	70° 31.1'	149° 47.1'	7	2.13
D	70° 31.7'	149° 46.5'	8	2.44
E	70° 32.4'	149° 45.9'	7	2.13
F	70° 33.1'	149° 45.2'	7	2.13
G	70° 33.7'	149° 44.7'	4	1.22
H	70° 34.4'	149° 44.0'	6	1.83
I	70° 35.1'	149° 43.4'	33	10.06
J	70° 35.7'	149° 42.8'	40	12.19
K	70° 36.4'	149° 42.0'	43	13.11
L	70° 37.0'	149° 41.5'	45	13.72
M	70° 37.6'	149° 41.0'	45	13.72
N	70° 38.3'	149° 40.3'	52	15.85
O	70° 38.9'	149° 39.6'	50	15.24
P	70° 39.4'	149° 39.0'	50	15.24
SIM 104E	70° 32.8'	149° 46.6'	12	3.66
F	70° 33.1'	149° 46.2	7	2.13
SIM 111A	70° 30.9'	149° 51.5'	7	2.13
SIM 118A	70° 26.6'	150° 4.7'	4	1.22
B	70° 27.2'	150° 4.1'	6	1.83
C	70° 27.8'	150° 3.5'	8	2.44
D	70° 28.5'	150° 2.8'	7	2.13
E	70° 29.1'	150° 2.2'	8	2.44
F	70° 29.8'	150° 1.6'	8	2.44
G	70° 30.4'	150° 1.0'	10	3.05
H	70° 31.1'	150° 0.3'	10	3.05

STATION LOCATIONS

Code	N. Latitude	W. Longitude	Depth Feet	Depth Meters
I	70° 31.7'	149° 59.8'	10	3.05
J	70° 32.3'	149° 59.0'	4	1.22
K	70° 33.0'	149° 58.5'	12	3.66
L	70° 33.6'	149° 57.8'	17	5.18
M	70° 34.3'	149° 57.2'	25	7.62
N	70° 34.9'	149° 56.5'	32	9.75
O	70° 35.6'	149° 56.0'	35	10.67
P	70° 36.2'	149° 56.4'	35	10.67
Q	70° 36.9'	149" 54.7'	43	13.11
R	70° 37.5'	149° 54.1'	45	13.72
S	70° 38.1'	149° 54.6'	46	14.0
T	70° 38.9'	149° 53.9'	46	14.0
U	70" 39.5'	149° 52.2'	47	14.33

For OCSEAP use only:
RU #
Discipline
Area of Operation

LOGISTICS REQUIREMENTS

Please fill in all spaces or indicate not applicable (N/A). Use additional sheets as necessary. Budget line items concerning logistics should be keyed to the relevant item described on these forms.

INSTITUTION Geophysical Institute PRINCIPAL INVESTIGATOR J. B. Matthews

A. SHIP SUPPORT

1. Delineate proposed tracks and/or sampling grids, by leg, on a chart of the area. Include a list of proposed station geographic positions.
   See seperate chart and station list. (attached)

2. Describe types of observations to be made on tracks and/or at each grid station. Include a description of shipboard sampling operations. Be as specific and comprehensive as possible.

   See attached sheet.

3. What is the optimum time chronology of observations on a leg and seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification.)
   1-5 and 25-30 August ± 5 days

4. How many sea days are required for each leg? (Assume vessel cruising speed of 14 knots for NOAA vessels. Do not include running time from port to beginning point and from end point to port and do not include a weather factor.)
   3 days each leg

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback?
   Principal Operation

   Approximately how many vessel hours per day will be required for your observations and must these hours be during daylight? Include an estimate of sampling-time on station and sample processing time between stations.
   12 hours per day all daylight hours

6. What equipment and personnel would you expect the ship to provide?

   hydrographic winch, wet lab winch operator,

7. What is the approximate weight and volume of equipment you will bring?
   1500 lb. 50 cu. ft.

8. Will your data or equipment require special handling? no If yes, please describe:

9. Will you require any gasses and/or chemicals? no If yes, they should be on board the ship prior to departure from Seattle or time allowed for shipment by barge.

10. Do you have a ship preference, either NOAA or non-NOAA? If "yes" please name the vessel and give the reason for so specifying.
    Yes RVAZUMIAK shallow draft 'arctic' equipped vessel

11. If you recommend the use of a non-NOAA vessel, what is the per sea day charter cost and have you verified its availability

12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals.

Dr. J. B. Matthews, (no foreign nationals)

LOGISTICS SUPPORT

A.2 1) Current meter or in situ tide gauge
Station code SIM 104F
SIM 105G
SIM 52 D
SIM 29 C
SIM 13 B
SIM 11 C

2) Temperature/salinity, current/ depth profiles observations at beginning and end of August at stations accessible to RV Alumiak selected from list in A1.

RV Alumiak cannot enter the lagoon because of shallow depths, therefore stations outside the lagoon only will be taken from RV Alumiak as ice conditions allow.

B. AIRCRAFT SUPPORT — FIXED WING

1. Delineate proposed flight lines on a chart of the area. Indicate desired flight altitude on each line. (Note: If flights are for transportation only, chart submission is not necessary but origin and destination points should be listed)

   Weekly flight and taxing by float plane to service stations within lagoon approximately 50 n. miles from Deadhorse Airport

2. Describe types of observations to be made.

   Set current meters and tide gauges
   Profiles of temperature/salinity and current in depths up to 8 feet water

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification)

   1-30 August 5 full days at weekly intervals +2 days

4. How many days of flight operations are required and how many flight hours per day?

   5 full days 1 1/2 hours fliying 3 hrs taxing 5 1/2 hours anchored

   Total flight hours?

5. Do you consider your investigation to the principal one for the flight thus precluding other activities or requiring other activities to piggyback or could you piggyback? Principal

6. What types of special equipment are required for the aircraft (non carry-on)?

   none

   What are the weights, dimensions, power requirements, and installation problems unique to the specific equipment.

7. What are the weights, dimensions and power requirements of carry-on equipment?

   4 meters, 100 lbs each, 3 cu. ft., no power required

8. What type of aircraft is best suited for the purpose?

   Float Plane

9. Do you recommend a source for the aircraft?
   If "yes" please name the source and the reason for your recommendation.

   No

10. What is the per hour charter cost of the aircraft?

    $150.00

11. How many people are required on board for each flight (exclusive of flight crew)?

    2

12. Where do you recommend that flights be staged from?

    Deadhorse

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

Deadhorse
27 July - 1 September
4 people per day
37 man days

NARL, Barrow
26 July - 1 Sugust
2 people per day
10 man days

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

No

3. What is your estimated per man day cost for this support at each location?
$2960 Deadhorse - Total
$ 800 Barrow - Total

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

Rates based on 1977 published costs

K. SPECIAL LOGISTICS PROBLEMS

1. What special logistics problems do you anticipate under your proposal and how do you propose that the problems be solved? (Provide cost estimates and indicate whether you propose handling the problems yourself or whether you must depend on NOAA to solve them for you?

Problems of installing in situ recorders in shallow water (3-8ft) with float plane or boat. We expect to solve our own problems.

XIV. Outlook:

1. Nature of final results and data products:

The final results will be computer plots of currents under various combinations of external driving forces accompanies by a narrative. The verification field data will be the products.

2. Significant milestones:

Completion of the first field season and evalution of the effectiveness of our methods. Fall 1977.

Revision of the numerical models using field data and completion of the second field season. Fall 1978.

3. Additional major equipment required:
   3 in situ tide guages
   2 in situ current meters
   Profiling digital temperature salinity sensor
   Hard copy graphics printer

4. Location of future field efforts:
   Simpson Lagoon region, Beaufort Sea, Alaska

5. Logistics Requirements:

See section XIV

XV. Contractual Statements:

1. A schedule for data submission for each task order has been, and will continue to be, submitted and updated each quarter.

2. This statement is in accordance with our base contract, and we will continue to comply.

3. See section XIII of this proposal. The University of Alaska will continue to negotiate a Voucher Specimen Policy with NOAA/OCS. We will comply with the then agreed to policy.

4. See section XV of this proposal. The University of Alaska agrees that the Principal Investigators can travel to the Project Office at least twice during the contract year, provided that such travel is in accordance with University of Alaska travel policy and consistent with other University duties of the Principal Investigator.

5. Data will be provided in the form and format agreed to by the University and NOAA/OCS in the negotiating of the Data Management Plans for each of the tasks falling under the jurisdiction of this office.

6. As per Article 9 of the base contract, the University of Alaska agrees to the following: "...all archivable data is to be submitted by the contractor to the Contract Data Manager within 120 days after acquisition. Certain data sets such as plankton counts or volumes are not available until sorting of samples is complete. The data so obtained are archivable 120 days following the actual sorting or other laboratory procedure."

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager by the Chief Scientist. If the Chief Scientist represents the contracts covered by this office, the form will be sent through this office.

8. This is in accordance with the base contract with which we shall comply.

9. Three copies of all publications or presentation abstracts or manuscripts pertaining to technical or scientific material developed under OCSEAP funding will be submitted to the COTR sixty days prior to publication or presentation. Copies of all news releases mentioning OCS or using information gathered by OCS funding will be sent to the COTR two working days prior to release.

10. The following acknowledgment of sponsorship will be used:

> "This study was supported under contract 03-5-022-56 between the University of Alaska and NOAA, Department of Commerce through the Outer Continental Shelf Environmental Assessment Program to which funds were provided by the Bureau of Land Management, Department of Interior."

MILESTONE CHART

RU #: 526 PI: J. B. Matthews

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978												
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Evaluation of first field season				X												
Annual Report							X									
Evaluation of model run with first field data										X						
Completion of second field season												X				
Evaluation of second field season data																X
Quarterly Reports				X						X			X			

PUBLICATIONS:

Published Articles

Matthews, J. B., Some electrical effects associated with the formation of precipitation elements, Ph.D. Thesis, University of London, England, 1963.

Matthews, J. B. and B. J. Mason, Electrification accompanying the melting of ice and snow, Quart. J. Roy. Met. Soc., 89, 376-380, 1963.

Matthews, J. B. and B. J. Mason, Electrification produced by the rupture of large water drops in an electric field, Quart. J. Roy. Met. Soc., 90, 275-286, 1964.

Matthews, J. B., An unusual type of lightning, Weather, XIX, 291, 1964.

Matthews, J. B., Mass loss and distortion of freely falling water drops in an electric field, J. Geophys. Res., 72(13), 3007-3013, 1967.

Matthews, J. B., The tides of Puerto Penasco, Gulf of California, J. Ariz. Acad., 5(2), 131-134, 1968.

Matthews, J. B., M. B. Allen, D. C. Burrell, J. J. Goering and C. P. McRoy, Coastal ecosystems of Alaska, In H. T. Odum, B. J. Copeland and E. A. McMahan, eds., Coastal Ecological Systems of the United States, North Carolina University, 5-13, 1969.

Matthews, J. B. and J. C. H. Mungall, A two dimensional variable boundary tidal model, Nature, 226(5248), 835-836, 1970.

Matthews, J. B., Tides at Point Barrow, Northern Engineer, 2(2), 12-13, 1970.

Matthews, J. B. and D. L. Nebert, A modified pooh-bah float for Arctic conditions, Cahiers Oceanog., 23(9), 795-799, 1971.

PUBLISHED ARTICLES (Cont'd)

Matthews, J. B., Long period gravity waves and storm surges on the Arctic Ocean continental shelf, Proc. Joint Oceanogr. Assembly (Tokyo 1970), 332, 1971.

Matthews, J. B. and J. C. H. Mungall, A nuermical tidal model and its application to Cook Inlet, Alaska, J. Mar. Res., 30(1), 27-38, 1972.

Matthews, J. B., Towards the development of a numerical fjord circulation model in Alaska, Proceedings of the 3rd Conference on Pacific Northwest Estuaries, Corvallis, Oregon, 1973.

Matthews, J. B. and G. J. Mimken, A novel underwater weather station, Proc. OCEAN 74 IEEE Conf. on Eng. in Ocean Env., Vol. 1, 359-363, 1974.

Matthews, J. B. and A. V. Quinlan, Seasonal characteristics of water masses in Muir Inlet, a fjord with tidewater glaciers, J. Fish. Res. Bd. Canada, 32(10), 1693-1703, 1975.

Matthews, J. B. and T. Laevastu, Hydrodynamical-numerical models for coastal waters and open ocean areas, EOS, 56(9), 580-583, 1975.

Mungall, J. C. H. and J. B. Matthews, The M_2 tide of the Irish Sea, Estuarine and Coastal Marine Science, accepted for publication, 1976.

Matthews, J. B., The coastal oceanography of the Labrador Coast, A review, Estuarine and Coastal Marine Science, in preparation, 1977.

Matthews, J. B., The seasonal circulation of the Glacier Bay fjord system, Alaska, Estuarine and Coastal Marine Science, in preparation, 1977.

Reports

Matthews, J. B., S. R. Browning and D. A. Thomson, Tide calendar for the northern Gulf of California, University of Arizona Press, 14 pp., 1968.

Matthews, J. B., Tides in the Gulf of California, In Probable Environmental Impact of Heated Brine Effluents from a Nuclear Desalination Plant on the Northern Gulf of California, D. A. Thomson, A. R. Mead and J. F. Schreider, eds., Dept. of Interior, Rept. Contract OSW 1401-0001-1665, 14-50, 1968.

REPORTS (Cont'd):

Matthews, J. B. and D. H. Rosenberg, Possible effects of the brine effluent on salinities of the northern gulf waters, In Probable Environmental Impact of Heated Brine Effluents from a Nuclear Desalination Plant on the Northern Gulf of California, D. A. Thomson, A. R. Mead and J. F. Schreider, eds., Dept. of Interior, Rept. Contract OSW 1401-0001-1665, 128-138, 1968.

Matthews, J. B. and D. H. Rosenberg, Numeric modeling in a fiord estuary, Progress Rept. 1966-1968, Office of Naval Research, Contract NONR 3010(5), Institute of Marine Science, University of Alaska, Report No. 69-4, 77 pp., 1969.

Matthews, J. B., Numeric modeling of a fiord estuary, Institute of Marine Science, University of Alaska, Report P69-28, 16-48, 1969.

Matthews, J. B., D. W. Hood, J. J. Goering and R. Horner, A Preliminary report on Cruise 010 of the R/V Ursa Minor to Berners and Katlian Bays in Southeast Alaska for site selection evaluation for a wood pulp mill, Institute of Marine Science, University of Alaska Report R69-14, 1969.

Matthews, J. B., Valdez - Prince William Sound environmental study report, Institute of Marine Science, University of Alaska Report R69-15, 1969.

Matthews, J. B., S. R. Browning and D. A. Thomson, Tide calendar for the northern Gulf of California for 1970, University of Arizona Press, 14 pp., 1969.

Matthews, J. B. and D. L. Nebert, A proposed circulation model for Endicott Arm and Alaskan Fjord, Report R72-10, Institute of Marine Science, University of Alaska, 90 pp., 1972.

Matthews, J. B., A numerical model of a fjord estuary. I. Basic considerations and proposed finite difference schemes, Report R72-15, Institute of Marine Science, University of Alaska, 72 pp., 1972.

Matthews, J. B. and J. C. H. Mungall, Numerical tidal models with unequal grid spacing, Tech Rept. R73-2 to Office of Naval Research, Institute of Marine Science, University of Alaska, 1973.

Matthews, J. B., H. J. A. Meu and P. Vandall Jr., Oceanography of The Labrador Coast, Bedford Institute of Oceanography, Blue Cover Report 77-R-1.

FILMS:

Imperial College Underwater Archaeological Expedition to Sicily 16mm, 20 min with soundtrack, Martini International Club London, 1962.

The M_2 Tides of Cook Inlet Alaska, 16 mm 7 min with soundtrack University of Alaska, 1972 (with J. C. H. Mungall).

The M_2 Tides of the Irish Sea, 16 mm, 7 min with soundtrack University of Alaska, 1972 (with J. C. H. Mungall).

Reviews

Matthews, J. B., Wind waves: Their generation and propagation on the ocean surface, by Blair Kinsman, J. Mar. Tech. Soc., 4:6, 1970.

Matthews, J. B., Ebb and Flow, by Albert Defant, J. Mar. Tech. Soc., 5(1), 1971.

Matthews, J. B., Tidal Power, by T. J. Gray and O. K. Gashus (eds.), J. Mar. Tech. Soc., 1972.

Matthews, J. B., Tsunamis in the Pacific Ocean, Adams (ed.), J. Mar. Tech. Soc., 6(5):56-7, 1972.

Matthews, J. B., Man's Impact on Terrestrial and Oceanic Ecosystems, W. H. Matthews, F. E. Smith and E. D. Goldberg (eds.), J. Mar. Tech. Soc., 1973.

Matthews, J. B., Estuaries: A physical introduction, by K. R. Dyer, J. Mar. Tech. Soc., 9(4):44, 1975.

January 1977

PROPOSAL

OCSEAP Data Processing Services

Submitted by:

The University of Rhode Island

Kingston, Rhode Island 02881

To:

The Environmental Research Laboratories -- NOAA
Outer Continental Shelf Environmental Assessment Program
Bering Sea -- Gulf of Alaska Project Office
P.O. Box 1808, Juneau, Alaska 99802

Total Cost of Proposal: $30,000

Period Covered: 1 March 1978 - 30 September 1978

Principal Investigator:

Harold Petersen Jr.
Pastore Laboratory
(401) 792-2320

Harold Petersen Jr.

Official Authorized to
Commit the University:

William Ferrante
Vice President for Academic Affairs
Administration Building
(401) 792-2447

or

Office of Coordinator of Research
Davis Hall
(401) 792-2635

TECHNICAL PROPOSAL

I. Title:

OCSEAP Data Management Services

Research Unit Number: 527 (Existing Contract)

Contract Number: 03-7-022-3519 (Existing Contract)

Proposed Dates of Contract:

1 March 1978 - 30 September 1978

II. Principal Investigator:

Dr. Harold Petersen Jr.
Pastore Laboratory
University of Rhode Island
Kingston, Rhode Island 02881

III. Cost of Proposal (Federal Fiscal Year 1978):

Total $30,000

Distribution of Effort by Lease Area: Effort is independent of lease areas.

IV. Background:

Data management procedures associated with the BLM-sponsored, NOAA-administered program responding to the needs of petroleum development of the Alaskan shelf call for baseline study data to be submitted to the Bering Sea - Gulf of Alaska Project Office at Juneau, Alaska (JPO). These data are subsequently sent to the National Oceanic Data Center (NODC) for archival and product development.

The need arose for the application of detailed data validation steps to this data prior to its formal acceptance for archival. Checks have been found necessary in the areas of valid code use, reasonableness of data values (range and relational checking), and general format adherance.

During the contract year ending 28 February 1978, this RU has begun the task of validating file type 033 data (Ship and Aircraft Census - Marine Birds), one of several data types associated with the program. The work is ongoing, and involves extensive code and raw number validation steps as well as data reformatting. A summary of these procedures is given in Appendix I. The procedures followed are heavily influenced by characteristics found in incoming data, and are frequently modified. Consequently, the report given in Appendix I should be viewed as a "working document", subject to revision.

The scope of activities related to validating file type 033 data has been greatly expanded during the present contract year, primarily in response to characteristics of incoming data. For example, previously unused codes and code groups came into use and required validation, new range checks were found necessary on certain data fields, and new techniques were implemented for other types of data field manipulations.

File type 033 data is only one of the file types which require validation. Many others are being carried out at NODC. The rapidly expanding scope of activities associated with this work represents a significant time and resource demand on that site not anticipated at program initiation, and must be dealt with to ensure a smooth flow of validated data for use in program product generation.

V. Objectives:

It is the objective of this research to provide, within budgetary limits, validity checks on and reformatting of file type 033 and other types of data submitted to JPO, as well as to supply that office with other program products of value in terms of the efficient processing of OCSEAP data.

VI. General Strategy and Approach:

Introduction:

Data is received by JPO either in a format unique to the Principal Investigator (PI), i.e. an "internal format", or in adherance to OCSEAP-designated format acceptable for subsequent delivery to NODC ("NODC format").

In the former case, the format may contain, in addition to program related data, other data not solicited by the program. Also, the codes used for coded data may contain extensions which are not part of NODC approved codes. In both cases, data may exceed reasonable ranges, some segments of a multi-segment data field may be missing, invalid data codes may be present, or data record types may be incorrectly coded.

The task, then, is to ensure that data sent to NODC conforms to approved style in terms of code use, data reasonableness, and format adherance.

File Type 033 Data:

The steps involved in ongoing work on data of this file type are summarized in Appendix I, however a scenario of events is provided here in order to more fully describe the present day-to-day processing activities.

> Data for several field operations are received on tape. The tape is read and the contents made into a disk data set. The data set is backed up on another tape for security, and then split into separate data sets, one for each field operation. Each is passed through the program CODEPULL which first sorts the data by station number, transect type, record type (record types 4 and 5 are grouped together in the file type 033 format for this purpose), and sequence number within each record type. The program then checks each code field of each record type for adherance to allowable codes, and also flags cases where required card types are not present (for example, card types 1 and 2 should appear before card types 3, 4, or 5 in file type 033 data). Invalid codes and invalid record types are flagged.
>
> Examination of the flagged records sometimes shows that the record type has been incorrectly assigned. By inspection, the correct record type is discerned, and used with two programs, SETUPCTF and URUNCTF, to change the record type in the field operation file. CODEPULL is again run, and output exhibiting invalid codes which require attention by the PI is returned to that site for resolution.
>
> Data fields are then range and relationally checked (for example, if barometric pressure trend is coded, then barometric pressure must also be coded) using the program LOGLIST. This output is also sent to the PI for resolution, and all corrections received from the PI are used to update the file with the programs EDITLOG and FLDFILL. The two validation programs are again run on the data, and if no additional errors are found, the data are converted (if necessary) to acceptable NODC format prior to submission. The conversion process is quite

elaborate, and involves unit conversions, code conversions, data truncation, and relocation of data fields within card types or between card types. The program CONVPROG is used for this purpose.

If subsequent quality control or processing is desired, the data are converted to a MIS data base, which then makes a variety of procedures, such as time-distance checks and plotting routines available. Any errors in the data found as a result of these techniques would be used to update the NODC files prior to their submission.

Work status as of January 1978 is summarized in Appendix II. While considerable progress is expected before the end of the present contract year, it is not possible to finish it by that time. Thus, it is proposed that this RU continue processing file type 033 data already received as well as any new data of this type received during the proposed contract period. It is estimated that data presently in the processing stream will be completed by June 1978.

Other Bird Data:

Two additional situations present themselves with respect to validation of OCSEAP-related bird data. First, there are approximately seven bird data formats presently in use which also require validation procedures. Second, the types of formats to be used in future field operations is under review at the present time, and may indeed result in replacement of existing formats with fewer, new ones.

It is proposed that this RU participate in the validation of new and existing data of these types. The task would capitalize on expertise and procedures resulting from file type 033 work, and assist both JPO and NODC in ensuring a smooth flow of OCSEAP bird data.

Other Data Types:

Encumbent upon the OCSEAP program is the collection, validation, and analysis of data types corresponding to a wide variety of environmental parameters. One of the types of data currently being submitted is that corresponding to marine mammals. The data is coded in three file types (025 - Marine Specimen Format, 026 - Marine Mammal Sighting II, and 027 - Marine Mammal Sighting I). Approximately 95 data sets have been prepared to date. One of the contributing PI's has developed data checking procedures for this data type, however most of this data has not been fully validated.

It is proposed that this RU provide marine mammal data validation for OCSEAP, utilizing, in part, the referenced procedures. In this way, advantage can be taken of an in-place, generalized data validating scheme together with data checking procedures developed specifically for marine mammal data.

VII. Anticipated Problems:

While no major problems are anticipated in the production use of this scheme, it should be pointed out that new problems often arise from unanticipated sources. In work carried out to date, one of the most celebrated examples has been the use of unauthorized codes by PI's. When they are encountered, Program authorization must be secured with respect to their acceptance, rejection, or translation before the data sets can be further processed. This illustrates how an unanticipated event or perhaps a series of them can hold up processing. It is, of course, impossible to foresee all possible cases prior to their occurrence. Events such as these also underscore the need for flexibility in the system.

VIII. Deliverable Products:

A. Digital Data Products: Results of this work will be coded in EBCDIC on 9 TK tape in NODC-acceptable format for delivery to NODC and also to the respective PI's.

B. Visual Data: If desired by JPO, cruise tracks, station position plots, other graphical displays, or additional quality control outputs will be provided.

C. Data Submission Schedule: Data should have a nominal four week turnaround time after delivery from JPO for validation checks, and conversion (if necessary). This schedule is subject to the conditions described above.

IX. Information Required from Other Investigators:

In order to successfully carry out the proposed research, data must be collected by PI's, entered, submitted to JPO, and subsequently sent to this site for processing.

X. Quality Assurance Plans:

By the inherent design of the data validation steps described, no data which does not pass established criteria will appear in products generated in this work. The criteria are established in conjunction with JPO and PI representatives. Data fields not validated in this process are, of course, subject to errors.

XI. Management Plan:

The proposer will provide overall coordination of the work. He will serve as Principal Investigator, be responsible for all negotiations with the granting agency, conduct meetings at which data validation procedures are established, direct the activities of other personnel supported by contract funds, and prepare all Quarterly, Annual, and Final Reports. Other personnel will include two programmers and an operations manager. The programmers will be responsible for the generation and maintenance of all software aspects of the research. The operations manager will be responsible for the orderly flow of data through the system, and delivery of the validated data to NODC and the respective PI's. In addition, both the programmers and the operations manager will be expected to originate their own work assignments in support of the overall project. See also the accompanying Activity/Milestone/Data Management Chart (note that this chart covers the existing as well as proposed contract periods).

XII. Outlook:

It is expected that the validation procedures established under the present contract and those anticipated for other types of data will be required in FY'79. Funding requests for FY'79 should not be significantly greater than those in FY'78, increasing only as a function of inflation and small equipment changes (perhaps 10-15%).

Present and anticipated data processing loads can be handled within the personnel and equipment framework described in the Cost Proposal below. However, this load is only a part of the entire JPO data flow. Should significant increases be made in this load, additional personnel and small equipment will be necessary. An increase of one staff member plus computer time, small equipment, etc. would cost approximately $33 K.

Other areas of potential increases in activity include: design and implementation of optical scanning techniques for data entry, establishment of key/disk or other equivalent key entry service, design and implementation of automated field data entry techniques, new products which will aid JPO personnel in data management activities. It is difficult to assess the cost associated with these possibilities, however research in these areas would form a natural extension to existing and other proposed work.

XIII. Basic Agreements:

The following statements cover areas of agreement between the proposer and the granting agency.

A. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

B. Quarterly Reports will be submitted in sufficient time during the contract period to be in OCSEAP hands by the first day of January, July, and October, and Annual Reports by 1 April. The Final Report will be submitted within 90 days of the termination of the contract.

C. At the option of JPO, the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be bourne by JPO.

D. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

E. Reformatted and/or validated (as necessary) data will be made available within approximately one month after receipt from JPO or designated source when such procedures are in production status. New procedures will require approximately three months to be put into production.

F. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

G. Three copies of all publications or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to JPO at least sixty days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty days shall be made only with prior written consent of JPO. News releases will first be cleared with JPO.

H. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship, using the standard acknowledgment.

Activity/Milestone/Data Management Chart

RU #: 527 PI: Harold Petersen Jr. -- University of Rhode Island

	1977										1978											
Major Milestones	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Choice of validation criteria for type 033 data		A																				
Procedures for validation of FWS type 033 data operational					A																	
Procedures for reformatting FWS type 033 data to NODC type 033 format operational												P										
Quarterly Reports					A			A			A						P			P		
Procedures for validation of NODC type 033 data operational								A														
Typical set-up period for new type of data validation and reformatting, including meetings, programming, etc.								<-	P	->												
Field Operation Status Report operational											A											
Annual Report														P								
Final Report																					P	

<-------- Existing Contract Period -------><-- Proposed Contract Period ->

P = Planned Completion Date
FWS = Fish and Wildlife Service

A = Actual Completion Date
NODC = National Oceanic Data Center

APPENDIX I.

Data Validation Procedures for File Type 033 Data

OCSEAP DATA VALIDATION PROCEDURES
For File Type 033

In order to provide data validation for the File Type 033 data from the OCSEAP Project, four areas need consideration. These include card type validation, data range and relational parameter checking, and format, code, or unit conversion. Since this is a multi-card type file, the card type designation must first be verified (an incorrect value would lead to the improper interpretation of remaining fields on that card), along with the occurrence and sequencing of card types. Second, codes used in each code field (ex. - a two digit weather code) must be compared against all valid codes for that field for verification. Next, range checks must be carried out on all appropriate fields (ex. - sea surface temperature should be between certain upper and lower limits), and relational checks on interrelated fields (ex. - wet bulb temperature readings should be less than or equal to corresponding dry bulb temperature readings). Lastly, if the data are not coded in NODC format, the necessary format changes must be carried out.

Card type designation and sequencing, and valid code field contents are checked in a program called CODEPULL. First the card type is verified. This must be between one and five, and certain other fields are also checked for further verification (ex. - a type five card must have a taxonomic code and a sequence number). Extra cards and missing cards are detected with the sequencing routine. This checks that the cards are in order, that each station has a unique one card followed by a unique two card, and that there are no duplicated or skipped sequence numbers. Then the appropriate code tables are called, and each code of each code field is compared with the appropriate table containing all valid codes for that field.

The output from CODEPULL is a listing of the file in order by station number. Any errors detected are flagged with a brief descriptive message, including a record count for ease in correcting, and, in the case of a bad code, a string of asterisks under the field. Following the file listing is a summary of all the codes used for each code field and their definitions. For a bad code, the record in which it appeared replaces the definition. Figure 1 is a list of the code groups checked and Figure 2 is a portion of a CODEPULL listing.

Data range and relational checking are done in a program called LOGLIST. This verifies the data coded as raw numbers, rather than as codes. The contents of the data fields are first checked for numerics, signs, and leading zeros and then compared to upper and lower limits appropriate to each field. In some cases the value of one field is dependent on the value of another field and these relational checks are also made.

LOGLIST prints a columnular listing for each card type. The columns are identified by a three character field code defined prior to the data listing. The record number is listed on the left and any errors detected are flagged in the diagnostics section on the right. A totally blank field is indicated by a row of dots and imbedded blanks by an asterisk. Figure 3 is a list of the limit and relational checks made and Figure 4 is a portion of a LOGLIST listing.

These outputs are sent to the Principal Investigator for correcting. He checks the diagnostic messages and the data and marks any necessary corrections directly on the listing. These are returned to us and the updates made to the file with an interactive program called EDITLOG. Then CODEPULL and LOGLIST are rerun for final verification.

Finally the data is converted to NODC format (if it was coded in another format) and submitted to NODC. Format conversion is done with a program called CONVPROG. Many different operations are carried out at this point. For example, data fields are moved from one place to another on a given card, or onto a different card; units are converted and rounded or truncated, or converted to codes; and codes are converted to those equivalent codes acceptable to NODC. Figure 5 is a list of the special conversion routines carried out.

All of these programs form part of the MARMAP Information System. Their operation is directed by a Master System Table (MST). The MST has an entry for each field of each card type in a file. This contains all the information needed for processing, including field code, data type, position, upper limit, lower limit, relational checking and conversion routines. The programs therefore are data independent and readily adaptable to any file type.

Figure 1
File Type 033 Code Groups Validated

	Field	FWS Columns	NODC Columns
Card Type 1			
	Platform Type	67-68	69
	Ship Activity	70	71
	Sampling Technique	69	70
	Collection Code	-	72
	Zone Scheme	-	73
	Angle of View	-	74
	Observation Conditions	-	75
	Speed Type	60	-
	O.B.S. Region	28-30	-
	Observer Location	74	-
Card Type 2			
	Wind Direction	-	45-46
	Swell Direction	-	50-51
	Sea State	-	49
	Weather	16-17	55-56
	Cloud Type	-	57
	Cloud Amount	-	58
	Water Color	-	59
	Visibility	18	61
	Sun Direction	-	62
	Glare Intensity	61	63
	Glare Area	62	64
	Moon Phase	-	68
	Tide Height	-	69
	Debris	-	80
	Observation Conditions	19	-
	Turbidity	-	63
Card Type 3			
	Ice Cover	16,23,35	16,22
	Ice Pattern/Description	17, 24	32
	Ice Type	18, 25	17, 23
	Ice Form	19,26,34	18, 24
	Ice Relief	20, 27	19, 25
	Ice Thickness	21, 28	20, 26
	Ice Melting Stage	22, 29	21, 27
	Open Water Type	30	28
	Ice Direction	31, 36	29, 33
	Distance	32,37,40	30, 34
	Lead/Polyna Width	33, 39	31
	Ship in Lead/Polyna Location	38	-
	Collection Code	41,42,43	35,36,37
	Mammal Trace	44, 45	38, 39
	Pond Size	-	49
Card Type 5			
	Age Class	50	32
	Sex	51	33
	Color Phase	52	34
	Plumage	53	35
	Molt	54	36

Figure 1 (cont.)

Field	FWS Columns	NODC Columns
Counting Method	-	42
Reliability	-	43
Distance Measurement Type	-	44
Association Type	55-56	50
Behavior	46-47	56-57
Special Marks	62	58
Bird Condition	63	59
Food Source Association	-	60
Debris	74	71
Oil	-	72
Habitat	-	76,77
Substrate Type	-	81
Cover Code	-	82
Outside Zone	-	83
Text Flag	77	-

Figure 2

Sample CODEPULL Listing

CODEPULL consists of two major sections.

Figure 2A is a page from the first section showing how the file is listed. It is sorted by Station, Card Type and Sequence Number and has dotted lines dividing the Stations. The errors flagged are "Bad Card Type" because the Card Type 4 has no sequence number; "Bad Sequence Number" because the sequence number field is not numeric; and "Bad Code" because the code entered is invalid.

Figure 2B is a portion of the second section. This first gives a summary of the number of each type of record found in the file, then a list of the codes used and appropriate definitions. For an invalid code the definition is replaced by the record number in which it appeared. This can be seen for the Weather Code on Card Type 2.

***** CODEPULL *****

Figure 2A

FOR CRUISE FW7032

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

*** CODEPULL - CRUISE FW7032

```
-------------------------------------------------------------------------------------------------------------------------
                                 033FW70321 1073595250N1492600W7705232105              10+09 1119  6      4        30
                                 033FW70322 1073 260                          2      03
RECORD #     3
TYPE 4 #     1  BAD CARD TYPE -->
                                 033FW70324 1073 WAY UP BACK SIDE. SEE FIELD NOTES.

RECORD #     4
TYPE 4 #     2  BAD SEQUENCE# -->
                                 033FW70324 1073 KIWH ALL 3 VERY GREY BACKS ONE FEMALE WITH NOTCH IN DORSAL HALF
                                 033FW70325 1073  91290106              1                                     001  0
                                 033FW70325 1073  9128020301            1                                     002  0
                                 033FW70325 1073  9129010502            2                                     003  2
                                 033FW70325 1073  9218021601     1      1       001                           004  0
                                 033FW70325 1073  9218021601     2      4       001                           005  0
-------------------------------------------------------------------------------------------------------------------------
                                 033FW70321 1173595130N1492615W7705232115              10+09 1120  6      4        30
RECORD #    11
TYPE 2 #     2  BAD CODE -->     033FW70322 1173 256    + 81                  2       03
                                                                                      **
                                 033FW70325 1173  9129011302            2     10      20                      001  0
                                 033FW70325 1173  9128020301            1             20                      002  0
                                 033FW70325 1173  9129010301            4     10      20                      003  0
                                 033FW70325 1173  91290106              2     10      20                      004  0
-------------------------------------------------------------------------------------------------------------------------
                                 033FW70321 1273595000N1492730W7705232125              10+09 1118  6      4        30
                                 033FW70322 1273 256    + 84                  2      03
                                 033FW70325 1273  9128020103            1     09      20                      001  0
                                 033FW70325 1273  9129C10301            8     09      20                      002  0
                                 033FW70325 1273  9127070301            3             20                      003  0
                                 033FW70325 1273  9109030201            2             61                      004  0
                                 033FW70325 1273  91290106              2             20                      005  0
-------------------------------------------------------------------------------------------------------------------------
                                 033FW70321 1373594800N1492715W7705232135              10+09 1118  6      3        30
RECORD #    24
TYPE 2 #     4  BAD CODE -->     033FW70322 1373 265                          3       03
                                                                                      **
                                 033FW70325 1373  9128020103            4     09      20                      001  0
                                 033FW70325 1373  9129011401            2     09      20                      002  0
                                 033FW70325 1373  9129011302            2             03                      003  0
                                 033FW70325 1373  91290103              3     10      20                      004  0
                                 033FW70325 1373  9129010601            2             03                      005  0
-------------------------------------------------------------------------------------------------------------------------
                                 033FW70321 1473594600N1492715W7705232145              10+09 1118  6      3        30
                                 033FW70322 1473 220                          3      03
                                 033FW70325 1473  9129011401            1             20                      001  0
                                 033FW70325 1473  9128020301            1             20                      002  0
                                 033FW70325 1473  912901                5             20                      003  0
                                 033FW70325 1473  9128020103            1             20                      004  0
                                 033FW70325 1473  91290103              2             20                      005  0
-------------------------------------------------------------------------------------------------------------------------
                                 033FW70321 1573594430N1492715W7705232155              10+09 1118  6      3        30
                                 033FW70322 1573  91    + 78                  3      03
                                 033FW70325 1573  9129011401            5     09      20                      001  0
                                 033FW70325 1573  9129011401            9             01                      002  0
                                 033FW70325 1573  9218022001            1                                     003  2
                                 033FW70325 1573  9128020103            1             20                      004  0
                                 033FW70325 1573  9129011302            2     09      20                      005  0
```

Figure 2B

***** SUMMARY *****

FOR CRUISE FW7032

2219 TOTAL RECORDS

277 TYPE 1 RECORDS
277 TYPE 2 RECORDS
0 TYPE 3 RECORDS
6 TYPE 4 RECORDS
1659 TYPE 5 RECORDS

0 RECORDS WITH AN INVALID TYPE

RECORD TYPE 1

CODE FIELD: PLATFORM TYPE - NODC(1:69)

CODES	COMMENT
BLANK	-

CODE FIELD: SAMPLING TECHNIQUE - NODC(1:70) - FWS(1:69)

CODES	COMMENT
BLANK	-

CODE FIELD: SHIP ACTIVITY - NODC(1:71)

CODES	COMMENT
BLANK	-

CODE FIELD: COLLECTION CODE (PHOTOS TAKEN) - NODC(1:72)

CODES	COMMENT
BLANK	-

CODE FIELD: ZONE SCHEME (TRANSECT WIDTH) - NODC(1:73)

CODES	COMMENT
BLANK	-

CODE FIELD: ANGLE OF VIEW - NODC(1:74)

CODES	COMMENT
BLANK	

CODE FIELD: OBSERVATION CONDITIONS - NODC(1:75)

CODES	COMMENT
4	AVERAGE
3	POOR
2	MARGINAL
7	EXCELLENT
6	GOOD
5	FINE
BLANK	

Figure 2B (cont.)

RECORD TYPE 2

CODE FIELD: WIND & SWELL DIRECTION - NODC(2:45-46)(2:50-51)

CODES	COMMENT
BLANK	-
31	305-314 DEG.
14	135-144 DEG.

CODE FIELD: SEA STATE - NODC(2:49)

CODES	COMMENT
2	SMOOTH-WAVELET
3	SLIGHT
4	MODERATE
1	CALM-RIPPLED
0	CALM-GLASSY
BLANK	-

CODE FIELD: WIND & SWELL DIRECTION - NODC(2:45-46)(2:50-51)

CODES	COMMENT
BLANK	-

CODE FIELD: WEATHER - NODC(2:55-56) - FWS(2:16-17)

CODES	COMMENT
03	CLOUDS GENERALLY FORMING OR DEVELOPING
0	*** 000011 000024 000045 000051 000690 000721
68	RAIN OR DRIZZLE AND SNOW, SLIGHT
00	CLOUD DEVELOPMENT NOT OBSERVED OR NOT OBSERVABLE
71	CONTINUOUS FALL OF SNOW FLAKES, SLIGHT
61	RAIN, NOT FREEZING, CONTINUOUS, SLIGHT
41	FOG OR ICE FOG IN PATCHES
43	FOG OR ICE FOG, SKY INVISIBLE, THINNING DURING LAST HOUR

CODE FIELD: CLOUD TYPE - NODC(2:57)

CODES	COMMENT
BLANK	-
3	ALTOCUMULUS

CODE FIELD: CLOUD AMOUNT - NODC(2:58)

CODES	COMMEN
BLANK	-

CODE FIELD: WATER COLOR - NODC(2:59)

CODES	COMMENT
BLANK	-

CODE FIELD: VISIBILITY - NODC(2:61) - FWS(2:18)

CODES	COMMENT
BLANK	-

CODE FIELD: COMPASS DIRECTION (SUN) - NODC(2:62)

CODES	COMMENT
BLANK	-

CODE FIELD: GLARE INTENSITY - NODC(2:63) - FWS(2:61)

CODES	COMMENT
BLANK	-

CODE FIELD: GLARE AREA - NODC(2:64) - FWS(2:62)

CODES	COMMENT
BLANK	-

Figure 3
Limits and Relational Checks

Note: Entries apply to both FWS and NODC unless otherwise noted.

Card Type 1

Longitude should be between 120 and 180 degrees.
Hemisphere should be "w" and Time Zone "+".
Date: Day between 1 and 31, month between 1 and 12.
Time: Hour between 0 and 23, minutes between 1 and 59.
Elapsed Time should be between 0 and 30 minutes.
FWS Heading between 0 and 359 degrees. (NODC between 00 and 35).
FWS Speed between 0 and 15 knots when platform type is ship.
FWS Speed greater than 5 knots when transect type is 71.

Card Type 2

FWS Wind Direction between 0 and 360 degrees. (NODC uses a code).
Wind Speed between 0 and 50 knots.
Swell Height between 0 and 25 feet.
Sea Surface Temperature between -2°C and +10°C.
Wet and Dry Bulb Temperature between -10°C and +70°C.
Wet Bulb Temperature should be less than or equal to Dry Bulb Temperature.
Temperatures are also checked for signs, numerics, and leading zeros.
Barometric Trend should not be coded when Barometric Pressure is blank.
Salinity between 20°/oo and 34°/oo.
Thermocline Depth between 0 and 100 meters.

Card Type 3

Excess Sediment, Ice Algae, or Other Features fields should be blank. (FWS only).

Card Type 5

Taxonomic Code between 88 and 92.
FWS Direction of Flight between 1 and 12 o'clock (NODC between 0 and 35 degrees).
FWS Begin Zone should be less than End Zone.
FWS Begin Zone and End Zone between 0 and 30 when Transect Type is 71 or 78 (unless BZN coded 97-99).
FWS Begin Zone and End Zone between 0 and 60 when Transect Type is 70 or 77 (unless BZN coded 97-99).

Figure 4

Sample LOGLIST Listing

LOGLIST lists the data for each card type individually. Fields in each record are then keyed by acronym codes.

Figure 4A shows the header page and the list of acronym definitions.

Figure 4B is a page from the data listing of Card Type 1. Blank data fields are depicted by a series of dots as in the LTD and LNG fields while leading or imbedded blanks appear as asterisks as in the SPD and HGT fields. The diagnostics are flagged with the messages at the right. Here the HED field is out of range because it should be between 0 and 35 degrees.

Figure 4A

***** LOGLIST *****

FOR CRUISE FW7032

CALL FILE ********

CARD TYPE 1

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

*** LOGLIST - CRUISE FW7032 - CALL FILE ******** - CARD TYPE 1

Figure 4A (cont.)

ACRONYM DEFINITIONS

STA	STATION
LAT	START LATITUDE
LON	START LONGITUDE
DEG	DEGREES (SUBFIELD OF LON)
DAT	DATE - YYMMDD
DAY	DAY (SUBFIELD OF DAT)
MON	MONTH (SUBFIELD OF DAT)
TIM	TIME - HHMM
HOR	HOUR (SUBFIELD OF TIM)
MIN	MINUTES (SUBFIELD OF TIM)
LTD	END LATITUDE
LNG	END LONGITUDE
ELT	ELAPSED TIME
TZS	TIME ZONE SIGN
TZN	TIME ZONE NUMBER
SPD	SPEED MADE GOOD
HED	COURSE MADE GOOD
HGT	HEIGHT OF OBS. EYES (ABOVE SEA)
PLT	PLATFORM TYPE
SMP	SAMPLING TECHNIQUE
ACT	SHIP ACTIVITY
PHO	PHOTOS TAKEN
TRW	TRANSECT WIDTH
ANG	ANGLE OF VIEW
OBC	OBSERVATION CONDITIONS
DIS	DISTANCE MADE GOOD

ACRONYM DEFINITIONS

WTP	WATCH TYPE
TRN	TRANSECT WIDTH

SPECIAL CHARACTERS

-	INDICATES A CODE FIELD
*	INDICATES A BLANK CHARACTER IN A FIELD
.	INDICATES A TOTALLY BLANK FIELD
/	FIELD IS LISTED IN THE DIAGNOSTICS IF NON-BLANK (DATA WOULD OTHERWISE NOT FIT ON ONE LINE)

*** LOGLIST - CRUISE FW7032 - CALL FILE ******** - CARD TYPE 1

	STA	LAT	LON	DAT	TIM	LTD	LNG	ELT	TZS	TZN	SPD	HED	HGT	PLT	SMP	ACT	PHO	TRW	ANG	OBC	DIS	WTP	TRN	DIAGNOSTICS
52	*7279	565358N	1523630W	770528	1950	....	....	10	+	09	**9	36	**8	.	.	.	.	.	.	6	....	.	*30	* HED FIELD OUTSIDE *
53	*7379	565408N	1523518W	770528	2000	....	....	10	+	09	**9	36	**8	.	.	.	.	.	.	6	....	.	*30	* HED FIELD OUTSIDE *
54	*7478	565537N	1523458W	770528	2010	....	....	10	+	09	**9	36	**8	.	.	.	.	.	.	7	....	.	*30	* HED FIELD OUTSIDE *
55	*7578	565712N	1523446W	770528	2020	....	....	10	+	09	**9	35	**8	.	.	.	.	.	.	7	....	.	*30	
56	*7679	565850N	1523508W	770528	2030	....	....	10	+	09	**9	35	**8	.	.	.	.	.	.	7	....	.	*30	
57	*7779	570022N	1523530W	770528	2040	....	....	10	+	09	**9	35	**8	.	.	.	.	.	.	7	....	.	*30	
58	*7878	570155N	1523554W	770528	2050	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	7	....	.	*30	
59	*7978	570308N	1523712W	770528	2100	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	7	....	.	*30	
60	*8079	570418N	1523823W	770528	2110	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
61	*8178	570548N	1523948W	770528	2120	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
62	*8279	570706N	1524106W	770528	2130	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
63	*8378	570830N	1524236W	770528	2140	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
64	*8479	571000N	1524044W	770528	2150	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	5	....	.	*30	
65	*8578	571116N	1524524W	770528	2200	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	5	....	.	*30	
66	*8678	571242N	1524648W	770528	2210	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	5	....	.	*30	
67	*8777	571707N	1525048W	770529	0400	....	....	20	+	09	**0	..	**4	.	.	.	.	.	.	7	....	.	*60	
68	*8873	571448N	1525027W	770529	1737	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	
69	*8973	571310N	1525025W	770529	1747	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	
70	*9073	571124N	1525028W	770529	1757	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	
71	*9179	570942N	1525030W	770529	1807	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
72	*9278	570757N	1525100W	770529	1817	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
73	*9378	570612N	1525200W	770529	1827	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
74	*9479	570315N	1525250W	770529	1837	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
75	*9578	570255N	1525326W	770529	1847	....	....	10	+	09	*10	19	...	.	.	.	.	.	.	5	....	.	*30	
76	*9678	570114N	1525345W	770529	1857	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
77	*9779	565925N	1525345W	770529	1907	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	

Figure 5

Conversion Routines

Card Type 1

Latitude - convert tenths of minutes to seconds and add hemisphere.
Longitude - convert tenths of minutes to seconds.
Date - add decade in year field.
Speed - tenths of knots to whole knots.
Course - truncate three digits into two digits.
Height of observers eyes - convert feet to meters.
Observation conditions - move from card type two to card type one.
Platform Type - convert FWS code to NODC code.
Ship Activity - convert FWS code to NODC code.

Card Type 2

Bottom Depth - convert fathoms to meters.
Barometric Pressure - truncate leftmost digits.
Swell Height - tenths of feet to whole meters.
Wind Direction - convert degrees to NODC code.
Temperatures - move signs to a position adjacent to digits.

Card Type 3

Collection Code - convert FWS code to NODC code.

Card Type 5

Taxonomic Code - blank fill trailing doublets.
Time - convert tenths of minutes to whole minutes.
Direction of Flight - convert clock position relative to ship to degrees and add Course Heading from card type 1 for compass direction.
Association Type - convert FWS code to NODC code.

APPENDIX II.

Field Operation Status Report

*** FIELD OPERATION STATUS REPORT ***

AS OF 01/18/78

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

COLUMN HEADING DEFINITIONS:

TAPE NUMBER -	IDENTIFYING NUMBER ASSIGNED TO THE TAPE AS IT IS RECEIVED BY RU 527.
DATE RECEIVED -	DATE THE TAPE WAS RECEIVED BY RU 527.
FILE FORMAT -	FORMAT IN WHICH THE DATA ON THE TAPE HAVE BEEN CODED.
CRUISE NAME -	NAME ASSIGNED TO THE FIELD OPERATION BY THE PRINCIPAL INVESTIGATOR. "FW" CRUISES FROM DR. CALVIN LENSINK; "UCI" CRUISES FROM DR. GEORGE HUNT; "W" CRUISES FROM DR. JOHN WEINS; "UC" CRUISES FROM DR. JUAN GUZMAN.
CODEPULL MAILED -	DATE THE OUTPUT FROM THE QUALITY CONTROL PROGRAM "CODEPULL" WAS MAILED TO THE PRINCIPAL INVESTIGATOR FOR CORRECTIONS.
LOGLIST MAILED -	DATE THE OUTPUT FROM THE QUALITY CONTROL PROGRAM "LOGLIST" WAS MAILED TO THE PRINCIPAL INVESTIGATOR FOR CORRECTIONS.
CODEPULL RETURNED -	DATE THE CORRECTED OUTPUT FROM "CODEPULL" WAS RECEIVED BY RU 527.
LOGLIST RETURNED -	DATE THE CORRECTED OUTPUT FROM "LOGLIST" WAS RECEIVED BY RU 527.
EDITLOG COMPLETE -	DATE THE CORRECTIONS WERE MADE TO THE CRUISE AT RU 527, THROUGH THE USE OF AN INTERACTIVE PROGRAM "EDITLOG".
FINAL CHECK -	DATE THE CRUISE WAS READY FOR CONVERSION TO NODC FORMAT. OCCASIONALLY ADDITIONAL PROBLEMS ARISE WHEN "CODEPULL" AND "LOGLIST" ARE RERUN AFTER EDITING. IF THESE CANNOT BE RESOLVED OVER THE TELEPHONE THE LISTINGS ARE SENT BACK TO THE PI FOR FURTHER CORRECTIONS. THIS FIELD IS NOT FILLED IN UNTIL ALL CORRECTIONS HAVE BEEN MADE.
CONVERT TO NODC -	DATE THE CRUISE WAS CONVERTED FROM FWS FORMAT TO NODC FORMAT. AN "NA" (NOT APPLICABLE) IS ENTERED HERE FOR CRUISES RECEIVED IN NODC FORMAT.
MAIL TO NODC -	DATE THE CRUISE IN FINAL FORM WAS SUBMITTED TO NODC.
ENDNOTES -	REFERENCE NUMBER TO ADDITIONAL COMMENTS FOLLOWING THE TABLE.

*** FIELD OPERATION STATUS REPORT ***

AS OF 01/18/78

THE MARMAP INFORMATION SYSTEM OCSEAP - GULF OF ALASKA PROJECT

TAPE NUMBER	DATE RECEIVED	FILE FORMAT	CRUISE NAME	CODEPULL MAILED	LOGLIST MAILED	CODEPULL RETURNED	LOGLIST RETURNED	EDITLOG COMPLETE	FINAL CHECK	CONVERT TO NODC	MAIL TO NODC	END NOTES
ALASKA1	03/12/77	FWS	FW5004	07/12/77	08/16/77	08/29/77	10/06/77	11/20/77				1
ALASKA2	03/12/77	FWS	FW5009	07/12/77	08/16/77	10/06/77	10/06/77	11/28/77				1
			FW5013	07/12/77	08/16/77	08/29/77	10/06/77	11/30/77				1
			FW5018	07/12/77	08/16/77	08/29/77	10/06/77	12/06/77				1
			FW5023	07/12/77	08/16/77	08/29/77	10/06/77	12/06/77				1
			FW5024	07/12/77	08/16/77	08/29/77	10/06/77	11/30/77				1
			FW5030	07/12/77	08/16/77	08/29/77	10/06/77	12/01/77	12/05/77			
			FW5032	07/12/77	08/16/77	08/29/77	10/06/77	12/01/77	12/05/77			
ALASKA3	05/27/77	FWS	FW5008	07/14/77	08/16/77	09/06/77	09/06/77	12/09/77	12/09/77			
			FW5016	07/14/77	08/16/77	09/06/77	09/06/77	12/12/77				1
			FW5021	07/14/77	08/16/77	09/06/77	09/06/77	12/31/77				
			FW5026	07/14/77	08/16/77	09/06/77	09/06/77					
			FW5027	07/14/77	08/16/77	09/06/77	09/06/77					
			FW5033	07/14/77	08/16/77	09/06/77	09/06/77					
			FW5035	07/14/77	08/16/77	09/06/77	09/06/77					
			FW6008	12/12/77	12/12/77	01/10/78	01/10/78					
			FW6027	07/14/77	08/16/77	09/06/77	09/06/77					
			FW6050	07/14/77	08/16/77	09/06/77	09/06/77					
			FW6051	07/14/77	08/16/77	09/06/77	09/06/77					
			FW6074	07/14/77	08/16/77	09/06/77	09/06/77					
			FW6083	07/14/77	08/16/77	09/06/77	09/06/77					
ALASKA4	06/24/77	FWS	FW5011	08/16/77	08/16/77	11/01/77	11/01/77					
			FW5012	08/16/77	08/16/77	11/01/77	11/01/77					
			FW5020	08/16/77	08/16/77	11/01/77	11/01/77					
			FW5031	08/16/77	08/16/77	11/01/77	11/01/77					
			FW5034	08/16/77	08/16/77	11/01/77	11/01/77					
			FW6015	08/16/77	08/16/77	11/01/77	11/01/77					
			FW6018	08/16/77	08/16/77	11/01/77	11/01/77					
			FW6019	08/16/77	08/16/77	11/01/77	11/01/77					
			FW6067	08/16/77	08/16/77	11/01/77	11/01/77					
			FW6068	08/16/77	08/16/77	11/01/77	11/01/77					
			FW6088	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6089	08/16/77	08/16/77	11/01/77	11/01/77					
			FW6094	08/16/77	08/16/77	11/01/77	11/01/77					
ALASKA5	07/01/77	FWS	FW5015	09/29/77	09/29/77	10/20/77	10/20/77					

*** FIELD OPERATION STATUS REPORT ***

AS OF 01/18/78

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

TAPE NUMBER	DATE RECEIVED	FILE FORMAT	CRUISE NAME	CODEPULL MAILED	LOGLIST MAILED	CODEPULL RETURNED	LOGLIST RETURNED	EDITLOG COMPLETE	FINAL CHECK	CONVERT TO NODC	MAIL TO NODC	END NOTES
ALASKA5	07/01/77	FWS	FW5025	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6001	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6002	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6007	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6009	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6021	10/28/77	10/28/77	11/30/77	11/30/77					
			FW6026	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6029	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6057	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6064	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6066	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6070	09/29/77	09/29/77	10/20/77	10/20/77					
			FW6095	09/29/77	09/29/77	10/20/77	10/20/77					
ALASKA6	07/07/77	FWS	FW5014	10/21/77	10/21/77	11/14/77	11/14/77					
			FW5022	10/21/77	10/21/77	11/14/77	11/14/77					
			FW5029	10/21/77	10/21/77	11/14/77	11/14/77					
			FW5036	10/21/77	10/21/77	11/14/77	11/14/77					
			FW5037	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6004	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6005	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6010	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6011	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6012	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6016	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6028	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6052	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6077	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6078	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6084	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6085	10/21/77	10/21/77	11/14/77	11/14/77					
			FW6092	10/21/77	10/21/77	11/14/77	11/14/77					
			FW7026	10/21/77	10/21/77	11/14/77	11/14/77					
			FW7027	10/21/77	10/21/77	11/14/77	11/14/77					
ALASKA7	07/07/77	FWS	UCI501	10/07/77	10/07/77							
			UCI601	10/07/77	10/07/77							
ALASKA8	07/28/77	FWS	FW5038	10/28/77	10/28/77	11/30/77	11/30/77					
			FW6013	10/28/77	10/28/77	11/30/77	11/30/77					
			FW6025	10/28/77	10/28/77	11/30/77	11/30/77					

*** FIELD OPERATION STATUS REPORT ***

AS OF 01/18/78

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

TAPE NUMBER	DATE RECEIVED	FILE FORMAT	CRUISE NAME	CODEPULL MAILED	LOGLIST MAILED	CODEPULL RETURNED	LOGLIST RETURNED	EDITLOG COMPLETE	FINAL CHECK	CONVERT TO NODC	MAIL TO NODC	END NOTES
ALASKA8	07/28/77	FWS	FW6082	10/28/77	10/28/77	11/30/77	11/30/77					
			FW6087	10/28/77	10/28/77	11/30/77	11/30/77					
ALASKA9	08/03/77	FWS	FW5003	10/28/77	10/28/77	11/30/77	11/30/77					2
			FW5006	10/28/77	10/28/77	11/30/77	11/30/77					
			FW5010	10/28/77	10/28/77	11/30/77	11/30/77					
			FW6006	10/28/77	10/28/77	11/30/77	11/30/77					
			FW6014	10/28/77	10/28/77	11/30/77	11/30/77					
ALASKA10	09/06/77	NODC	FW7032	10/07/77	10/07/77	11/03/77	11/03/77	11/22/77	11/30/77	/NA/	12/12/77	
			FW7033	10/07/77	10/07/77	11/03/77	11/03/77	11/22/77	11/30/77	/NA/	12/12/77	
ALASKA11	11/16/77	NODC	FW7034	11/30/77	11/30/77	01/04/78	01/04/78	01/09/78	01/10/78	/NA/		
			FW7035	11/30/77	11/30/77	01/04/78	01/04/78	01/06/78	01/17/78	/NA/		
			FW7042	11/30/77	11/30/77	01/04/78	01/04/78	01/09/78	01/16/78	/NA/		
			FW7046	11/30/77	11/30/77	01/04/78	01/04/78	01/09/78	01/16/78	/NA/		
ALASKA12	01/10/78	NODC	FW7028	01/18/78	01/18/78							
			FW7031	01/18/78	01/18/78							
			FW7036	01/18/78	01/18/78							
			FW7045	01/18/78	01/18/78							
ALASKA13	01/10/78	FWS	FW6086	01/18/78	01/18/78							
			FW6186	01/18/78	01/18/78							5
OREGON1	05/25/77	NODC	W05220	10/26/77	10/26/77	01/03/78				/NA/		
			W05221	10/26/77	10/26/77	01/03/78				/NA/		
			W05310	10/26/77	10/26/77	01/03/78				/NA/		
			W05311	10/26/77	10/26/77	01/03/78				/NA/		
			W05325	10/26/77	10/26/77	01/03/78				/NA/		
			W06211	10/26/77	10/26/77	01/03/78				/NA/		3
			W06221	10/26/77	10/26/77	01/03/78				/NA/		3
			W16140	10/26/77	10/26/77	01/03/78				/NA/		
			W16150	10/26/77	10/26/77	01/03/78				/NA/		
			W16161	10/26/77	10/26/77	01/03/78				/NA/		3
			W26140	10/26/77	10/26/77	01/03/78				/NA/		
			W36070	10/26/77	10/26/77	01/03/78				/NA/		

*** FIELD OPERATION STATUS REPORT ***

AS OF 01/18/78

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

TAPE NUMBER	DATE RECEIVED	FILE FORMAT	CRUISE NAME	CODEPULL MAILED	LOGLIST MAILED	CODEPULL RETURNED	LOGLIST RETURNED	EDITLOG COMPLETE	FINAL CHECK	CONVERT TO NODC	MAIL TO NODC	END NOTES
CANADA1	08/01/77	FWS	01UC75	10/07/77	10/07/77							

ENDNOTES:

1. LOGLIST & CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (12/12/77), RETURNED TO RU 527 (01/10/78).
2. TAPE WAS UNREADABLE, SENT BACK TO PI TO BE RE-GENERATED (08/31/77), RETURNED TO RU 527 (10/21/77).
3. UNAUTHORIZED LIGHT LEVEL AND WEATHER CODES USED BY PI, THESE WILL NOT BE INCLUDED IN SUBMISSION TO NODC.
4. TAPE RETURNED TO PI BECAUSE SEVEN OF THE EIGHT EXPECTED CRUISES COULD NOT BE FOUND (01/03/78).
5. CRUISE FW6186 IS A CONTINUATION OF CRUISE FW6086 BECAUSE FW6086 NEEDED MORE THAN 999 STATIONS.

*** FIELD OPERATION STATUS REPORT ***

AS OF 01/18/78

THE MARMAP INFORMATION SYSTEM OCSEAP - GULF OF ALASKA PROJECT

SUMMARY:

TOTAL CRUISES RECEIVED BY RU 527	105
CODEPULLS MAILED TO INVESTIGATOR	105
LOGLISTS MAILED TO INVESTIGATOR	105
CODEPULLS RETURNED TO RU 527	96
LOGLISTS RETURNED TO RU 527	83
TOTAL CRUISES EDITED AT RU 527	17
CRUISES CONVERTED TO NODC	0
CRUISES MAILED TO NODC	2

RESEARCH PROPOSAL

TO: National Oceanic and Atmospheric Administration
Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado 80302

FROM: Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

TITLE: Sediment Characteristics, Stability, and Origin of the Barrier Island-Lagoon Complex, North Arctic Alaska
Research Unit #529

principal investigator: Dr. A. S. Naidu
SS# 574-26-7802

TOTAL COST OF PROPOSAL: $69,883

DURATION: October 1, 1977 to September 30, 1978

A. S. Naidu
Assistant Professor in Marine Science
University of Alaska
(907) 479-7032

J. R. Moore, Director
Institute of Marine Science
University of Alaska
(907) 479-7531

A. B. Frol
Director of Admin. Services
University of Alaska
(907) 479-7632

K. B. Mather
Vice-Chancellor for Research and Advanced Study
University of Alaska
(907) 479-7282

OCS Proposal No. 77-25 Mod. 1
July 29, 1977

C. TECHNICAL PROPOSAL

I. Title

Sediment Characteristics, Stability, and Origin of the Barrier Island-Lagoon Complex, North Arctic Alaska

Research Unit number: OCSEAP R.U. #529. Contract Number: 03-5-002-56. Proposed dates of contract: October 1, 1977 to September 30, 1978.

II. Principal Investigator

A. S. Naidu, Assistant Professor of Marine Science, Institute of Marine Science, University of Alaska, Fairbanks, Alaska 99701.

III. Cost of Proposal (for FY 1978)

C. Total: $70,443

D. Distribution of Effort by Lease Area: Beaufort Sea - 100%

IV. Background

The exploitation of the petroleum reserves in the North Slope of Alaska has commenced with the recent flow of oil through the trans-Alaska pipeline. The present trend is towards exploration in the adjacent continental shelf of the Beaufort Sea. As a consequence of the OCS petroleum and gas development activities, the nearshore and the open shelf ecosystem of the Beaufort Sea is bound to be subjected to some degree of anthropogenic perturbations. The industrial activities which most likely will be introduced in this area include the construction of artificial islands and causeways for the use of drilling operations and docking facilities, dredging for maintaining navigation, and the exploitation of gravel and sand deposits from several possible sources as construction and fill materials. The impact of these activities, as well as others such as a blow-out, inadvertent discharge of cuttings and muds from drilling operations, and accidental oil spills on the nearshore ecosystem are unknown. However, several attempts have been made postulating the possible socio-economic scenario and environmental perturbations that might result during the exploration and exploitation of petroleum reserves from the OCS lease areas of the Beaufort Sea (Arnold, 1975; Weller *et al.*, 1977). It is of interest to note that significant changes in the size distributions, benthic and chemical attributes of bottom sediments, as well as on the nearshore bathymetry have already been recognized in the vicinity of Prudhoe Bay, consequent to the building of the new ARCO causeway (Feder *et al.*, 1976; Barnes *et al.*, 1977).

If the response of the physical environment and biological resources of the area to such changes can be properly assessed, or even predicted, it is quite possible that effective measures can be developed to protect or enhance existing resources. Few environmental studies of arctic barrier islands, lagoons, and the contiguous shallow marine regime of north arctic Alaska have been carried out, and none of these in detail. The existing data gaps for this area were identified in a recent OCSEAP meeting held at Barrow to synthesize the current state of knowledge on the Beaufort Sea. One of the questions that was raised numerous times at this meeting related to the composition, stability and origin of the barrier island-lagoon complex, and the directions and amounts of sediment transport along the shore of north arctic Alaska. It was the unanimous opinion of the meeting participants that unless satisfactory answers are available to the above questions, it would not be possible to quantitatively assess - or even speculate - the possible impacts of industrial development on the Beaufort Sea nearshore ecosystem.

It is proposed to continue essentially the ongoing geological-geochemical studies, embodied in the OCSEAP R.U. #529-77 and included under Task 2 of the Master Research Plan submitted by the LGL Limited, U.S., Inc. to the OCSEAP office. Briefly, our studies will be concerned with collection of all basic data on the size distributions, mineralogy, and certain biologically "critical" chemical attributes of sediments of the barrier island-lagoon complex of north arctic Alaska. In addition, research will be continued to assess the long-term directions and net volumes of alongshore transport of sediment, as well as the stability and origin of the barrier islands along the Beaufort Sea coast. It is also proposed to collect additional lithological and chemical baseline data from the contiguous area of the continental shelf of the Beaufort Sea. The chief purpose of this latter effort will be to fill in the small data gaps that were identified in the last Beaufort Sea synthesis meeting in Barrow. This would also maintain a continuity of the inshore sedimentological work into the contiguous shelf area of the Beaufort Sea.

V. Objectives

The overall research objectives of the FY 1978 study will be the same as those enumerated in the OCSEAP R.U. #529-77, with the exception that studies on the nutrient dynamics of sediment substrates will be omitted. It is understood that the latter investigations will be an intrinsic aspect of the biological studies that are being simultaneously proposed by the LGL Limited, U.S., Inc. to the OCSEAP office. Our geological investigations will, of course, coordinate and interface with the LGL program. Therefore, the specific objectives of this proposal will be:

1. To continue gathering basic data on the grain size distributions of substrate sediment habitats from the coastal beaches, lagoons, barrier islands, and the adjacent continental shelf area. It is proposed to extend our studies laterally beyond the FY 1977 study area, embracing the continental margin region from the Milne Point in the Simpson Lagoon eastward up to the Prudhoe Bay. Such regional extension will help establish a wider sampling base for a better understanding of sediment dynamics in the North Slope coastal region.

2. To complete background data collection on the contents of organic carbon and partioning patterns of a selected group of biologically "critical" heavy metals (e.g., Fe, Mn, Cu, Ni, Zn, V, Cr, and Co) in the lithogenous (crystal lattice-held) and nonlithogenous (readily mobilized phase) fractions of sediment samples from the lagoon and adjacent shelf region. In addition, Ba background concentrations in sediments will be analyzed, considering the importance of this element in the detection of pollution relating to discharge of drilling muds. This aspect of the study will fill in the small data gaps that exist on heavy metal backgrounds that have been collected by Dr. A. S. Naidu for the last 8 years in the Beaufort Sea and which could not be continued under an ongoing OCSEAP heavy metal program (R.U. #162).
3. To define the net, long-term alongshore transport directions of gravel and sand-sized sediments, and to assess the volume of this alongshore drift during the open water season on the barrier islands.
4. To define the mineral characteristics, source, migratory pathways, and depositional sites of clay-sized particles in the deltaic-continental shelf complex of the Beaufort Sea.
5. To elucidate the origin, development, and stability of the barrier islands in north arctic Alaska, via paleogeographic and geomorphic studies. The latter aspect of the investigation will be a complementary counterpart of Dr. Jan Cannon's geomorphological studies under the current OCSEAP R.U. #530.

The relevance of these objectives to an environmental assessment of the Beaufort Sea continental shelf during petroleum and gas leasing and development process have been elaborately dealt with in our original proposal (OCSEAP R.U. #529-77).

VI. General Strategy and Approach

We hope to consolidate all sedimentological data presently available with us and those to be gathered by the end of this calendar year as part of Phase I of this study. This data consolidation should permit us to establish the compositions and the basic trends on the lateral and stratigraphic variations in sediment size distributions and the sources of gravel, sand and clay-sized particles in the barrier island-lagoon regime of north arctic Alaska. Further, at the end of the currently funded (FY 1977) study we should be able to define in a general way the net long-term sediment transport directions along the North Slope coastal area. However, the approach during the FY 1978 study will be to concentrate efforts to confirm the net alongshore sediment drift directions to be established in FY 1977, as well as to quantify the volume of this drift along a few representative barrier island and coastal beach stretches. In order to achieve the latter objective the sediment erosional-depositional budgets at the representative beach stretches will be continuously monitored on a time series basis throughout the 1978 summer. However, in order to test the viability of the methods that we have planned to adopt to quantify beach drifts (refer to R.U. #529-77 for details) we will initiate a trial time-series monitoring program of beach levels for one month in August 1977. Thus, any shortcomings in FY 1977 field season will be rectified in 1978 summer. It must be borne in mind that beach level monitoring in the arctic could be beset with unexpected complications resulting from large-scale beach drifting impelled by unusual sea ice piling accompanied during occasional severe storms. On such occasions a difference must be made to understand the impact of the catastrophic storm surge versus normal current actions on the alongshore drifts.

Our approach for assessing the sediment source and transport directions will be the same as those elaborated in the initial proposal (R.U. #529-77). Briefly, this would call for effectively discriminating the mineralogy of the sand and clay-sized particles of the various North Slope rivers, and using characteristic minerals as natural "tracers" to establish sediment migratory pathways.

It is believed that the key to a satisfactory geologic explanation to the barrier island origin lies in the deciphering of the paleogeographic history of the continental margin of the Beaufort Sea over the last 10,000 years (e.g., Holocene Epoch). Our approach to infer this history would depend heavily on the sedimentological criteria that have been developed (Naidu and Mowatt, 1975, 1976) to recognize various paleodepositional facies, using data on contemporary arctic sediments.

The strategy for elucidating the stability and origin of the barrier islands will remain the same as that enumerated in the initial proposal (R.U. #529-77). Basically, efforts will be concentrated on stratigraphic studies of vibrocores to determine whether the islands are relict coastal features or are contemporary depositional resultants. Investigations on the temporal stability of the islands during the last three decades will be addressed through the examination of time-series aerial photographs and satellite imageries, in coordination with Dr. Cannon's investigations (R.U. #530).

The partitioning patterns of the heavy metals in the different sediment phases will be elucidated following the methods outlined by Chester and Hughes (1967) and Presley *et al.* (1972). It would seem futile to get very precise data on the metal fractionation because of the lack of a satisfactory method to effectively and in a meaningful way isolate the individual sediment phases (e.g., adsorbed, exchangeable, organic, ferric versus manganic hydroxide-scavenged, etc.). However, our plans call for differentiating the proportions of the various metals partitioned between the lithogenous (crystal lattice-held) and the nonlithogenous (relatively readily "mobilized") sediment fractions. Research along these lines for a few metals have already been initiated by us (Naidu, in Burrell, 1977) on the Beaufort Sea continental shelf sediments. It is assumed that by determining the inter-element relationships in the lithogenous and nonlithogenous sediment fractions, and also analyzing the covariances or lack of them between metal concentrations, sediment size grades and mineralogic attributes, the partition patterns of metals can be fairly well interpreted. It is proposed to complete this work on the Beaufort Sea shelf sediments and extend our data base to the adjacent lagoon areas. The strategy will be to fill in the information gaps and consolidate all the geochemical data rather than duplicate past efforts.

VII. Sampling Methods

We have plannea to collect 75% of the sediment samples, while the rest of the samples will be provided to us by Dr. P. W. Barnes of the U.S. Geological Survey and Dr. D. G. Shaw - two OCSEAP investigators. Most of our samples will be collected in 1977 summer from the barrier islands, west Simpson Lagoon and contiguous shallow marine environment, as planned in the April 1977 Vancouver workshop. The lagoon grab samples will be collected from stations located at 1/2 mile intervals along longitudinal traverses extending across the lagoon length. The traverses will be set up at about 1 mile intervals. To avoid any sampling bias a few samples will be obtained at locations randomly dispersed inbetween the traverses. In order to calculate sampling precision we have planned to collect replicate samples from a few random stations.

Representative surficial sediment samples will be handpicked from all major barrier islands extending from the Canning to the Colville Rivers. However, more intensive sampling will be conducted on a closely-spaced grid extending across the landward and seaward beaches of the Pingok and Spy Islands. Since the barrier islands will have a number of depositional sub-environments it would obviously be necessary to make very detailed field notes regarding each sample location.

Dr. Peter W. Barnes of the USGS has already provided us with splits of 15 vibrocore samples that were collected from the shallow marine areas adjacent to the North Slope barrier islands. We have requested Dr. Barnes for a few additional core samples from the Simpson Lagoon. These samples should be adequate provisionally for the proposed lithological and mineral stratigraphic studies relating to barrier island origin.

Dr. David G. Shaw will be collecting this summer (1977) van Veen and/or Haps core sediment samples from the Alumiak along the inshore area extending from Point Barrow to the Demarcation Point. Dr. Shaw has promised to provide us with splits of all these sediment samples.

In addition, Dr. Naidu has planned to participate for two weeks in August-September 1977 in the Coast Guard and OCSEAP-sponsored cruise of the USCGC *Glacier* in the Beaufort Sea. The chief purpose of Dr. Naidu's participation would be to collect both surface and gravity core sediment samples from the shelf area off the Demarcation Point and Point Barrow. Thus, the presently existing sample gaps will be narrowed for the Beaufort Sea shelf.

The OCSEAP Arctic Project Office has agreed to provide us with the logistic support for collecting sediment samples from the North Slope rivers and the barrier islands. This would include a fixed wing float plane and/or helicopter flying time. Our logistic requirements, including camping, boat, and sampling gears relating to the Simpson Lagoon work will have to be arranged by the Arctic Project Office with the other OCSEAP investigator in the area, namely the LGL Limited, U.S., Inc. An arrangement similar to the one existing currently will be acceptable to us.

Dr. Naidu participated in the Long Beach planning meeting to coordinate with the U.S. Coast Guard the USCGC *Glacier* 1977 Beaufort Sea cruise. The Coast Guard will be responsible for providing van Veen grab and gravity core sampling units. All lagoon and offshore sediment samples will be stored in a frozen state until ready for analysis in the Fairbanks laboratories.

VIII. Analytical Methods

Laboratory analysis

The analytical methods to be adopted have been elaborately described in the current (FY 1977) OCSEAP R.U. #529-77. Briefly, the sediment size distribution analysis will be performed by the usual sieve-pipetting method, and calculation of the conventional statistical grain size parameters will be after Folk and Ward (1957). The clay mineral composition of the <2 μm of sediments will be accomplished according to the methods elaborated by Naidu *et al.* (1971) and Naidu and Mowatt (1974) using X-ray diffraction technique. A variety of chemical and heat treatments will be adopted to assist in the clay mineral identification.

Heavy mineral analysis will be performed on coarse, medium, and fine size grades of sands. The heavy mineral crops will be separated in heavy liquid media, and the quantitative assessments of the various minerals will be accomplished using a petrographic microscope. Coarse-fraction analysis (Shepard and Moore, 1954) on a selected group of sand samples from various horizons of the vibro cores will be conducted under a binocular microscope.

Heavy metal concentrations in sediments will be measured by atomic absorption spectrophotometry, using a Perkin-Elmer, 603 Model unit equipped with HGA-2100 Graphite furnace. Details on the methods of acid digestion of sediments and the determination of analytical precision and accuracy have been elaborated by Naidu and Hood (1972). Vanadium concentrations in the nonlithogenous sediment fractions, however, will be analyzed by neutron activation, using the isotope dilution technique described by Weiss *et al.* (in press). Organic carbon will be calculated from the difference between total carbon and carbonate carbon. The total carbon will be analyzed in a LECO, TC-12 automatic carbon determinator, whereas the carbonate carbon will be determined manometrically (Hülsemann, 1969).

All available aerial photographs and remote sensing imageries will be studied in conjunction with Dr. Cannon, to assess temporal changes in barrier island and lagoon morphology, as well as to map the dispersal pattern of turbid plumes of fluvial water masses in the nearshore environment.

Statistical analysis

Fundamental statistical analyses will be executed by means of numerous programs previously developed by, or supplied to, the University of Alaska Computer Network (UACN) for the Honeywell Series 60(level 66)/6000 computer. Numerical data sets will be analyzed using a mixed hierarchical model of the analysis of variance (Kirk, 1968; Winer, 1971) to test hypotheses and to provide measures of precision. The Ullrich-Pitz Analysis of Variance

Program (Ullrich and Pitz, 1976) has been sufficiently modified and updated (Geist, 1977) to run on the Honeywell 66/40 and will provide maximal power for the analysis of variance of the relatively large data sets which are currently anticipated. Chi square values, determinants, F-max values, F ratios, means, mean squares, sums of squares, transformations, variances, variance-covariance matrices, and exact probability levels represent standard output parameters. Coefficients of correlation will be determined for many of the variables of the numerical data sets in order to more closely establish and estimate the degree of association or interdependence between selected parameters (Sokal and Rohlf, 1969). *Post hoc* statistical analyses will consist of chi square values, confidence intervals for differences between means, confidence limits, Scheffe's test for multiple comparisons, t tests for differences between means, and, importantly, trend analyses of the cubic, linear, and quadratic components using orthogonal polynomials. Statistical computer programs, the University of California Los Angeles Biomedical Computer Programs and the Statistical Package for the Social Sciences, exist to facilitate most *a priori* and *post hoc* analyses (Dixon, 1974; Nie *et al.*, 1975). The techniques of cluster analysis will be employed to examine the anticipated large sets of multivariate observations and parameters by partitioning into disjoint clusters of observations that are in some sense dissimilar from one another. Two Fortran IV cluster analysis programs have recently been modified and updated to run on the Honeywell 66/40 (Geist, 1977), MIKCA: Multivariate Iterative K-Means Cluster Analysis (McRae, 1970), and TAXMAP: The TAXMAP Classification Program (Carmichael, 1974). Factor analytical techniques may be employed in a similar fashion to that of cluster analysis (Dixon, 1974; Honeywell, 1974).

IX. Anticipated Problems

No major problems are anticipated at this point in time to fulfill the objectives of the proposal, providing requests made to various OCSEAP investigators for sediment samples, and the Arctic Project Office for logistic support, are satisfactorily fulfilled. Although we have acquired quite a number of offshore vibrocore samples from Dr. Barnes, we would still need a few core samples from the North Slope lagoons. The latter samples will be quite critical in the elucidation of the barrier island origin. Dr. Barnes has been most sympathetic in this matter and has consented to do his best to help us this summer.

We had assumed that a physical oceanographic group would provide us in the FY 1977 with wave refraction data for the Beaufort Sea inshore area. We were contemplating employing this data to better understand the role of physical processes in the formation of barrier islands. However, we understood recently that the physical oceanographers involved in the current OCSEAP barrier island-lagoon project (R.U. #526 and 531) will not be collecting any wave data in the FY 1977, but may launch a modest program in FY 1978.

X. Deliverable Products

A.1. All data products forthcoming from this study will be submitted to the OCSEAP Data Management Group in the accepted format. In addition, we hope to provide the OCSEAP office with the following data:

a) All basic data pertaining to grain size distributions, heavy minerals and clay minerals, organic carbon, and heavy metal geochemistry on substrate sediments will be provided in tabulated form, and classed according to various depositional environments (e.g., barrier islands, lagoons, coastal beaches, open-marine shelf, inter-barrier inlets, river channels, etc.). Efforts will be concentrated to consolidate all published and unpublished data available with us in a manner best suited for coastal management purposes. This would obviously incur vigorous statistical analysis of all data.

b) Lateral variations in the conventional statistical grain size parameters, clay mineralogy, and heavy metal concentrations will be depicted on standard OCSEAP Beaufort Sea maps for the purpose of ready graphical reference.

c) Correlation coefficient analysis between textural, mineral, and chemical attributes will be determined by statistical calculations. Other statistical analysis that are to be followed for processing the massive data, have been elaborated under Section VIII relating to analytical methods.

d) Sediment transport trajectories for sand and clay-sized particles will be mapped for different sections of the investigated coastlines.

e) The stratigraphic variations in the lithology will be depicted graphically, and the significance in vertical variations of various textural and mineralogical attributes will be determined statistically.

f) A geological report will be prepared that will include chapters on the sediment characteristics of the various subenvironments under study, the inferred sediment transport vectors, and on the stability and origin of the barrier island-lagoon complex. Consolidation of the grain size distribution data should help us to understand better the processes and products of contemporary sedimentation, and also provide reliable "signatures" to decipher paleogeography of the

Beaufort Sea continental margin. The above report will also include a section predicting possible perturbations on the barrier island-lagoon ecosystem that may directly or indirectly result from various oil-related industrial activities in the North Slope of Alaska.

g) All attempts will be made to interface the sedimentological studies with other disciplines of the overall OCSEAP barrier island-lagoon ecosystem modelling study.

A.2. List of Digital products:

a) Sediment size distribution data (e.g., weight percentages of various fractions, percentiles, mean and median size, sorting, skewness, and kurtosis of size distributions.

b) Weighed peak area percents of the various clay mineral types, and the number percentages of various heavy minerals.

c) Concentrations of various heavy metals in the lithogenous and nonlithogenous fractions, in µg/g values. We would need additional funds to cover the cost of recording this data on magnetic tapes. However, we have no idea how much this would cost.

B. Narrative reports: C and D, please refer to the Section A.1 for details.

E. Data submission schedule: It is anticipated that by February 1978 all data on grain size distributions of sediments will be completed, while by that time clay and heavy mineral anlayses and documentation of heavy metal partitioning patterns in the lithogenous and nonlithogenous fractions will be about 75% covered through. Hopefully, by June 1978 all basic data collection will be finished. We would, however, need two more months for processing the data, and by the end of September 1978 we hope to submit the Final Report. Periodic data will be submitted to the Project Offices in the form of Quarterly and Annual Reports, as per the OCSEAP schedules.

XI. Information Required from Other Investigators

It has been planned to coordinate this study with other investigators of the OCSEAP barrier island-lagoon ecosystem study. These investigators will be the LGL Limited, U.S., Inc., Drs. Jan Cannon, J. B. Matthews, and C. Mungall. At the last Vancouver Workshop held in April 1977, a matrix was outlined showing the interrelationships between the information products to be generated by different investigators, and the responsibilities of each to the overall ecosystem modelling. The above matrix has been included in the Master Research Plan submitted by the LGL Limited to the NOAA Boulder Office in January 1977.

In addition, it will be useful to exchange data that are being gathered by Drs. P. W. Barnes and E. Reimnitz on the geologic action of ice as well as on the temporal changes in bathymetry and small-scale bottom topography of the inshore Beaufort Sea area (R.U. #205). We would also be interested in sharing data with Dr. D. M. Hopkins on the Late Cenozoic history of the Beaufort Sea continental margin (R.U. #204 and 473).

XII. Quality Assurance Plans

Calculation of the percentage coefficient of variations based on results of replicate analysis of individual sediment parameters will provide the analytical precisions. The accuracy of our heavy metal analysis will be checked by analyzing the U.S. Geological Survey Standard rocks. Representative splits of at least 5% of all sediment samples collected by us will be submitted, if required, to the National Bureau of Standards for interlaboratory calibration.

XIII. Special Sample and Voucher Specimen Archival Plans

Splits of all sediment samples analyzed will be stored for future reference. In order to minimize biodegration and post-sampling changes in sediment phases, all samples for geochemical analysis will be stored in a frozen state. There is adequate freezer space at Dr. Naidu's laboratories at the Institute of Marine Science. No annual cost of archiving the samples are anticipated.

XIV. Logistic Requirement

As mentioned earlier, our logistic requirements in the field for the collection of sediment samples, in addition to our 1977 summer sample suite, will be arranged by the OCSEAP Arctic Project Office. A possible convenient way would be to coordinate our field logistics with the LGL Limited, U.S., Inc., who presumably would be again the major contractor of the OCSEAP Beaufort Sea barrier island-lagoon ecosystem modelling study. Our coordination with the LGL has been excellent up to now and we wish to continue the present logistic arrangements with them. However, the logistic and ice-breaker ship requirements for the offshore sampling work will have to be provided by the U.S. Coast Guard as per the April 1977 planning meeting held in Long Beach.

Please refer to the standard attached form for further details.

XV. Management Plan

Dr. A. S. Naidu will serve as the Principal Investigator of this project. His responsibilities will include analyses and interpretation of all sedimentological data, meeting delivery milestones for data submission, as well as the deadlines for reports as required by the OCSEAP Arctic Project Office. Dr. Charles R. Geist, Assistant Professor at the Institute of Marine Science will be an Associate Investigator in this study. His prime responsibility will be to help Dr. Naidu in the statistical analysis of the sedimentological data. A graduate student/Student Aide will help Dr. Naidu in the mechanical analysis of the sediment parameters. Mr. Mike Sweeney, a graduate student presently working with Dr. Naidu and funded by the USGS, will also be involved in the collection and chemical analysis of sediment samples. The outcome of the heavy metal work will be included by Sweeney in a M.S. thesis dissertation.

As mentioned earlier, this study will be conducted in conjunction with the geomorphic studies of Dr. J. Cannon, and the physical oceanographic and biological investigations to be pursued, respectively, by Drs. Matthews and C. Mungall and the LGL Limited, U.S., Inc., as part of the overall OCSEAP program on the barrier island-lagoon ecosystem model of north arctic Alaska.

Target dates, for field sampling, sample analysis, processing, data submission, and final reports are outlined in a chart appended separately.

XVI. Outlook

1. The nature of the final results and data products: The ultimate long-term goal of this study will be to understand and quantify the processes and physical and chemical products of sedimentation in the continental margin and shelf areas of the Beaufort Sea. This knowledge would be of fundamental use to any individual or group concerned with management of the renewal and nonrenewal resources of arctic Alaska, with least ecological perturbations.

2. Significant milestones: It would seem that at least a decade of concerted effort may be involved before any quantitative understanding of sediment dynamics can be expected. Lack of proper logistics has been a traditional hurdle in the way of achieving knowledge in this area. However,

primarily through the efforts during the past six years and the ongoing interests, it is believed that adequate basic data would be available by the end of 1978. It would seem that for the next decade efforts should be concentrated on process understanding studies.

3. Cost by fiscal year: It would seem that continuous funding in the order of $300,000/year for the next 5-10 years would be considered a marginal amount to achieve understanding of the gross depositional processes in arctic continental margin. However, the most likely way to achieve this goal would be to initiate a long-term, multidisciplinary "mission-oriented" study under one organization. We have most of the expertise and facilities to carry on this program at the Institute of Marine Science.

4. Additional major equipment required: Some of the major equipments that we would like to acquire would include a side-scan sonar unit and a portable vibrocorer. We would also like to update our X-ray diffraction unit, by adding to it a monochromator, controlled humidity chamber and an automatic sample changer.

5. Location of future field efforts: We would like to continue concentrating our efforts in the continental margin and shelf areas of the Beaufort Sea. However, presently our investigations as in the past have been focussed on the central Beaufort Sea coast in the vicinity of the Colville and adjacent deltas. In the future we would like to extend laterally as far as Point Barrow in the west and the Demarcation Point in the east.

6. Logistic requirements: Collection of sediment samples from the lagoons adjacent to the North Slope has been a matter of constant concern for us, primarily because of a lack of proper large boat and navigational facilities to locate sample stations. We have traditionally depended either on the USGS or our own limited logistic support for samples. Presumably,

an ideal boat to this area would be a 30-foot arctic cruiser or a vessel similar to NARL's R/V *Natchik*. It would seem only appropriate that some Federal or State agency maintain a permanent boat in the North Slope coastal area specifically for scientific research.

The introduction of *Alumiak* is certainly an encouraging feature and we hope to make use of it in 1978 summer. However, through small boat operations it would seem possible to accomplish, as in the past, considerable amount of our sampling providing proper facilities are provided to locate sample stations. The latter could be partly accomplished by setting up identifiable landmarks on the coast and buoys in the water.

XVII. Contractual Statements

1. A schedule for data submission for each task order has been, and will continue to be, submitted and updated each quarter.
2. This statement is in accordance with our base contract, and we will continue to comply.
3. See Section XIII of this proposal. The University of Alaska will continue to negotiate a Voucher Specimen Policy with NOAA/OCS. We will comply with the then agreed to policy.
4. See Section XV of this proposal. The University of Alaska agrees that the Principal Investigators can travel to the Project Office at least twice during the contract year, provided that such travel is in accordance with University of Alaska travel policy and consistent with other University duties of the Principal Investigator.
5. Data will be provided in the form and format agreed to by the University and NOAA/OCS in the negotiating of the Data Management Plans for each of the tasks falling under the jurisdiction of this office.

6. As per Article 9 of the base contract, the University of Alaska agrees to the following: "...all archivable data is to be submitted by the contractor to the Contract Data Manager within 120 days after acquisition. Certain data sets such as plankton counts or volumes are not available until sorting of samples is complete. The data so obtained are archivable 120 days following the actual sorting or other laboratory procedure."

7. Within 10 days of the completion of a cruise or data gathering effort a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager by the Chief Scientist. If the Chief Scientist represents the contracts covered by this office, the form will be sent through this office.

8. This is in accordance with base contract with which we shall comply.

9. Three copies of all publications or presentation abstracts or manuscripts pertaining to technical or scientific material developed under OCSEAP funding will be submitted to the COTR sixty days prior to publication or presentation. Copies of all news releases mentioning OCS or using information gathered by OCS funding will be sent to the COTR.

10. The following acknowledgement of sponsorship will be used:

> "This study was supported under contract 03-5-022-56 between the University of Alaska and NOAA, Department of Commerce through the Outer Continental Shelf Environmental Assessment Program to which funds were provided by the Bureau of Land Management, Department of Interior."

Data Products Schedule

Data Type (ie. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by P.I. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Sediment size distribution (in tabulated form)	-	Roughly for 100 samples; a total of 9 parameters	I understand there is one	NO	October 1977 to July 1978	September 19
Clay mineral weighted peak area % (in tabulated form)	-	About 30 samples - total 10 parameters	None I guess	NO	October 1977 to March 1978	September 19
Heavy metal concentrations (ppm, in tabulated form)	-	About 30 samples - total 30 parameters	I understand there is one	NO	October 1977 to July 1978	September 19

RU #
Discipline
Area of Operation

LOGISTICS REQUIREMENTS

Please fill in all spaces or indicate not applicable (N/A). Use additional sheets as necessary. Budget line items concerning logistics should be keyed to the relevant item described on these forms.

INSTITUTION University of Alaska Institute of Marine Science PRINCIPAL INVESTIGATOR A. S. Naidu

A. SHIP SUPPORT

1. Delineate proposed tracks and/or sampling grids, by leg, on a chart of the area. Include a list of proposed station geographic positions. Beaufort Sea continental shelf, between Point Barrow and Demarcation Point

2. Describe types of observations to be made on tracks and/or at each grid station. Include a description of shipboard sampling operations. Be as specific and comprehensive as possible. At each station, grab and gravity core samples will be collected, as well as 1 to 2-liter water samples for measurement of suspended loads

3. What is the optimum time chronology of observations on a leg and seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification.) One cruise only, 15-25 days in August-September 1978, with possible extension by a week

4. How many sea days are required for each leg? (Assume vessel cruising speed of 14 knots for NOAA vessels. Do not include running time from port to beginning point and from end point to port and do not include a weather factor.) 15-25 days (to participate in one leg only)

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback? My investigation will be part of a round-the-clock multidisciplinary investigation
Approximately how many vessel hours per day will be required for your observations and must these hours be during daylight? Include an estimate of sampling-time on station and sample processing time between stations. A total of 6 hours/day on a 24-hour basis. Between 1.5 to 2 hours will be the sampling time at each station.

6. What equipment and personnel would you expect the ship to provide? Trained MST help as well as a grab and gravity corer will be needed. Two 20-30 liter Niskin water samplers will also be needed.

7. What is the approximate weight and volume of equipment you will bring? 500 lbs.

8. Will your data or equipment require special handling? Yes If yes, please describe: Operation of the gravity corer will need a heavy winch

9. Will you require any gasses and/or chemicals? Yes If yes, they should be on board the ship prior to departure from Seattle or time allowed for shipment by barge. One nitrogen gas tank will be loaded in Point Barrow

10. Do you have a ship preference, either NOAA or non-NOAA? If "yes" please name the vessel and give the reason for so specifying. Yes, a U.S. Coast Guard ice-breaker ship is only acceptable because of the heavy pack ice conditions

11. If you recommend the use of a non-NOAA vessel, what is the per sea day charter cost and have you verified its availability As in the past, the U.S. Coast Guard could come up with the ship time at no cost.

12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals. Dr. A. S. Naidu and his student will participate. Generally, several other scientists join in too. Dr. Naidu is a citizen of India, with permanent resident status in the U.S.

C. AIRCRAFT SUPPORT - HELICOPTER

1. Delineate proposed transects and/or station scheme on a chart of the area. (Note: If flights are for transport of personnel or equipment only from base camps to field camps and visa versa, chart submission is not necessary but origin and destination points should be listed) Airlifting of personnel and equipment is contemplated either from Barrow or Deadhorse and back. Helicopter support will be needed to collect sediment samples and aerial survey of the barrier islands of North Slope area.

2. Describe types of observations to be made.

Geomorphological surveys and nature of sediment substrates

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

Between July 20th to September 10th, 1978; a week's departure would be acceptable.

4. How many days of helicopter operations are required and how many flight hours per day? 2 hrs/day for 5 days

Total flight hours? 10 hours

5. How many people are required on board for each flight (exclusive of the pilot)?

Two scientists

6. What are the weights and dimensions of equipment or supplies to be transported?

Weight: maximum 200 lbs.
Dimension: 4 x 3 feet; a portable inflatable boat may be included

7. What type of helicopter do you recommend for your operations and why?

Not too familiar; but one similar to those carried on the USCGC *Glacier* will be adequate

8. Do you recommend a particular source for the helicopter? If "yes" please name the source and the reason for your recommendation.

The Coast Guard generally has two helicopters onboard the USCGC *Glacier*, and are generally available for scientific logistics

9. What is the per hour charter cost of the helicopter?

N/A

10. Where do you recommend that flights be staged from?
Either from the Coast Guard ice-breaker ships or from Deadhorse and/or Barrow.

11. Will special navigation and communications be required?

Conventional facilities will be O.K.

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

   Pingok Island: Between July 10th and August 15th, 1978; for two scientists; 16 total days on a continuous 8 days basis on each trip.

   Deadhorse/Spy Island: Between July 10th and August 20th, 1978; simultaneous stay of 2 scientists; 16 total days on a continuous 8 days basis on each trip. Obviously, the stay in the above two camps shall not overlap.

   USCGC *Glacier*: Between August 16th to September 10th, 1978; to cruise on the eastern half of the Alaskan Beaufort Sea

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.
   1) LGL Limited-U.S., Inc. (Texas) have been providing us with field support now, and this arrangement will be suitable to continue for the lagoon sediment collection.
   2) OCSEAP Arctic Project Office, Fairbanks, which has been most helpful to date.
   3) U.S. Coast Guard, Oceanographic Unit: The only U.S. agency to run ice-breaker cruises in the arctic.

3. What is your estimated per man day cost for this support at each location?

   $35-40/day/man

   How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

   Reasonable guesses based on current rates.

SPECIAL LOGISTICS PROBLEMS

1. What special logistics problems do you anticipate under your proposal and how do you propose that the problems be solved? (Provide cost estimates and indicate whether you propose handling the problems yourself or whether you must depend on NOAA to solve them for you?

With the exception of obtaining vibrocore and grab sediment samples, respectively, from the North Slope lagoons and the large rivers, we do not anticipate any major difficulties in fulfilling the proposal objectives.

The U.S. Geological Survey should be specially requested by the OCSEAP office to obtain a few vibrocore samples from the lagoons in the summer of 1977 and 1978. Presumably this effort could be dovetailed into their ongoing coring program in the continental margin area of the North Slope, with minimum expense. Collection of the river samples could be suitably achieved using a helicopter. Since samples need to be preferably collected from the river mid-channels, presumably the use of a portable boat would be necessary. Such a boat could possibly be carried on the helicopter and inflated in the field. I would guess one hour at each river station will be the time for this kind of sampling. We are relying on NOAA-OCSEAP office to solve this sampling problem, through the Arctic Project Office.

MILESTONE CHART

RU #: 529-   PI: A. S. Naidu

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Report on the field work, sample collection and participation in 1977 Beaufort Sea cruise	X														
Size distribution data on vibrocore samples	X														
Heavy mineral contents in various sand size grades of rivers	X														
Presentation of preliminary mineralogical and core size distribution data			X												
Completion of size distribution data on lagoon sediment samples collected in summer 1977			X												
Completion of clay mineral data on archived and summer 1977 samples				X											
Completion of heavy metal work on summer 1977 samples						X									
Completion of vanadium analysis in San Diego and consultation with USGS						X									
Completion of organic carbon and carbonate analysis					X										
Sediment transport directions; preliminary report			X												
First Quarterly Report				X											
Second Quarterly Report							X								
Completion of heavy mineral work							X								
Field work on sediment drift studies and collection of additional samples									X	X	X				
Third Quarterly Report															
Final Report												X			

REFERENCES

Arnold, K. 1975. Data for State of Alaska socio-economic impact assessment of leashing in the Beaufort Sea. Submitted to the Dept. of Community and Regional Affairs, State of Alaska, Juneau. pp. 1-24.

Barnes, P., E. Reimnitz, G. Smith and J. Melchior. 1977. Bathymetric and shoreline changes northwestern Prudhoe Bay, Alaska. U.S. Geol. Survey Open File Rept. 77-161. 10 p.

Burrell, D. C. 1977. Natural distribution of trace heavy metals and environmental background in Alaskan shelf and estuarine areas. Annual Rept. to BLM-OCSEAP Office, Boulder. Inst. Mar. Sci., Univ. Alaska, Fairbanks. 204 p.

Carmichael, J. W. 1974. The TAXMAP Classification Program. Edmonton, Canada, Dept. of Medical Bacteriology, Univ. of Alberta. pp. 1-10.

Chester, R. and M. J. Hughes. 1967. A chemical technique for the separation of ferro-manganese minerals, carbonate minerals and adsorbed trace elements from pelagic sediments. *Chem. Geol.* 2:249-262.

Dixon, W. J. 1974. BMD Biomedical Computer Programs. Berkeley, California, Univ. of California Press.

Feder, H. M., A. S. Naidu, D. Schammel, D. G. Shaw, E. R. Smith and G. W. Smith. 1976. The arctic coastal environment of Alaska, Vol. III. The nearshore marine environment in Prudhoe Bay, Alaska. Rept. R76-7, Inst. Mar. Sci., Univ. of Alaska, Fairbanks. 153 p.

Folk, R. L. and W. C. Ward. 1957. Brazos River bar - a study in the significance of grain size parameters. *J. Sedimentary Petrology* 27:2-26.

Geist, C. R. 1977. MIKCA - Multivariate Iterative K-Means Cluster Analysis: A Revision. Inst. Mar. Sci., Univ. of Alaska, Fairbanks.

Geist, C. R. 1977. The TAXMAP Classification Program: A Revision. Inst. Mar. Sci., Univ. of Alaska, Fairbanks.

Geist, C. R. 1977. The Ullrich-Pitz Analysis of Variance Program: A Revision. Inst. Mar. Sci., Univ. of Alaska, Fairbanks.

Honeywell Series 600. 1976. Biomedical (BMD) Statistical Programs Reference Manual.

Hülsemann, J. 1966. On the routine analysis of carbonates in unconsolidated sediments. *J. Sedimentary Petrology* 36:622-625.

Kirk, R. E. 1968. Experimental Design: Procedures for the Behavioral Sciences. Brooks/Cole, Belmont, California. 577 p.

McRae, D. J. 1974. MIKCA - A Fortran IV Iterative K-Means Cluster Analysis Program. CTB McGraw Hill, 1974, Monterey, California. pp. 1-21.

Naidu, A. S., D. C. Burrell and D. W. Hood. 1971. Clay mineral composition and geologic significance of some Beaufort Sea sediments. *J. Sedimentary Petroleum* 41:691-694.

Naidu, A. S. and D. W. Hood. 1972. Chemical composition of bottom sediments of the Beaufort Sea, Arctic Ocean. Proc. 24th Int. Geol. Congress, Montreal, Canada 10:307-317.

Naidu, A. S. and T. C. Mowatt. 1974. Aspects of size distributions, mineralogy, and geochemistry of deltaic and adjacent shallow marine sediments, north arctic Alaska. *In* An Ecological Survey in the Beaufort Sea. U.S. Coast Guard Ocng. Unit, Washington, D.C. *Ocng. Rept.* CG373-64:238-262.

Naidu, A. S. and T. C. Mowatt. 1976. Significance of textural criteria in the recognition of ancient polar deltaic sediments. *In* Recent and Ancient Sedimentary Environments in Alaska, T. Miller, ed. Alaska Geol. Society, Anchorage. pp. D1-D11.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner and D. H. Bent. 1975. Statistical Package for the Social Sciences. McGraw-Hill, New York. 675 p.

Presley, B. J., Y. Kolodny, A. Nissenbaum and I. R. Kaplan. Early diagenesis in a reducing fjord, Saanich Inlet, British Columbia - II. Trace element distribution in interstitial water and sediment. *Geochim. Cosmochim. Acta* 36:1073-1090.

Shepard, F. P. and D. G. Moore. 1954. Sedimentary environments differentiated by coarse-fraction studies. *Bull. Amer. Assoc. of Petroleum Geologists* 38:1792-1802.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman, San Francisco, California. 776 p.

Ullrich, J. R. and G. F. Pitz. 1976. Fortran IV ANOVA for the DEC System 10. Missoula, Montana, Dept. of Psychology, Univ. of Montana. pp. 1-16.

Weller, G., D. Norton and T. Johnson. 1977. Environmental impacts of OCS development in northern Alaska. Beaufort Sea Synthesis Report (draft). Special Bull. #15, Arctic Project Office, Univ. of Alaska, Fairbanks. 219 p.

Weiss, H. V., M. A. Guttman, J. Korkisch and I. Steffan. In Press. A comparison of methods in the determination of vanadium in seawater.

Winer, B. J. 1971. Statistical Principles in Experimental Design. McGraw-Hill, New York.

Publications: Reviewed Articles

Naidu, A. S. 1960. Geology of the Birmitrapur area with special reference to the origin of the limestone and dolomite deposits. M.Sc. Thesis. Andhra Univ., India.

Naidu, A. S., and C. B. Rao. 1963. Native sulphur in recent sediments from the Godavari Delta Basin. Current Sci. 32: 264-265.

Naidu, A. S. 1966. Lithological and chemical facies changes in the recent deltaic sediments of the Godavari River, India. *In* Deltas in their geologic framework, M. L. Shirley, ed. Houston Geol. Soc. pp. 125-257.

Naidu, A. S. 1967. Radiocarbon date of an oolitic sand collected from the shelf off the east coast of India. Proc. Symp. Indian Ocean, 1967, Nat'l Inst. Sci., India. pp. 467-471.

Naidu, A. S., G. K. Rao and C. B. Rao. 1967. Geochemistry of manganese in recent clay-sized marine sediments of the Godavari Delta. Bull. Geochem. Soc. India. 2(1 & 2): 20-26.

Naidu, A. S. and Y. L. Dora. 1967. Geochemical behavior of phosphorus in the non-detrital sedimentary cycle: a review. Bull. Dept. Mar. Biol. Oceanogr., Univ. Kerala. pp. 33-40.

Naidu, A. S. 1968. Some aspects of texture, mineralogy and geochemistry of modern deltaic sediments of the Godavari River, India. Ph.D. Dissertation. Andhra University.

Naidu, A. S. and K. V. S. Acharyulu. 1968. Geochemical behavior of iron in the non-detrital sedimentary cycle: a review. J. Geol. Soc. Saugar (Vasundhara), Vol. 4:47-53.

Naidu, A. S., D. C. Burrell and D. W. Hood. 1971. Clay mineral composition and geologic significance of some Beaufort Sea sediments. J. Sedimentary Petrol. 41:691-694.

Kinney, P. J., D. M. Schell, V. Alexander, A. S. Naidu, C. P. McRoy and D. C. Burrell. 1971. Nearshore and estuarine environments of the Alaskan Arctic coast: parameters for engineering solutions. Proc. 1st Int. Conf. Port and Ocean Engineering Under Arctic Conditions, Trondheim, Norway, August 1971. pp. 48-72.

Sharma, G. D., A. S. Naidu and D. W. Hood. 1972. Bristol Bay: A model contemporary graded shelf. Am. Assoc. Petrol. Geol. Bull. 56(10):2000-2012.

Naidu, A. S. and D. W. Hood. 1972. Chemical composition of bottom sediments of the Beaufort Sea, Arctic Ocean. Section 10, Geochemistry, Proc. 24th Int. Geol. Congr., Montreal, Canada. pp. 307-317.

Naidu, A. S. and G. D. Sharma. 1972. Geological, biological and chemical oceanography of the east central Chukchi Sea. U.S. Coast Guard Report CG373-50, Washington, D.C. pp. 173-195.

Naidu, A. S. 1974. Sedimentation in the Beaufort Sea: A synthesis. *In* Marine Geology and Oceanography of the Arctic Seas, Y. Herman, ed. Springer-Verlag, New York. pp. 173-190.

Publications: (con't)

Naidu, A. S. and T. C. Mowatt. 1974. Aspects of size distributions, mineralogy, and geochemistry of deltaic and adjacent shallow marine sediments, north arctic Alaska. U.S. Coast Guard CGC Report, Washington, D.C. pp. 238-268.

Naidu, A. S. and T. C. Mowatt. 1974. Clay mineralogy and geochemistry of continental shelf sediments of the Beaufort Sea. *In* Proc. Symp. Beaufort Sea Coast and Shelf Research, San Francisco. pp. 493-510.

Naidu, A. S., D. C. Burrell, D. W. Hood and J. A. Dygas. 1975. Texture, clay mineralogy and chemistry of bottom sediments, West Beaufort Sea, Arctic Ocean. Geol. Soc. Amer. Spec. Paper 151. pp. 49-58.

Naidu, A. S. and T. C. Mowatt. 1975. Environments and sediments of the Colville Delta complex, north arctic Alaska. *In* Deltas Models for Subsurface Exploration, M.L.S. Broussard, ed. Houston Geological Society. Houston, Texas. pp. 283-309.

Naidu, A. S., T. C. Mowatt, D. B. Hawkins and D. W. Hood. 1975. Clay mineralogy and geochemistry of some Arctic Ocean sediments: significance on paleoclimate interpretation. *In* Climate of the Arctic, G. Weller and S. A. Bowling, eds., Geophys. Inst., Univ. Alaska. pp. 59-67.

Naidu, A. S. Continental shelf sediments of high latitudes. *In* Encyclopedia for Sedimentology, R. W. Fairbridge, ed. Invited chapter (In press).

Naidu, A. S. and T. C. Mowatt. 1976. Significance of textural criteria in the recognition of ancient polar deltaic sediments. *In* Recent and Ancient Sedimentary Environments in Alaska, T. Miller, ed. Alaska Geol. Soc., Anchorage. pp. D1-D11.

Naidu, A. S., C. J. Lee and T. C. Mowatt. 1976. Chemistry of deep-sea sediments in the Canada Basin, west Arctic Ocean. *In* Assessment of the Arctic Marine Environment: Selected Topics. D. W. Hood, ed. Inst. Mar. Sci. Occas. Publ. No. 4 (POAC 75), Univ. of Alaska, Fairbanks. pp. 121-129.

Unpublished Reports (Excludes Progress Reports)

Naidu, A. S. and C. B. Rao. 1967. Results of investigations carried out on the deltaic sediments of the Godavari River. *In* Oceanography in India, Report of Indian participation in the International Indian Ocean Expedition, New Delhi. Publ. No. 4:63-64.

Kinney, P., D. Schell, V. Alexander, S. Naidu, C. P. McRoy and D. C. Burrell. 1971. Baseline data study of the Alaskan Arctic aquatic environments; eight month progress, 1970. Inst. Mar. Sci. Rept. R-71-4, Univ. Alaska, Fairbanks.

Naidu, A. S. and G. D. Sharma. 1971. Texture, mineralogy, and chemistry of Arctic Ocean sediments. Progress Report for 1970-71 to the U.S. Geological Survey. Inst. Mar. Sci. Rept. No. R71-16. Univ. Alaska, Fairbanks. 17 pp.

Naidu, A. S. 1972. Clay mineralogy and heavy-metal geochemistry of deltaic sediments of the Colville and adjacent rivers. Pages 123-138 *In* Baseline Data Study of the Alaskan Arctic Aquatic Environment. Inst. Mar. Sci. Rept. No. R72-3. Univ. Alaska, Fairbanks.

Publications: (con't)

Mowatt, T. C. and A. S. Naidu. 1974. Gravels from the Alaska continental shelf, Beaufort Sea, Arctic Ocean: Petrologic character, and implications for sediment source and transport. Open File Report 43. State of Alaska Dept. Nat. Res. Div. Geol. and Geophys. Surv., Fairbanks, Alaska. 12 pp.

Mowatt, T. C., A. S. Naidu and N. Veach. 1974. Clay mineralogy of the lower Colville River Delta, north arctic Alaska. State of Alaska Dept. Nat. Res. Div. Geol. and Geophys. Surv., Fairbanks, Alaska. 21 pp.

Naidu, A. S. 1975. Clay minerals and chemical stratigraphy of unconsolidated sediments, Beaufort Sea, Arctic Ocean, Alaska. Inst. Mar. Sci. Report submitted to the U.S. Geol. Survey, Menlo Park, California. 21 pp.

Alexander, V. *et al.* (Co-author A. S. Naidu). 1975. Environmental studies of an Arctic estuarine system. Final Report U.S.E.P.A., Rept. No. EPA-660/3-75-026. Corvallis, Oregon. 536 pp.

Mueller, G. J., A. S. Naidu and D. Schamel. 1976. Background benthic studies of the Torch Bay-Dixon Harbor area of the Glacier Bay National Monument, Southeast Alaska. Inst. Mar. Sci. Report submitted to National Park Service.

Feder, H. M. *et al.* (Co-author A. S. Naidu). 1976. The sediment environment of Port Valdez, Alaska and the effect of oil on this ecosystem. Report submitted to U.S.E.P.A., Washington, D.C. 320 pp. (2 volumes).

Feder, H. M., D. G. Shaw and A. S. Naidu. 1976. The nearshore marine environment in Prudhoe Bay, Alaska. Inst. Mar. Sci. Report No. 76-1 submitted to the Atlantic Richfield Co., Anchorage. 161 pp.

Published Abstracts (National/International Meetings)

Naidu, A. S. and C. B. Rao. 1968. Lateral clay mineral variations in modern deltaic sediments of the Godavari River. Proc. S.E.P.M. Symp., 1968, Oklahoma City. A.A.P.G. Bull. 52(3):543.

Naidu, A. S. and C. B. Rao. 1969. Clay mineral composition of modern deltaic sediments of the Godavari River. Proc. Symp. Processes and Products of Sedimentation. 1967, Waltair, India.

Naidu, A. S. 1969. Texture of modern deltaic sediments of Godavari River (India). Proc. AAPG-SEPM Annual Meeting, Dallas, Texas, 1969. A.A.P.G. Bull. 53(3):733-734.

Naidu, A. S., D. C. Burrell and C. M. Hoskin. 1970. Sediments of the South Beaufort Sea. Trans. Am. Geophys. Union Meeting, Washington, D.C., April 1970.

Naidu, A. S., D. C. Burrell, J. A. Dygas and R. Tucker. 1970. Sedimentological studies on coastal beach deposits of northern Arctic Alaska. Proc. Second GSA-SEPM Coastal Res. Group Symp., Kalamazoo, Michigan, November 1970.

Naidu, A. S., D. C. Burrell and J. A. Dygas. 1971. Texture, organic carbon and clay mineralogy of Western Beaufort Sea sediments. Pages 39-40 *In* Proc. Second Int. Symp. Arctic Geology, San Francisco, February 1971. And in A.A.P.G. Bull. 54:2497-2498.

Publications: (con't)

Naidu, A. S. 1971. Clay mineral composition of the Beaufort Sea sediments, Arctic Ocean. AAPG-SEPM Annual Meeting, Houston, Texas, 1971. Am. Assoc. Petrol. Geol. Bull. 55:355.

Dygas, J. A., D. C. Burrell and A. S. Naidu. 1973. Sediment transport and shoreline changes along the Alaskan arctic coast. Presented by A. S. Naidu at the AAPG-SEPM meeting, Anaheim, California, May 1973.

Naidu, A. S. and T. C. Mowatt. 1973. Lateral variations of clay minerals in the deltaic sediments of the Colville and adjacent rivers, north arctic Alaska. Ibid.

Naidu, A. S. and T. C. Mowatt. 1975. Clay mineral composition of the Alaskan Chukchi Sea, Arctic Ocean. *In* Proc. Int. Clay Mineral Conference, Mexico. 112-113 pp.

Naidu, A. S., G. Freitag and T. C. Mowatt. 1976. Clay minerals in recent sediments of the continental shelf, central and western Gulf of Alaska. Proc. 27th Alaska Sci. Conf., Univ. Alaska. 25 p.

Publications: Pettus, J. P., C. R. Geist, G. E. Schulta, and R. R. Zimmermann. 1974. Recovery from malnutrition: food preference and neophobia. Perceptual and Motor Skills 38:767-773.

Strobel, D. A., C. R. Geist, R. R. Zimmermann, and E. K. Lindvig. 1974. Cue locus - a factor in the behavioral deficiency of the developing protein malnourished monkey (*Macaca mulatta*). Behavioral Biology 10:473-484.

Wells, A., A. Jones, M. Williams, and C. R. Geist. 1974. Noise, vitamin A deficiency, and emotional behavior in rats. Perceptual and Motor Skills 38:392-394.

Zimmermann, R. R. and C. R. Geist. 1974. A primer of animal behavior for the lay-person. Contemporary Psychology 19: 115-116.

Zimmermann, R. R., C. R. Geist, and L. A. Wise. 1974. Behavioral development, environmental deprivation, and malnutrition. *In* Advances in Psychobiology, vol. 2, ch. 3, G. Newton and A. H. Riesen, eds. John Wiley & Sons, Inc., New York.

Zimmermann, R. R., R. Guest, and C. R. Geist. 1974. Improvements in self-concept during psychotherapy in a maximum security prison. Perceptual and Motor Skills 39:311-314.

Zimmermann, R. R., C. R. Geist and P. K. Ackels. 1975. Changes in the social behavior of rhesus monkeys during rehabilitation from prolonged protein-calorie malnutrition. Behavioral Biology 14:325-333.

Zimmermann, R. R., C. R. Geist, D. A. Strobel and T. J. Cleveland. 1975. Attention deficiencies in malnourished monkeys. *In* Early Malnutrition and Mental Development. (Symposium of the Swedish Nutrition Foundation, vol. XII.) J. Craviota, L. Hambraeus, and B. Vahlquist, eds. Uppsala, Sweden, Almquist and Wiks Wiksells.

Zimmermann, R. R., C. R. Geist and D. A. Strobel. 1975. The behavioral deficiencies in protein deprived monkeys. *In* Nutrition: Its Contribution to Mental Function. (Advances in Behavioral Biology Series, vol. 14.) Plenum Publishing Co., New York.

Zimmermann, R. R., D. A. Strobel, P. Steere and C. R. Geist. 1975. Behavior and malnutrition in the rhesus monkey. *In* Primate Behavior, vol. 4, L. Rosenblum, ed. Academic Press, New York.

Geist, C. R. 1976. Drugs and Drug Dependence. *In* Correspondence Study Program, Continuing Education Program, Univ. of Alaska, Fairbanks.

Geist, C. R., R. R. Zimmermann, O. W. Smith and E. M. Geist. 1977. The emergence of a kwashiorkor-like syndrome associated with protein calorie malnutrition in the developing rhesus monkey (*Macaca mulatta*). Psychological Reports 40:1339-1344.

Smith, O. W., P. C. Smith, R. R. Zimmermann, and C. R. Geist. 1977. A ratio scale for comparison and evaluation of visual size constancy data and theory. Perceptual and Motor Skills, submitted.

Research Proposal

to

National Oceanic and Atmospheric Administration
Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado 80302

THE ENVIRONMENTAL GEOLOGY AND GEOMORPHOLOGY OF THE BARRIER ISLAND - LAGOON SYSTEM ALONG THE BEAUFORT SEA COASTAL PLAIN FROM PRUDHOE BAY TO THE COVILLE RIVER

R.U. #530

College of Environmental Sciences
Solid Earth Science
University of Alaska
Fairbanks, Alaska 99701

TOTAL COST: $30,099

P. J. Cannon
Principal Investigator
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7809

V. Alexander, Acting Dean
College of Environmental Science
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7210

A. B. Frol, Director
Administrative Services
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7340

K. B. Mather, Vice Chancellor
Research and Advanced Study
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7282

June 30, 1977

I. Title

The Environmental Geology and Geomorphology of the Barrier Island - Lagoon System along the Beaufort Sea Coastal Plain from Prudhoe Bay to Coville River

Research Unit #530

II. Principal Investigator

Dr. P. Jan Cannon

III. Cost of Proposal

Total: $30,099
Beaufort 100%

IV. Background

The barrier islands of the Beaufort Sea are composed mainly of gravels. The natural habitats of much of the wildlife of the coastal zone have a substrate of gravel because of its stable properties. Development of energy resources in the area will require huge amounts of gravel for various uses. The Barrier islands would appear as a ready source of gravels for the developmental needs. However, the source of the gravels is not known and the stability of the Barrier islands is directly related to the gravels. In simple words: no gravel, no islands. The question to be answered first is why are the islands there or why is the gravel where it is? The outcome of this research is to provide information which can be used to determine the dynamics of the barrier island-lagoon system and the possible source of the gravel in the islands and sources of gravel for developmental use that will not effect the stability of the Barrier islands.

V. Objectives

1. To determine the origin and evolution (geomorphic history) of the Barrier islands and the coastal lagoons.

2. To determine the source(s) of the gravel size materials that make up the Barrier islands.

3. To determine the stability of the barrier island-lagoon system in respect to natural processes and man induced effects.

4. To determine the magnitude of the geomorphological relationships between the barrier island-lagoon system and the landforms of the coastal plain such as the various streams, dune fields, ground patterns, thermokarst features, deltas, pingos, lugs, and lakes.

5. To construct a spatial and temporal model of the environmental geology of the region.

VI. General Strategy and Approach

A geomorphic history is based on the construction of a chronology of geomorphic events. Spatial information and sequential observations of large portions of the coastal zone are necessary in order to construct a chronology. Landforms are the products of the manner in which the energy of geomorphic agents (such as wind, water, and ice) is expended upon terrestrial materials. Since geomorphic agents interact to various degrees at or near the earth's surface, a variety of landforms can be generated in almost any locality. Landforms are, therefore, a record of the geomorphic agents which have dominated or are presently dominating the patterns of energy interchange at some point on the earth.

The assemblage of landforms and the geomorphic processes which are effected as a result of the creation of the assemblage form that which is termed the environment of a particular area on the earth's surface. The identification of a landform or of an assemblage of landforms provides information about the environment which can be used to evaluate the natural history of the environment and to appraise the impact of induced changes.

The basic approaches are as follows:

1. Interpretation of aerial photographs, radar imagery, LANDSAT imagery and thermal infrared imagery.

2. Ground reconnaissance, on foot and boat.

3. Low altitude aerial reconnaissance, this is very important part of ground truth measurements and map unit verification.

4. Evaluation of existing literature. Note te term "evaluation," there exists several ambiguities in the literature about the area.

5. Exchange of data with A. S. Naidu.

6. Geomorphic analysis of existing maps.

7. Comparison of sequential data.

8. Compilation of a landforms map of the region.

9. Compilation of an environmental geologic hazards map of the region.

10. Compilation of a shoreline stability map.

11. Construction of an environmental energy flow model for the region.

12. Analysis of the future effects of natural processes and man-induced effects.

13. Establish the relationships between gravel deposits and possible sources of the gravel.

The thirteen preceeding statements are an outline of an approach to meet the scientific objectives and establish information which is to be displayed or discussed in the products. The initial step is to make a temporary identification of the existing landforms. The second step therrfore is to verify the landform identification. The landform verification is approached by utilizing the principles of the concept of multiple working hypotheses. In some cases the landform verification will necessitate ground samples and detail analysis of those samples (such is foreseen in the origin of Barrier islands). The verification of other landforms may call for a regional look at the geomorphic system. Often in geomorphology the answers are found outside of the area of specific interest. A delta quite often reflects factors that exist in the watershed of the streams at points somewhat removed from the delta itself. Therefore just looking that the delta itself will never answer all the questions. A case in point here is the stability of the Barrier islands of the Beaufort Sea. The expected life of the Barrier islands can be ascertained only by looking at the complete stream systems which terminate in the coastal zone. Directions of sampling, evaluation, and interpretation will continually change as information is collected and exchanged. The exchange of information as it is collected with A. S. Naidu will be extremely important to his project as well as to this project. Our interpretations will be based on the information collected and analyzed, and not on some vague preconceived ideas. In both projects "fingerprinting" of the sediments in the coastal zone will be used to determine the sediment sources. The project of A. S. Naidu will be used to determine the sediment sources. The project of A. S. Naidu will look at the fine-grain sediments and this project will look at the coarse-grain sediments. Our information will then be combined to produce a complete geomorphic history of the area.

Remote sensing data will be used to provide very important information about the subtle geomorphic features of the Barrier island system, and the impact of sea ice on the Barrier island system. The information from the various remote sensing techniques will be combined to produce the stability map.

Field observations, interpretation of the remote sensing data, and information from other projects operating in the barrier island system will be utilized to make an evaluation of possible environmental impact problems.

Side-looking airborne radar imagery (SLAR) of barrier island system is required. Low altitude K- or X-band required. X-band radar imagery is presently being acquired of the area for other OCS projects. This radar imagery would be usable, copies would only have to be made available to the investigators.

Thermal infrared imagery should be obtained anytime the barrier island system becomes ice free (late July or August). This thermal infrared imagery should be acquired from 40,000 feet AGL, by the NASA Convair 990 research aircraft with the Texas Instruments' thermal imager. The T.I. thermal imager on board the NASA Convair 990 has been used to acquire data for NOAA of parts of Alaska.

Almost any type of aerial photography taken during the summer will be a help to the study. The investigators can make use of either black and white, color, color IR, or multiband photography.

VII. Acquiring photographs and imagery from ground and aircraft.

VIII. Not applicable

IX. Anticipated Problems

The only problem anticipated at this time is obtaining information about ice dynamics during deep winter in December or January. Acquiring radar imagery of the area during this time of year will probably solve the problem.

X. Deliverable Products

A. Digital Data:

None.

B. Narrative Reports:

A report which provides the following:

1. A fact supported origin for the Barrier islands and the coastal lagoons.

2. An evaluation of possible environmental impact problems in the barrier-island-lagoon system.

3. A description of the geomorphic processes acting upon the barrier-island-lagoon system and the coastal plain.

The reports will discuss and explain the information displayed on the maps. The reports will explore possible impacts on the barrier island system and describe how these impacts would be related to the dynamics of the barier island-lagoon system and the coastal plain. The reports will be an expansion of the explanations that accompany the maps. The report. will stress the relationships between the Jones Islands and the Return Islands and the coastal plain.

C. Visual Data:

1. A landforms map of the Barrier Islands and the coastal plain identifying and describing important geomorphic features.

2. A map which indicates the potential environmental hazards.

3. A map which indicates the stability of the Barrier Islands and the shoreline of the coastal plain.

Environmental geologic data must be displayed in spatial format if a realistic evaluation is to be made of an area. If changes are induced, natural environments respond in all dimensions. Therefore, components of natural environments must be displayed in a spatial framework which portrays their degree of physical association. This makes it necessary to display environmental information on maps, because point values cannot convey a complete indication of the degree of interface between components. This is important if predictive model studies are to be made of the area.

Map 1. Landforms of the Coastal Zone

This map will locate, identify, and describe the various coastal landforms. The explanation will indicate the origin of the particular landform types, the possible lifetime or stability of each particular landform type, and the economic importance of each landform type.

Map 2. Potential Environmental Geologic Hazards

This map will indicate the extent of possible environmental geologic hazards such as storm flooding, seismic sea waves, tectonics, outburst flooding, and other hazards discovered during the project.

Map 3. Stability of the Barrier Islands and the Shoreline of the Coastal Plain

This map will indicate the relative stability of the Barrier Islands and the shoreline of the coastal plain as determined by landform analysis, sequential data, and quantitative data from other projects. This map will also show dominant longshore drift and can be used to determine the effects of man-made structures on the barrier island system.

D. None.

E. Data Submission Schedule

Narrative data will be submitted by quarter. All narrative data will be updated and combined in the final report. The maps will be submitted with final report on 30 September 1978. Data collection began May 1977 and will continue through July 1978. Map data concerning geomorphology will be incorporated into the maps as it is obtained.

XI. Information Required From Other Investigators

Information about fine-grained sediments will be obtained from R.U. #529. Arrangements have been made to communicate with the Principal Investigator of R.U. #529, Dr. A. S. Naidu.

XII. Not applicable.

XIII. Not applicable.

XIV. See attached form.

XV. Management Plan

This project will be managed by making observations of the field site at times predetermined with the use of remote sensing data. This will be done in order to observe the important geomorphic processess at the best time possible. A conceptual model will be constructed from preliminary data. This model will then be modified with field observations and new remote sensing data. As field facts are obtained they will be compiled on a preliminary map. This will form the basis for determining the map units and the direction of additional field study. This type of approach is shown in the milestone chart.

XVI. Outlook:

1. The maps which will be made would provide the reference data needed for various types of planning and land management. The Barrier Island model could be used to determine the potential problems of development in other parts of the arctic coast.

2. The determination of origin and stability of all parts of the arctic coastal zone would be an extremely significant milestone.

3. Cost by fiscal year would be approximately $35K.

4. A stereo transfer scope would be required for a larger mapping effort.

5. The rest of the arctic coast should be mapped.

6. Logistic requirements would not differ greatly from FY '78.

XVII. Contractual Statements:

1. A schedule for data submission for each task order has been, and will continue to be, submitted and updated each quarter.

2. This statement is in accordance with our base contract, and we will continue to comply.

3. See section XIII of this proposal. The University of Alaska will continue to negotiate a Voucher Specimen Policy with NOAA/OCS. We will comply with the then agreed to policy.

4. See section XV of this proposal. The University of Alaska agrees that the Principal Investigators can travel to the Project Office at least twice during the contract year, provided that such travel is in accordance with University of Alaska travel policy and consistent with other University duties of the Principal Investigator.

5. Data will be provided in the form and format agreed to by the University of Alaska and NOAA/OCS in the negotiating of the Data Management Plans for each of the tasks falling under the jurisdiction of this office.

6. As per Article 9 of the base contract, the University of Alaska agrees to the following: "...all archivable data is to be submitted by the contractor to the Contract Data Manager within 120 days after acquisition. Certain data sets such as plankton counts or volumes are not available until sorting of samples is complete. The data so obtained are archivable 120 days following the actual sorting or other laboratory procedure."

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager by the Chief Scientist.

   If the Chief Scientist represents the contracts covered by this office, the form will be sent through this office.

8. This is in accordance with the base contract with which we shall comply.

9. Three copies of all publications or presentation abstracts or manuscripts pertaining to technical or scientific material developed under OCSEAP funding will be submitted to the COTR sixty days prior to publication or presentation. Copies of all news releases mentioning OCS or using information gathered by OCS funding will be sent to the COTR.

10. The following acknowledgement of sponsorship will be used:

    "This study was supported under contract 03-5-022-56 between the University of Alaska and NOAA, Department of Commerce through the Outer Continental Shelf Environmental Assessment Program to which funds were provided by the Bureau of Land Management, Department of Interior."

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

(a) Will need to stay at NARL for about seven days during Freeze-up period. Will make observation flights out of NARL.

(b) Sept. 15 – 30, 1977 or Oct. 1 – Oct. 15, 1977.

(c) two people, P.I. and assistant. Total of 14 mandays at NARL.

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

No

3. What is your estimated per man day cost for this support at each location?

Whatever the daily rates per man are at the NARL Labs at the time.

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

E. SPECIAL LOGISTICS PROBLEMS

1. What special logistics problems do you anticipate under your proposal and how do you propose that the problems be solved? (Provide cost estimates and indicate whether you propose handling the problems yourself or whether you must depend on NOAA to solve them for you?

Will need Cold weather gear for Freeze-up observations in late September. This gear will be available from NARL.

MILESTONE CHART

RU #: 530 PI: P. Jan Cannon

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978												
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Assessment of Freeze-up data	Δ															
~~Determination of gravel sources~~		Δ														
Preliminary barrier island model			Δ													
Study Deep-Water Ice Dynamics			Δ	Δ												
Reverse barrier island model					Δ	Δ										
First draft of maps						Δ	Δ	Δ								
Field check map units									Δ	Δ						
Compile reports										Δ	Δ					
Revise and finish maps										Δ	Δ	Δ				
Complete reports											Δ	Δ				

PUBLICATIONS

Cannon, P. J., 1976, Generation of explicit parameters for a quantitative geomorphic study of the Mill Creek drainage basin: Oklahoma Geology Notes, February 1976, v. 36, no. 1, 4 tables, 3 figures, pp. 3-18.

________1976 (in press), Application of radar imagery to outer continental shelf studies in the Gulf of Alaska: in Remote Sensing of Earth Resources, v. V, F. Shahrokhi, editor, 18 p.

________1975, Environmental evaluation of coasts using radar imagery: in 1st. Congreso Venezolano de Geodesia, December 1975, Proceedings, 11 p.

________1975, Skylab view of Arbuckle Mountains: Oklahoma Geology Notes, October 1975, v. 35, no. 5, p. 165-166.

________1975, The application of radar imagery to specific problems of Interior Alaska: in NASA Earth Resources Survey Symposium, June 1975, Proceedings, v. 1-B, p. 761-768.

________1974, The application of radar imagery to environmental geologic mapping, in Approaches to Environmental Geology, Report of Investigations No. 81, Bureau of Economic Geology, The Univ. of Texas at Austin, pp. 224-236.

________1974, (with T. C. Gustavson), Preliminary environmental geologic mapping on the inner coastal plain, Southwest Texas, in Report of Investigations No. 81, Bureau of Economic Geology, The Univ. of Texas at Austin, pp. 79-101.

________1974, Application of radar imagery to environmental mapping of Texas, Proceedings, Ninth International Symposium on Remote Sensing of Environment, Univ. of Michigan, Ann Arbor, Michigan, pp. 216-218.

________1974, Rock type discrimination using radar imagery: in Remote Sensing of Earth Resources, v. III, F. Shahrokhi, editor, pp. 339-352.

________1974, (with E. G. Wermund, et. al.), Test of environmental geologic mapping, southern Edwards Plateau, Southwest Texas: Geol. Soc. America Bull., v. 85, no. 3, p. 423-432.

________1974, Drainage anomalies of the upper Nueces River in South-Central Texas: Geol. Soc. America, Abs. with Programs (South-Central Sec.), v. 5, no. 2, p. 98.

________1974, Applications of radar imagery to environmental geologic mapping: Am. Assoc. Petroleum Geologists (San Antonio, Texas) Annual Meetings Abs., v. 1, p. 16.

Cannon, P. J., 1974, The application of radar and infrared imagery to quantitative geomorphic investigations: abs., Oklahoma Geology Notes, v. 34, no. 3, p. 128.

________1974, Rock type discrimination using radar imagery: abs., Oklahoma Geology Notes, v. 34, no. 3, p. 128-129.

________1974, (Book Review) Slope Morphology by S. A. Schumm, and M. P. Mosley, AAPG Bull., v. 58, no. 4, p. 759-760.

________1974, Dougherty Anticline, Arbuckle Mountains: Oklahoma Geology Notes, v. 34, no. 2, p. 45-46.

________1973, The application of radar and infrared imagery to quantitative geomorphic investigations: Remote Sensing of Earth Resources, v. II, F. Shahrokhi, editor, pp. 503-520.

________1973, The generation of explicit parameters for quantitative geomorphic investigations: GSA Annual Meeting, South-Central Section, Little Rock, Arkansas, April 5-7, 1973, South Central Section Program of The Geological Society of America and Associated Societies, v. 5, no. 3, pp. 249-250.

________1973, The generation of explicit parameters for quantitative geomorphic investigations: Oklahoma Geology Notes, v. 33, no. 3, June, 1973, pp. 122-123.

________1973, Quantitative expressions of stream adjustment: GSA Annual Meeting, Dallas, Texas, Nov. 12-14, 1973, Abstracts with Programs, v. 5, no. 7, p. 567.

________1973, Applications of radar and infrared imagery to quantitative geomorphology: Proceedings of the International Conference on Remote Sensing in Arid Lands, Nov., 1972.

________1973, (with E. G. Wermund, et. al.), Test of environmental geologic mapping, Southern Edwards Plateau, Southwest Texas: abs., Geology, v. 1, no. 4, p. 169.

________1973, The application of radar and infrared imagery to quantitative geomorphic investigations: abs., in Radar remote sensing for geosciences, M. L. Bryan, ed., Environmental Research Institute of Michigan, Ann Arbor, p. 66.

________1973, (with L. C. Rowan) Remote-sensing investigations near Mill Creek, Okla.: abs., in Radar remote sensing for geosciences, M. L. Bryan, ed., Environmental Research Institute of Michigan, Ann Arbor, p. 121.

Cannon, P. J., 1971, Geologic map of the Sabine EB region of the moon: U.S.G.S. Miscellaneous Geologic Investigation Map I-679 (RLC-11), scale 1:5,000 (1 inch - 416 3/4 feet). Sheet 25 by 39 inches.

_______1971, (with M. West), Geologic map of Apollo landing sites 4 and 4R of Wichmann CA region Oceanus Procellarum: U.S.G.S. Miscellaneous Geologic Investigation Map I-625 (ORB III-11 (24), scale 1:25,000 (1 inch = about 2,080 feet). Sheet 25 by 48 inches. Accompanied by 4 page text.

_______1970, (with L. C. Rowan, et. al.), Remote sensor application studies progress report, July 1, 1968 to June 30, 1969: Controlled Field Experiments: Document No. 197 099, National Technical Information Serivce, U.S. Department of Commerce, Springfield, Va., pp. 1-36.

_______1970, (with L. C. Rowan, et. al.), Thermal infrared investigations, Arbuckle Mountains, Oklahoma: Geol. Soc. America Bull., v. 81, December, pp. 3549-3562.

_______1970 (with L. C. Rowan), Remote-sensing investigations near Mill Creek, Oklahoma: Oklahoma Geology Notes, v. 30, no. 6, December, pp. 127-135.

_______1970, Radar imagery of the Potato Hills: Oklahoma Geology Notes, v. 30, no. 6, December, p. 127.

_______1970, Lunar landslides: Sky and Telescope, v. 40, no. 4, October, pp. 215-218.

_______1969, The Physiography of Southwestern Oklahoma: The Compass, v. 47, no. 1, November, pp. 23-25.

_______1969, Geologic map of Apollo landing site 7: U.S.G.S. open file report.

_______1969, (with L. C. Rowan, et. al.), Thermal infrared investigations, Mill Creek area, Oklahoma: NASA Second Annual Earth Resources Aircraft Program Status Review, v. 1, Geol. and Geog., sect. 5, pp. 1-25.

_______1968, Pleistocene stream piracy in Southwestern Oklahoma: Oklahoma Geology Notes. v. 28, no. 6, December, pp. 183-187.

_______1968, Infrared Photograph of Turner Falls: Oklahoma Geology Notes, v. 28, no. 6, December, p. 182.

_______1968, Modification of Lunar Craters: The Compass, v. 45, no. 2, January, pp. 128-134.

_______1966, Infeasibility of terrestrial-type Volcanism as a generator of Lunar landforms: Oklahoma Geology Notes, v. 26, no. 8, August, pp. 215-217.

OCEANOGRAPHIC PROCESSES IN A BEAUFORT SEA BARRIER ISLAND - LAGOON SYSTEM: WAVE AND CURRENT MEASUREMENTS: NUMERICAL MODELING

OCSEAP Research Unit #531

Texas A & M Research Foundation Proposal #77-647

Principal Investigator: J.C.H. Mungall

Co-Principal Investigator: R.E. Whitaker

Total Cost of Proposal: $65,429

Institution:
Texas A & M Research Foundation
Faculty Exchange Box H
College Station, Texas 77843

Department Affiliation:
Department of Oceanography
Texas A&M University
College Station, Texas 77843

Date of Proposal: 30 June 1977

Funding Period: 1 March 1978 to 28 February 1979

Principal Investigator

Christian Mungall

J.C.H. Mungall
Assistant Professor
Oceanography Department
Texas A&M University
College Station, Texas 77843
713/845-1443

Required Organization Approval

W.D. Nowlin Jr.

for W.D. Nowlin, Jr.
Head
Oceanography Department
Texas A&M University
College Station, Texas 77843
713/845-7211

Organization Financial Officer

Fred J. Benson

Fred J. Benson
Vice President
Texas A & M Research Foundation
Faculty Exchange Box H
College Station, TX 77843
713/845-6434

I.

TITLE: OCEANOGRAPHIC PROCESSES IN A BEAUFORT SEA BARRIER ISLAND-LAGOON SYSTEM: WAVE AND CURRENT MEASUREMENTS, NUMERICAL MODELING

RESEARCH UNIT NUMBER: 531

CONTRACT NUMBER: 03-7-022-35182

CONTRACT DATES: 1 March 1978 to 28 February 1979

II. PRINCIPAL INVESTIGATORS:

J. C. H. Mungall, Principal Investigator

R. E. Whitaker, Co-principal Investigator

III. COST OF PROPOSAL

Total: $65,429

Distribution by Lease Area:

Beaufort Sea
(100%)

IV. BACKGROUND

The work proposed here represents the second year of studies undertaken with a view to understanding the hydrography and circulation of an Arctic Barrier Island-Lagoon ecosystem: Simpson Lagoon, Alaska. The project is complementary to R.U. 526 being undertaken by the University of Alaska. In the wider sense, the physical oceanography studies have the dual goals of providing supporting hydrographic data to the biological and geomorphological studies, and of assisting these disciplines in the overall goal of assessing the susceptibility of Arctic Barrier Island-Lagoon systems to modification by nearshore or offshore development.

Although the starting date for the first year of research was only a few days ago (13 June 1977), participation in two ecological modeling workshops and numerous discussions prior to the start date have provided a clear indication of the need by the biological and geomorphological disciplines for flow-rate, current and trajectory information. Furthermore, it is vital that information concerning the wave climate seaward of the barrier islands be made available to the geomorphologists. The first year of studies, still to be undertaken, will provide representative information on conditions at selected entrances to the lagoon (principally at the eastern and western ends) and along the longitudinal axis of the lagoon. Current, conductivity, and temperature profiles will be obtained during August 1977. These data, when combined with our initial numerical modeling experiments (see section VI) and with the results of the research being undertaken by the University of Alaska, should give us a fair idea of the overall circulation and hydrography of Simpson Lagoon, and of the relative importance of the various entrances.

Our proposed second year of studies covers three specific areas: first, the completion and verification (using field measurements) of the three-dimensional model of the lagoon principally aimed at the computation of flow rates, currents and particle trajectories; followed by an estimation of the winter current velocities (using a three-dimensional model) under a cover of ice; secondly field measurements in Simpson Lagoon and its entrances; and thirdly, the design and operation of a wave gauge. The first two of the above study areas will build upon the first year's research and field measurements. In particular, it is hoped that an optimum location of the current meters will be achieved as a result of the first year of modeling studies and measurements. The improvement of the three-dimensional model through use of the measurements taken during the first year should also follow. These improvements will also lead to greater confidence in the use of the model in simulations of an ice-covered region. The principal importance of the modeling and current and trajectory measurements will be that of providing information on the most likely transport of sessile organisms, nutrients, and sediment through Simpson Lagoon. This transport, which is of great importance in studying biology or sedimentology, is considerable during the Simpson Lagoon summer owing to the lagoon being essentially an open system driven principally by wind and sea level changes, occasionally by river flow, and possibly by the entrance density structure.

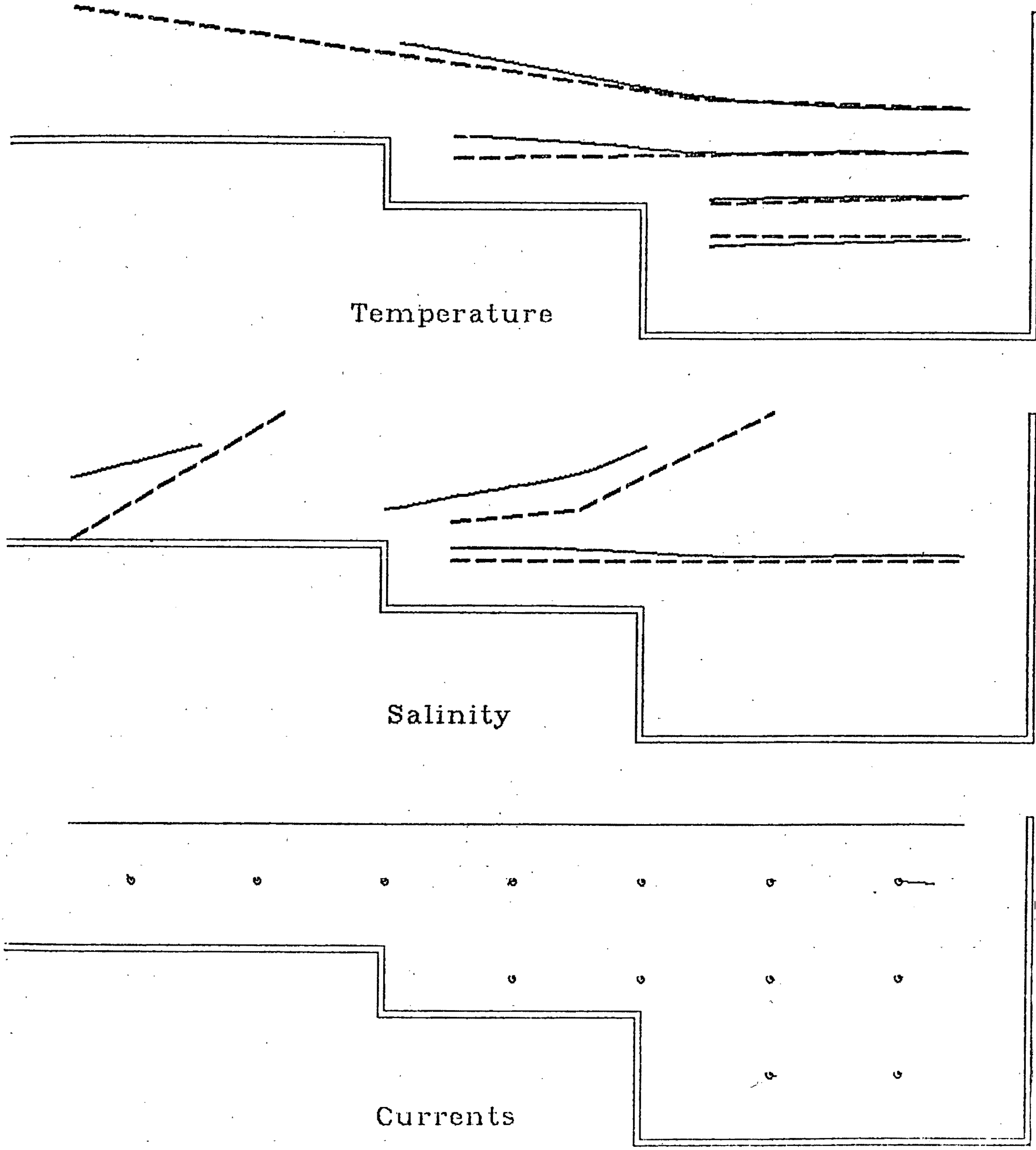
Wave measurements, neglected during the first year owing to budget restrictions, are essential for the study of the formation of barrier islands. Measurements inside Simpson Lagoon are probably not necessary, since they are of short period, and probably of importance only concerning the undercutting of the landward shores of the Lagoon. Measurements outside the Barrier Islands will do much to assist geomorphologists in estimating the causes of formation of Barrier Islands and the reason for their movement. Aerial photos should be obtained during the first year of studies and studied as a means of determining the distance of breaker zones from the shore. We hope to take such photos during the flights being made for the Lagoon hydrographic surveys.

A three-space variable density multi-level numerical model of shallow water hydrodynamics has been prepared and tested. The finite-difference equations are analogs of the vertically integrated (over each level) equations of motion, continuity, and conservation of salt and "heat." Terms in the vertical equation of motion of the same order as the local acceleration are neglected. The first order flow is treated explicitly while sub-grid scale motions are expressed as products of local gradients and eddy coefficients. The field acceleration terms are taken in divergence form to conserve the average and variance of the advected quantity.

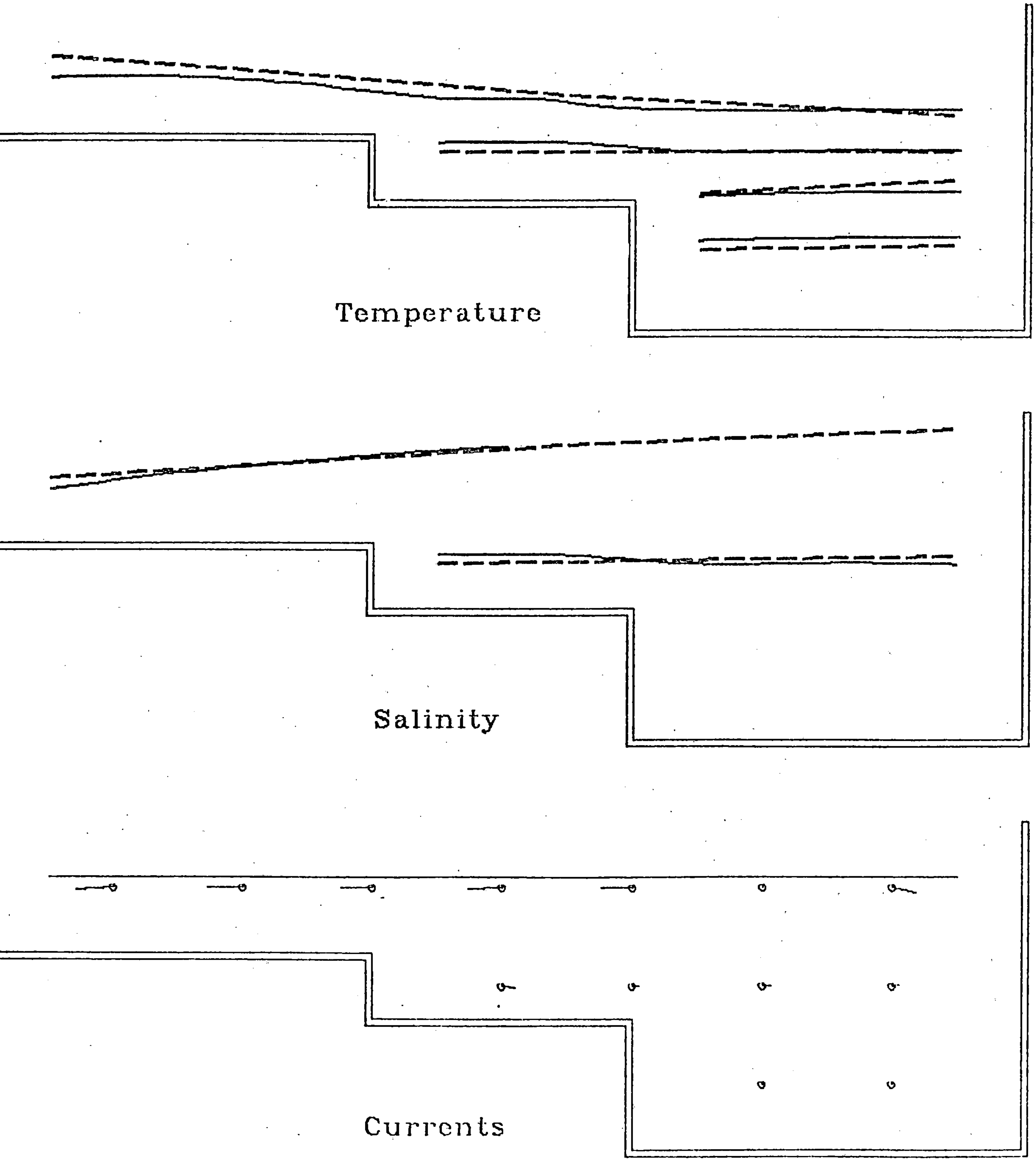
The vertical exchange coefficient is a function of a mixing length which is a parabolic function of depth, the vertical velocity shear, and stability. We feel this single modification greatly enhances the model's ability to portray turbulent mixing.

The model has been tested to determine its conservative characteristics, which are more than sufficient. Evaluating the model's sensitivity to variations in the lateral exchange coefficients proved difficult due to the lack of field observations. However, comparisons with exact solutions for steady flow revealed no radical change as the coefficients were varied over three decades.

The model has been applied to East Lagoon on Galveston Island. The lagoon is approximately 1.6 km long, 0.5 km wide, and has a maximum depth of 5 meters. It is connected to Bolivar Roads (the pass between Galveston Bay and the Gulf) by two 20 x 5 ft conduits at the shallow end of the lagoon. Extensive field observations of temperature, salinity, and currents were obtained over a three-day period by a biological oceanography student at Texas A&M. The results of simulating the flow in East Lagoon were subsequently used by the student as input to a biological model of species distribution. The following figures compare the computed (solid) and observed (dashed) temperatures and salinities in a vertical section down the lagoon's center. The bottom panel shows the computed currents and water surface. The results are indicative of what can be realized by applying a reliable model to a hydrodynamically simple system with adequate data to stipulate boundary conditions.

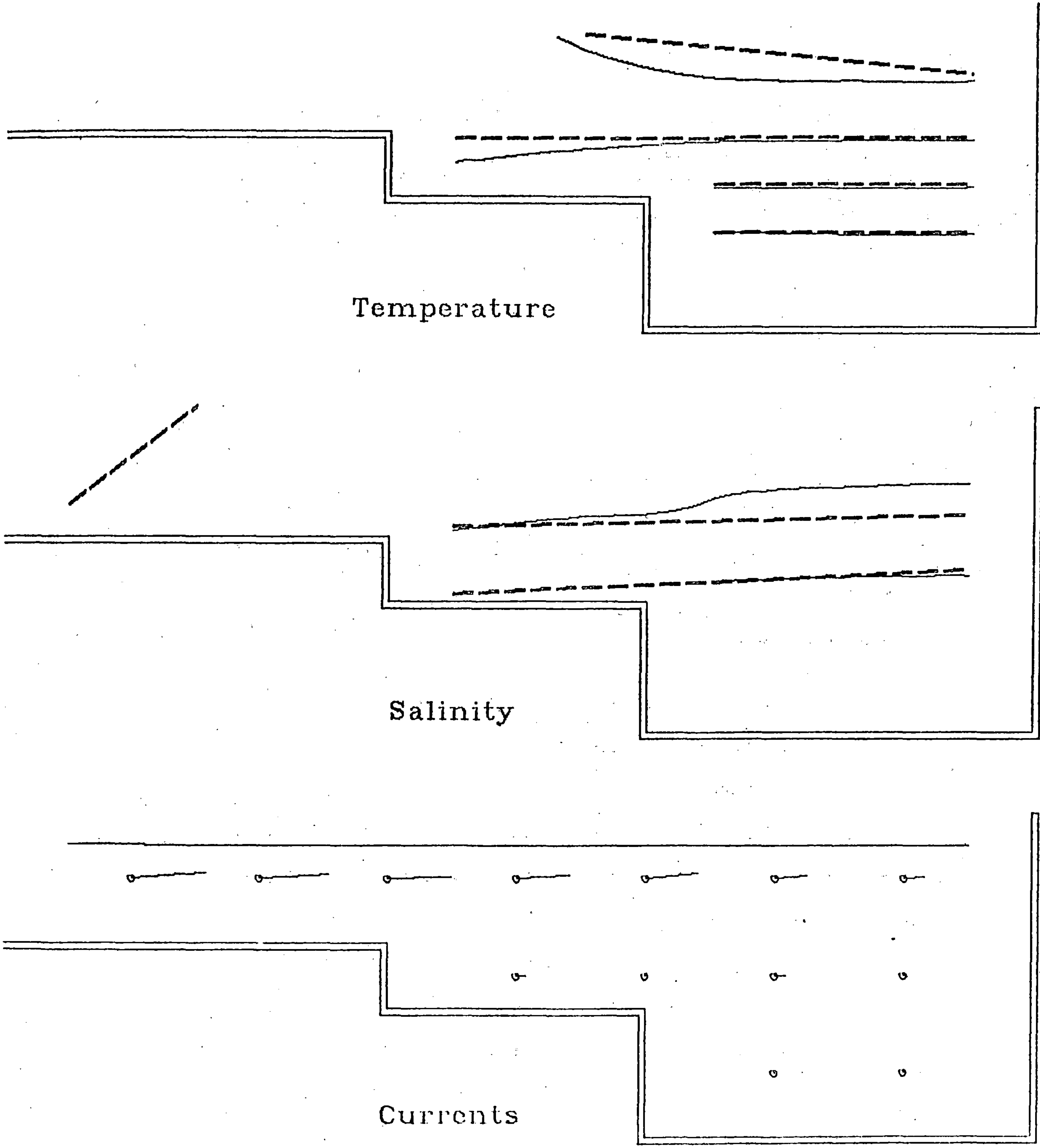


0400 Hrs 18 Sept 76



1200 Hrs 18 Sept 76

Figure 2



2000 Hrs 19 Sept 76

Figure 3

V. OBJECTIVES

1. Continuation of three-dimensional Simpson Lagoon numerical model design, computation and verification of flow rates, currents, and particle trajectories. Experiments will be conducted with the three-dimensional Simpson Lagoon model to simulate the effect of a total ice cover.

2. Summer field measurements to be made in Simpson Lagoon, principally of drogue movements and of entrance currents.

3. Wave gauge design, construction and initial testing. Wave measurements to be made outside Simpson Lagoon, up to 3 km from Pingok Island. Outputs from three pairs of pressure transducers will be monitored and the data stored digitally on cassette tape.

The first and second objectives can be considered together in that they are both aimed at providing other scientific disciplines with information concerning movement due to currents. The drogues will provide estimates of surface currents, while the model will provide estimates of currents throughout the (short) water column. This information will help the various scientific disciplines (and other interested parties) in the estimation of transit times of any substance or fluid introduced into the lagoon. Information of this type will allow verification of the numerical model (which can then be used to study a variety of new conditions: the effect of closures, for example). Furthermore, such information will assist greatly in the improvement of the understanding of the biology of the region and will facilitate the design of contingency plans.

The third objective -- that of providing wave information -- will principally benefit geomorphologists and other disciplines needing wave data for the successful completion of their research. In addition, the wave data will probably be of help in permitting the Bureau of Land Management to assess any statements relating to wave measurements that may be made by industrial concerns as part of their environmental impact statement. (An additional benefit of the proposed wave monitoring system is that a number of spare channels in the data gathering system will be made available to other disciplines wishing to record time series data. This will aid in the efficient handling of data.)

VI. GENERAL STRATEGY AND APPROACH:

Modeling

We are now in a position to initiate numerical experiments by applying the model to Simpson Lagoon under the influence of different winds and river outflows.

The Simpson Lagoon model will be excited with uniform winds of 5, 10 and 15 ms^{-1}. Only two wind directions, east northeast and northwest will be assumed. This is a reasonable set of forcing specifications considering the dominance of the wind directions cited and the small frequency of speeds greater than 20 ms^{-1} (EPA, 1975).

It is also anticipated that attempts will be made to simulate the flow in Simpson Lagoon under winter conditions. These initial efforts will treat the ice as a membrane responding as the free surface. It is possible to allow for variable ice thickness with a small amount of recoding the computer algorithm, but in the absence of ice condition observations we feel this degree of realism should be deferred. The computations proposed will at least provide the vertical current shear as modified by a uniform ice sheet.

The results of the numerical experiments will provide information from which trajectories and flow rates can be readily computed and be available as inputs to analyses by other disciplines.

When field data are lacking, specifying conditions on the seaward boundary poses a problem. Usually, we simply extend the computing grid seaward, which reduces the effect of the other conditions on the interior solutions. However, for Simpson

Lagoon this would require a grid array of approximately 100 x 50 km. A five-level rendition of the region with a grid of 2 x 0.5 km and a time step of 30 s would consume two to three minutes of computer time for each hour of prototype time. With a modest budget this is not feasible. Therefore, we suggest that only the lagoon proper be modeled. With a computing array 100 x 14 km and smaller depths, this would effectively reduce the computer time by 50-75%.

Boundary conditions on the flow at the passes will be derived from the results of applying a coarse-grid extended area model to the Simpson Lagoon region. Forcing will be identical with that taken for the limited area model. Historical data will be used to define the initial density field.

After the field program, we will perform computations with the limited area model to verify its ability to simulate the summer circulation within Simpson Lagoon. The field data will provide stipulation of realistic boundary conditions and forcing functions. The results of the computations will be compared with the Lagrangian and Eulerian current observations obtained during the corresponding simulation period.

Field Measurements

The 1978 summer field measurements will be undertaken with a view to providing current, flow rate, and trajectory information in the interior of Simpson Lagoon. The measurements will be made in cooperation with the University of Alaska. The information so derived will be used by biologists, geomorphologists, physical oceanographers and others.

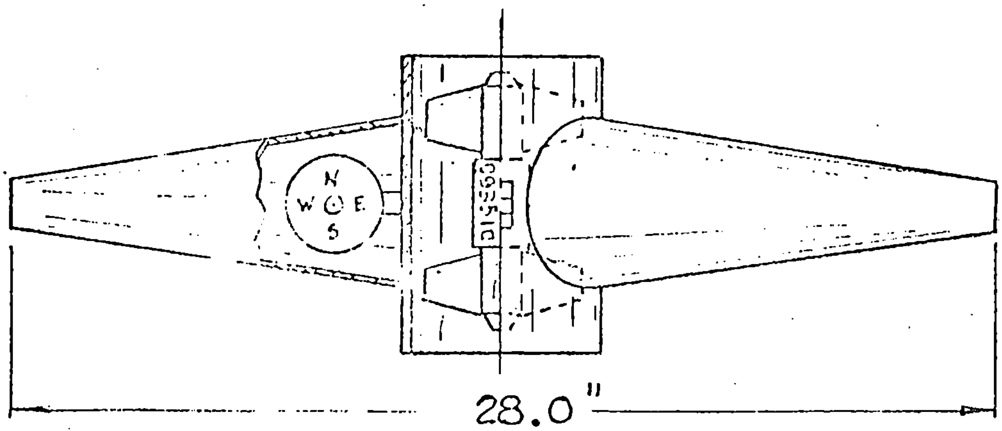
Although both Universities will be studying the entrance currents of Simpson Lagoon, Texas A&M University will primarily concentrate on trajectory measurements, while the University of Alaska will concentrate on water level measurements and on time series measurements of temperature and salinity. Texas A&M University will, in addition, assist in making salinity and temperature measurements along suitable entrance or lagoon cross-sections.

a) Entrance current meter measurements: Texas A&M University, in conjunction with the University of Alaska, will endeavour to obtain time-series measurements of a combined total of 8 entrances: by Summer 1978 the University of Alaska intends to have 5 current meters that record time, current speed and direction, temperature and salinity. Texas A&M requests funds in this proposal to purchase 3 current meters for recording only time, and current speed and direction.

As a result of discussions with Shale Niskin of General Oceanics, Texas A&M will be taking 3 especially-designed twin-rotor ducted current meters (see figure 4) to Simpson Lagoon for the Summer 1977 field season. These unique current meters

GENERAL OCEANICS, INC.

5535 N.W. 7th Avenue
Miami, Florida 33127 U.S.A.
Telephone: (305) 754-6658
Cable: GENOC-MIAMI
Telex: 51-9727



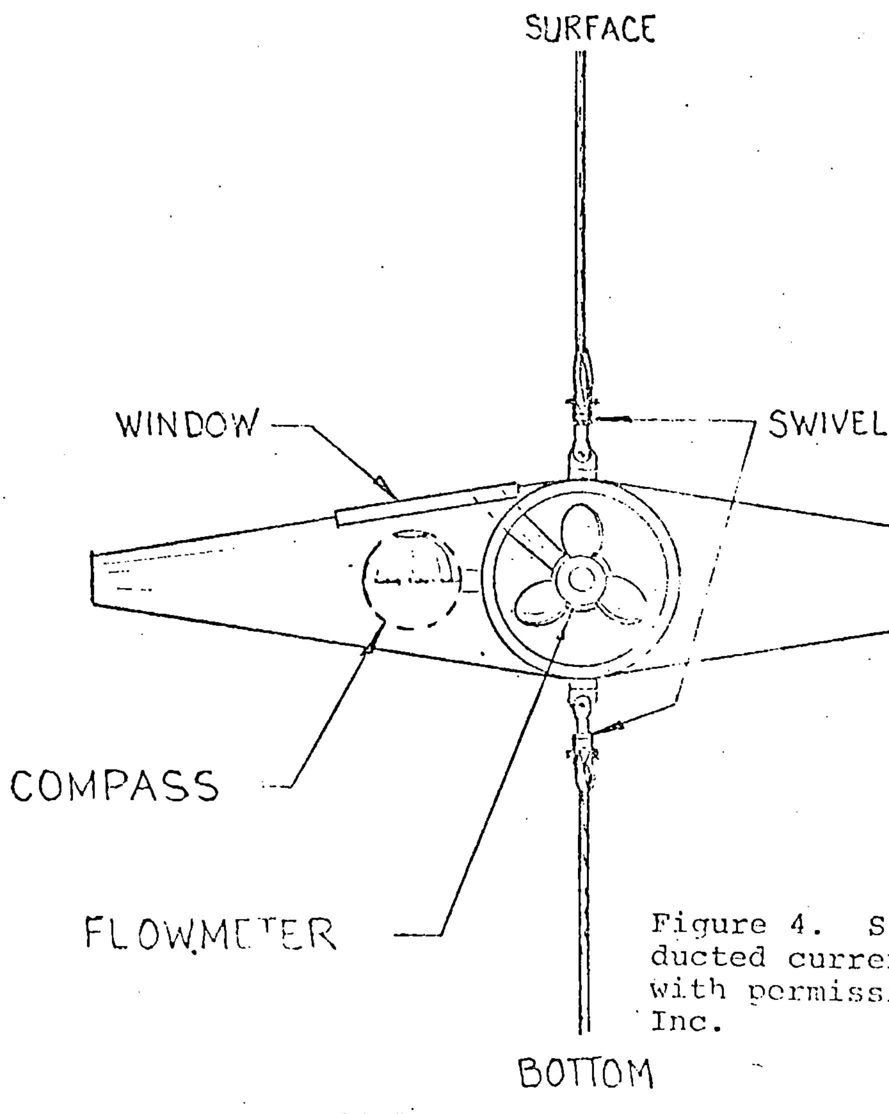


Figure 4. Stabilized twin-rotor ducted current meter. Reproduced with permission of General Oceanics Inc.

have: a) a rotor and gearing system that counts up and down with the passage of a wave so as to reduce wave contamination of the records, b) a double cone arrangement that keeps the duct parallel to the current direction, with no tendency to change direction by 180° with the passage of a wave (as is the case with meters having fins), and c) a compass that can be clamped after a passage of time to indicate one direction. We expect to find this a hardy and suitable instrument for use in a cold wave-subject environment. Consequently, for use during the Summer 1978 field season, we propose to order a modification of this design that will include in addition a clock, light, and cine camera. The three A&M recording ducted current meters will supplement the proposed 5 University of Alaska current meters (hopefully, modified to include the use of the new twin-rotor ducted velocity sensors) so as to provide an excellent coverage of the motion of water through the principal 8 entrances/exits of Simpson Lagoon. Regrettably no redundancy exists to cover the possible loss of meters.

b) Drogue tracking: As part of our goal of providing real data on the motion of particles through Simpson Lagoon (for use both by the various disciplines and for model verification) we propose to track surface and shallow current drogues in Simpson Lagoon through the use of radar. The seemingly expensive purchase of a radar set is easily justified in terms of the convenient recording of the drogue positions and through the reduction of the number of field assistants involved in the project. Costs for each system (excluding drogues, 3 personnel from Texas A&M) are:

Radar	
3 KW pulse, 16 mi radar	$3300
2.5 KW generator	660
Antenna tower	600
Cine camera (& film)	500
Cables, etc.	200
	$5060

Radio Direction Finding	
3 RDF radios + 10 x mtrs.	$ 1600
3 assistants, 1 mo each	4500
Minimum 60 days per diem	3000
Travel, minimum	600
	$ 9700

The general approach used will be to install the 40 ft triangular tower on the coast near the upwind end of the lagoon. The radar antenna will be placed on top of the tower, with video sign[illegible]ing transmitted down co-axial cables to the set. Reflector [illegible]oped drogues will then be released. A typical set (KONEL KRA116) can display ranges of 1/2, 1-1/2, 4, 8, and 16 mi on a 7 in screen. Reflector equipped drogues should be visible inside the lagoon at ranges of up to 10 mi. At this range we expect absolute accuracies of 0.2 mi in range. The drogue positions will be recorded using a super-8 cine camera equipped with an intervalometer - thus reducing to a minimum the possibility of mistaken drogue identities. For the long-term tracking experiments, when the drogues begin to pass out of range --probably after 24 hours -- the radar antenna will be moved to a new sight.

We plan to install the radar near the base camp (probably on Pingok Island) at the start of the 1978 summer field season. Drogues will be released and tracked at regular intervals. For two 5-day periods the radar will be moved to the shore (should this advantageously increase the range), and drogues will be tracked as they drift through the lagoon by moving the radar as necessary. At all other times the radar will serve as a navigation device which will materially improve position finding capabilities (through the use of 2-way radios). Last, but not least, the radar will prove a useful safety device in a region where few such safety aids exist.

Wave measurements

The selection of a wave measuring system suitable for use on the Simpson Lagoon barrier islands must take into account the risk to equipment due to the possible passage of ice. In particular, it is essential that a) equipment exposed to damage by ice be reduced to a minimum, and, b) that sensors be duplicated for redundancy or that means be found for their timely replacement. We feel that these constraints preclude the use of self-contained, pressure-type wave recorders and that the use of remote recording equipment is indicated -- using either bottom-mounted pressure sensors or resistance-wire wave staffs.

The choice between pressure sensors (with the attendant problem of wave pressure attentuation) and resistance-wire wave staffs (with the problems of nonlinearity due to water drainage, and susceptibility to damage) is an important one. Each sensor, without supporting structure, costs on the order of $650. The tripod, subsurface buoy or other structure needed to support the wave staff is likely to cost around $1,000 by the time it is on the barrier islands; furthermore its replacement (should such be necessary) using a Zodiac or Boston Whaler would be difficult. We are left with the conclusion that the pressure sensor will be the best alternative.

Discussions with Dr. A. S. Naidu at the Institute of Marine Science, University of Alaska, have indicated his need for wave measurements in 15-20 ft of water — preferably some 2½ nm on the seaward side of Pingok Island. Two problems thus arise: a) the laying and survivability of cables, and b) the need for encoding the small resistance or voltage changes. The first of these problems can partially be met by using a weighted cable with some redundancy (but may set an upper limit on the cable length), the second problem can be solved fairly easily by converting the pressure sensor output signal to a frequency-modulated audio-frequency signal (say, centered around 1500 HZ).

In view of the need for redundancy and for fairly detailed information concerning the wave climate as a function of distance from the shore, the need for a digital data logger is clearly evident. Furthermore, unless data are recorded digitally, processing the data in the time frame required would be almost out of the question. We, therefore, recommend the use of a multi-channel data logger. A visual output in the form of voltmeters and occasional paper chart records will be desirable for verifying equipment functioning and for assessing the day-to-day wave climate. The selection of a suitable data logger depends as much on the convenience with which the digital data can be extracted through interfacing with a mini-computer as on the sampling rate and number of channels. After discussions with the Texas A&M Data Processing Center, the need for a data reader with an 8 or 16-bit parallel output with "handshaking" (the means by which the mini-computer informs the data reader that it is ready for another word of data) is very clear. Considerations such as these have led us to one such combination: the Datel 32 channel DL2B data logger and DL2R reader or equivalent.

The wave measuring system as presently envisaged is as follows (approximate costs being added in parentheses):

A. Sensors

Stainless steel pressure sensor with strain gauge and water-tight connector ($400) mounted on simple pressure housing ($100) that contains the electronics. The electronics will consist essentially of: a constant current generator (power to be supplied from the shore), a precision reference resistor, a voltage controlled oscillator and an amplifier ($200). The sensor will be mounted on a suitable block.

B. Connecting wire

Two twisted pairs in a single non-floating cable ($150 per 1,000 ft). The two pairs will give us flexibility in the design, and will permit us to send power <u>to</u> the pressure sensors, and to receive two separate frequencies <u>from</u> the sensors.*

C. Decoder and display

The FM (audio-frequency) signal(s) will be converted to DC for the purpose of displaying the signal ($100). This signal could also be used as the input to the data logger, although it may be desirable to use an alternative form of convertor.

---

* Note: It may be desirable to use double armored cable ($825/1000 ft) at the shoreline. Strengthened (cadmium bronze) cable might provide greater underwater reliability ($510/1000 ft.)

D. Data logger

We present envisage a Datel Model DL2B 32-channel cassette tape recorder ($4440). Such recorders are self-contained, run off batteries, are housed in rugged containers, can record every second or better, and have a variety of controls for selecting recording times, channels, header information, etc.. Little is to be gained on reducing the number of channels. We hope that other disciplines, such as Meteorology, will make use of the logger to store their data.

E. Reader

The cassette tapes are read into a mini-computer and written onto conventional 9-track tape using a Datel model DL2B/ ($3500). Sixteen-bit words (in parallel) will provide a high rate of data input -- of the order of 30 minutes/cassette. The necessary interface mini-computer and expertise are available at the Texas A&M University Data Processing Center.

Timely construction and testing of the complete system in an ocean environment (Galveston, Texas) is essential. The starting date for assembling the system should be three months before the start of the field season (e.g., a start date of mid-March for a mid-June field season). In order to reap as much benefit as possible from the wave measurements, the system should be installed as early as possible during the field season. It is hoped that the system will be maintained by a combination of monthly visits from Texas A&M, visits by University of Alaska personnel, and by members of the LGL biology team.

VII. SAMPLING METHODS

Field measurements (excluding waves)

Three participants from Texas A&M University will be in the field during the Summer of 1978. The principal and co-principal investigators will each make two visits: the first being of 7 days duration, the second of 30 days duration. The 7-day visits will be used to establish and check the radar and wave recording facilities, and the two 30-day visits (overlapping by 20 days) will be used primarily for two intensive 5-day lagoon study periods. An assistant will be in the field during the overlap period.

The intensive study periods will consist of radar-aided drifter tracking, entrance current measurements (using 3 film recording current meters), entrance conductivity and temperature measurements (using 5 C, T, current recording meters), water elevation measurements, axial surveys of the lagoon hydrography (using float planes), meteorological measurements, and wave measurements (outside the lagoon). Underlined items are those to be performed by Texas A&M University.

The two periods will provide data for documenting the physical oceanography of the lagoon and for use in calibrating and verifying the numerical models.

Drifter tracking will be accomplished by moving the radar and antenna, probably once every day, should the drifters travel along the length of the lagoon.

Entrance current speeds and directions will be recorded on film at intervals of 10 minutes for later development, projection, key-punching, and analysis. The equipment is designed so as to reduce wave effects.

Axial surveys, undertaken in cooperation with the University of Alaska and the biological parties, will include current, conductivity and temperature measurements using previously-purchased instruments. Measurements will be taken at intervals of 10 km from one end of the lagoon to the other. A float plane will be used for reasons of security and speed.

At times other than the two intensive 5-day study periods, one specific entrance (to be chosen as a result of the first year's investigations) will be studied -- probably that off Oliktok Point. Visits will be made on a daily basis. Conductivity, temperature and currents will be measured. Drifters will be released upwind for tracking by the radar (based at the Pingok Camp). Weekly visits will be made to the 3 current meters in order to change the film and check the meters.

VIII. ANALYTICAL METHODS

Field measurements (excluding waves)

Current meter data (on film) will be projected frame-by-frame for eventual key punching. The data will be analyzed and plotted in the conventional manner (histograms, spectra, etc.).

Drifter data (on film) will be projected onto a Hewlett-Packard digitizing board. The individual frames will provide a means for identifying individual drifters. Every half hour the positions of the individual drifters (along with geographic coordinates) will be digitized. Tracks will then be plotted and velocities computed for eventual display, correlation with wind speeds and directions and model verification.

Wave measurements

The digitized wave records will be transferred from the cassettes to tape or disc for processing. A major step will be the correction for pressure attentuation (a function of depth and period). This will be accomplished by convolving the wave record with the transform of the pressure correction (the depth will be assumed constant for each 10 minute wave record). Wave spectra will then be computed by conventional FFT programs, and such quantities (bottom currents, etc.) as needed by the geomorphologists will be computed.

IX. ANTICIPATED PROBLEMS

Modeling

The boundary conditions to be used in the winter circulation simulations are not as physically satisfying as one might wish. This is due entirely to the lack of winter observations. The winter circulation computations are further limited by our lack of knowledge of how the ice thickness varies in space and time. Because of these considerations, applications of the multi-level model to Simpson Lagoon should be regarded as experiments to determine the response of the Lagoon to barotropic forcing under idealized winter conditions.

Another difficulty which may be encountered concerns the wind-driven recession of the water line over the northwest end of the Lagoon. If the water line recession exposes a significant area (on the order of 25 km^2) during the field program the multi-level model will not be applied to Simpson Lagoon. There exists a long-wave model that allows for a moving shoreline (Reid and Bodine, 1968) and it could be readily applied to Simpson Lagoon.

Field measurements (excluding waves)

Current meters;

The chief problem here will be the possible loss or failure of meters and the probable lack of back-up meters. We hope that the 8 meters of Texas A&M University and the University of Alaska will be supplemented by loans from NOAA.

Drifter tracking:

1) The transport of the antenna and its subsequent erection by 3 people will require logistic attention and some preparatory training. The use of individual 10 ft guyed sections to a maximum height of 40 ft, along with the use of safety belts and possibly of a portable winch, should deal with the latter problem. Extra manpower or the use of a structure such as the DEW line site might help.

2) Drifters may well go ashore and become lost or damaged. Adequate replacements and the full time use of a boat will be necessary.

Wave measurements

1) Loss of lines and/or sensors will be the most critical problem. Funds for sufficient wire and spare sensors must be provided.

2) Due to the occasional presence of Texas A&M University personnel (on account of funding limitations), we see the need for people to assist in making occasional checks, and change cassettes and batteries.

X. DELIVERABLE PRODUCTS

A. Digital data

1. Digital data will consist of serial readings of current speed, direction and bottom pressure as observed during the field program.

2. The raw data will provide for the construction of time-series of current speed, direction, bottom pressure, sea surface elevation, and drifter locations.

Vertical sections oriented along the lagoon's axis giving the conductivity, temperature and current speed fields will be prepared from data obtained during the three scheduled surveys.

B. Narrative reports

A report will be written giving the available technical information and specifications related to the design and construction of the mechanical and electronic components of the wave gauges. Additionally a guide will be provided outlining in detail the operation and maintenance of the apparatus.

C. Visual Data

Visual data will be in the form of black-and-white negatives or prints of the serial recordings of current speed, direction and drifter locations.

D. Other non-visual data

None

E. Data submission schedule

The initial data collection is provisionally scheduled for June 1978. Data collection will be completed by 1 September 1978. Submission of collected data will be three to four months after conclusion of 1978 summer field program.

Data Products Schedule

Data Type (i.e. Intertidal Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (if known)	Processing and Formating done by P.I.	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Current speed	Tape	12096 records	015	Yes	June 1978 to 1 Sept 1978	1 Jan 1979
Current direction	Tape	12096 records	"	"	June 1978 to 1 Sept 1978	1 Jan 1979
Bottom pressure	Tape	5 million records	"	"	June 1978 to 1 Sept 1978	1 Jan 1979
Drifter positions	Chart	60 pages	"	"	July 1978 to 1 Sept 1978	28 Feb 1979
Conductivity) Temperature) Current profiles)	Printout	70 pages	"	"	July 1978 to 1 Sept 1978	1 Jan 1979

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

Sea-level records from three or more sites, surface wind charts and currents, salinities and temperatures from the selected entrances are expected to be provided by the University of Alaska. Contact with University of Alaska personnel have been initiated and final arrangements are pending.

XII. QUALITY ASSURANCE PLANS

The current meters will be calibrated in a Texas A&M University flow tank under metered conditions and the pressure sensors will be calibrated in an appropriate pressure vessel. Radar vectoring will be checked by using sites of known locations as targets. The salinometer will be calibrated against a known sample.

In addition to the calibration outlined above, all of the instruments to be used in the 1978 summer observational program will be field-tested in the Galveston area.

After the field program the numerical model will be calibrated through comparisons of the observed and computed currents and water-level anomalies.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLANS

None

XIV. LOGISTICS REQUIREMENTS

See attached form

XV. MANAGEMENT PLAN

Field operations will be scheduled and altered through continuing communication with scientists in other disciplines active in Simpson Lagoon.

See attached milestone form.

For [illegible] Use Only:
RU #
Discipline
Area of Operation

LOGISTICS REQUIREMENTS

Please fill in all spaces or indicate not applicable (N/A). Use additional sheets as necessary. Budget line items concerning logistics should be keyed to the relevant item described on these forms.

INSTITUTION *Texas A&M University* PRINCIPAL INVESTIGATOR *J. C. H. MUNGALL*

A. SHIP SUPPORT

1. Delineate proposed tracks and/or sampling grids, by leg, on a chart of the area. Include a list of proposed station geographic positions.
No research vessel will be used; Boston Whaler only.

2. Describe types of observations to be made on tracks and/or at each grid station. Include a description of shipboard sampling operations. Be as specific and comprehensive as possible.
Conductivity, temperature measurements using deck-readout equipment. Current profiles using either deck-readout meter or meters suspended from a portable tripod.

3. What is the optimum time chronology of observations on a leg and seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification.)
From spring break-up to 1 September 1978

4. How many sea days are required for each leg? (Assume vessel cruising speed of 14 knots for NOAA vessels. Do not include running time from port to beginning point and from end point to port and do not include a weather factor.)
Boston Whaler needed for total of around 40 days.

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback?
Sole use
Approximately how many vessel hours per day will be required for your observations and must these hours be during daylight? Include an estimate of sampling-time on station and sample processing time between stations.
8 hrs/day 4 hrs on station minimum

6. What equipment and personnel would you expect the ship to provide?
N.A.R.L. to supply radios, running gear, fuel for Boston Whaler

7. What is the approximate weight and volume of equipment you will bring?
2,000 lbs.

8. Will your data or equipment require special handling? *No* If yes, please describe:
--

9. Will you require any gasses and/or chemicals? *No* If yes, they should be on board the ship prior to departure from Seattle or time allowed for shipment by barge. -

10. Do you have a ship preference, either NOAA or non-NOAA? If "yes" please name the vessel and give the reason for so specifying.
Yes. Boston Whaler with canvas roof.

11. If you recommend the use of a non-NOAA vessel, what is the per sea day charter cost and have you verified its availability
About $100/day (including motors, equipment, gas)

12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals.
Two to three only (U.S. citizens)

B. AIRCRAFT SUPPORT - FIXED WING

1. Delineate proposed flight lines on a chart of the area. Indicate desired flight altitude on each line. (Note: If flights are for transportation only, chart submission is not necessary but origin and destination points should be listed)
Three flights along axis of Simpson Lagoon; duration approximately 6 hrs. Samples to be taken every 10 km along track of 100 km. Eight trips to Pingok Isl.

2. Describe types of observations to be made.
Conductivity, temperature, currents.
Additional samples if a marine biologist accompanies us.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification)

Open water summer season.

4. How many days of flight operations are required and how many flight hours per day?
3 days @ 6 hrs.; 8 days @ 2 hrs.
Total flight hours? *34*

5. Do you consider your investigation to the principal one for the flight thus precluding other activities or requiring other activities to piggyback or could you piggyback?

Surveys are designed solely for physical and biological observations.

6. What types of special equipment are required for the aircraft (non carry-on)?
None
What are the weights, dimensions, power requirements, and installation problems unique to the specific equipment.
None

7. What are the weights, dimensions and power requirements of carry-on equipment?
1. Salinometer @ 15 lbs., 12" × 9" × 9"
2. Electronics, 5"×9"×9" @ 10 lbs; current sensors, 36"×9"×9" @ 30 lbs.
3. Float @ 2 lbs., 12" dia. + 10 lbs. weight

8. What type of aircraft is best suited for the purpose?
Fixed-wing aircraft equipped with floats.

9. Do you recommend a source for the aircraft? *Yes.*
If "yes" please name the source and the reason for your recommendation.
N.A.R.L. for convenience

10. What is the per hour charter cost of the aircraft?

$90 N.A.R.L. (1977 cost was $85)

11. How many people are required on board for each flight (exclusive of flight crew)?
Two or three.

12. Where do you recommend that flights be staged from?
Deadhorse.

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

1)	*Deadhorse*	*Summer 1978**	*3 max*	*June 78*	*2*
				July 78	*6*
				Aug. 78	*10*
2)	*Pingok Island or lagoon shore*	*Summer 1978**	*3 max*	*June 78*	*5*
				July 78	*10*
				Aug. 78	*55*

* *Dates to be determined after conference with all field teams.*

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

Yes.
OCSEAP. Reasons : Previous OCSEAP experience with Deadhorse and Pingok Island camps.

3. What is your estimated per man day cost for this support at each location?

Deadhorse : $100/man day
Pingok Island: $50/man day

How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

Deadhorse rate : OCSEAP Arctic project office quote.

Pingok Island, N.A.R.L. rental prices and estimate for food

XVI. Outlook

At this stage (after less than one month into the first year of funding) it would be invidious to say much about the period beyond the second year of funding. We suggest that the efforts of Texas A&M University can best be employed in three areas

a) Numerical modeling of ice-covered lagoon, given ice and water thickness,

b) Further wave measurements as required by geomorphologists, and

c) Estimation of longshore currents along the north coast of Alaska using TIROS N satellites.

The first two possibilities would require efforts comparable to those described in this proposal, the third one would require drifters at a cost of some $3-5,000 each, a charge from the satellite managers of some $20 per buoy per day. Costs for 3 months for 5 buoys would thus be around $35,000 excluding wages, initial deployment and re-deployment and data processing. The information so gained would, however, greatly extend knowledge concerning overall flow patterns along the north coast of Alaska.

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Not applicable.

4. At the option of the Project Office the P.I. is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following standard acknowledgment is acceptable.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

MILESTONE CHART

RU #: 531 P.I.: J. C. H. Mungall

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978												1979		
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Numerical modeling					X	X	X	X	X	X		X	X	X	X	X		
Wave gauge design						X	X	X										
Test wave gauge, current meters, radar								X										
Prepare for field season								X	X	X								
Write report on wave gauge									X									
Field season									X	X	X							
Data reduction										X	X	X	X	X	X	X		
Raw data report															X	X	X	
Numerical model verification												X	X	X	X	X		
Data analysis												X	X	X	X	X		
Modeling report															X	X	X	
Data report																X	X	

△ Planned Completion Date

△ Actual Completion Date

REFERENCES

EPA, 1975. Environmental studies of an Arctic estuarine-system, Final Report, National Environmental Research Center, Office of Research and Development, United States Environmental Protection Agency, Corvallis, Oregon, EPA-660/3-75-026. 536 pp.

Reid, R. O. and B. R. Bodine, 1968. Numerical model for storm surges in Galveston Bay. *J. of the Waterways and Harbors Div.*, ASCE, Vol. 94, No. WWI, Proc. Paper 5805, pp. 33-57.

LIST OF REFERENCES

Alvarez, J. A., 1973: Numerical prediction of story surges in the Rio de la Plata area. Dissertation presented to the University of Buenos Aires, Argentina.

Bernard, E. N. 1976: A numerical study of the tsunami response of the Hawaiian Islands. Ph.D. dissertation, Department of Oceanography, Texas A&M University, 74 pp.

Knowles, C. E., and R. O. Reid, 1973: The inverse tsunami problem for islands of general shape (In Russian; abstract in English). Tsunami, Transactions of the Tsunami Symposium on XV General Assembly, M.G.G.M., Moscow. Yuzhno-Sakhalinsk, 208 pp.

Mungall, J. C. H., and J. B. Matthews, 1973: Numerical tidal models with unequal grid spacing. Report R73-2, Institute of Marine Science, University of Alaska, 213 pp.

Reid, R. O., and B. R. Bodine, 1968: Numerical model for storm surges in Galveston Bay. Journal of the Waterways and Harbors Division, ASCE 94, WWI, 33-57.

______, and C. E. Knowles, 1970: An inverse tsunami problem, In: Tsunami in the Pacific Ocean, Proceedings, International Symposium on Tsunamis and Tsunami Research, East-West Press, Honolulu, Hawaii.

______, and A. C. Vastano, 1966: Orthogonal coordinates for the analysis of long gravity waves near islands. Proceedings of Santa Barbara Specialty Conference, Coastal Engineering, 1-20.

______, A. C. Vastano, and T. J. Reid, 1975: Development of SURGE II Program with application to the Sabine-Calcasieu area for Carla and design hurricanes. Report prepared for Department of the Army, Galveston District, Corps of Engineers.

______, and R. E. Whitaker, 1976: Wind-driven flow of water influenced by a canopy. Journal of the Waterways, Harbors & Coastal Engineering Division, ASCE, 102, WWI, 61-77.

Vastano, A. C., 1973: Long wave research at NCAR. Atm. Tech., 3.

______, and E. N. Bernard, 1973: Transient long wave response for a multiple island system. Journal of Physical Oceanography, 3, 406-418.

Vastano, and R. O. Reid, 1967: Tsunami response for islands: Verification of a numerical procedure. Journal of Marine Research, 25, 129-139.

_____, and _____, 1970: Tsunami response at Wake Island: Comparison of the hydraulic and numerical approaches. Journal of Marine Research, 28, 345-356.

Wanstrath, J. J., R. E. Whitaker, R. O. Reid, and A. C. Vastano, 1975: Storm surge simulation in transformed coordinates. Final Project Report No. 75-5-T to Department of the Army, Coastal Engineering Research Center, 189 pp.

PROPOSAL TO

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

FOR

DEVELOPMENT AND OPERATION OF A REMOTE

SENSING DATA ACQUISITION PLATFORM FOR OCS STUDIES

OCSEAP RESEARCH UNIT NO:	536
PRINCIPAL INVESTIGATORS:	Dr. Gary A. Laursen Michael D. Frank
TOTAL COST OF PROPOSAL:	$73,700
INSTITUTION AND DEPARTMENT:	University of Alaska/NARL Science Department Barrow, Alaska 99723
DATE OF PROPOSAL:	October 1, 1977 to September 30, 1978

Michael D. Frank
Co-Principal Investigator
Naval Arctic Research Laboratory
Barrow, Alaska 99723
Telephone: (907) 852-6588/7333/2155

Date:

Gary A. Laursen
Co-Principal Investigator
Naval Arctic Research Laboratory
Barrow, Alaska 99723
Telephone: (907) 852-6588/7333

Date:

K. B. Mather/jl
Keith B. Mather
Vice Chancellor for Research and
Advanced Study
University of Alaska
Fairbanks, Alaska 99701
Telephone: (907) 479-7282

Date: 8/25/77

Anthony B. Frol
Director of Administrative Services
Univeristy of Alaska
Fairbanks, Alaska 99701
Telephone: (907) 479-7632

Date: 8.26.77

Technical Proposal Form

I. Title and Task Statement Number
Development and operation of a Remote Sensing Data Acquisition Platform for OCS Studies.

RU#: 536 Contract#: Dates: Oct. 1, 1977 to Sept. 30, 1978

II. Principal Investigator(s)
Dr. Gary A. Laursen
Mr. Michael D. Frank

III. Cost of Proposal

Total 73,700

IV. Background:

To conduct a complete environmental assessment program in conjunction with ground truthing, aerial photography and imagery are needed and will aid in drawing conclusions relative to natural and induced temporal and spatial changes and perturbations. Much of the detailed terrestrial, littoral and off-shore island and estuarian studies can be enhanced with photo mapping and scanning. Infrared scanning will demonstrate changes in surface albedo and habitat configurations in vegetation analyses. SLAR imagery, unlike photographic enhancements, is an all weather tool good for navigation reconnaissance, erosion, ice lead and terrain imagery. The companion proposal (RU 267) provides a facility for data reduction, transmission and printing.

V. Primary Objective:

Meeting the objectives of OCSEAP scientists' remote sensing needs, as requested and coordinated through the OCSEAP Arctic Project Office in Fairbanks, will be the prime objective.

The primary objective will involve establishing, operating and maintaining aircraft remote sensing data collection platform capabilities. Secondarily, the data collected will be processed at the University of Alaska's Geophysical Institute to assist rapid turnaround of data for OCS scientists.

VI. General Strategy and Approach: Discuss your strategy to meet the objectives described in the task statement.

To provide a remote sensing capability to all OCSEAP investigators in the form of:

1. A C-117D aircraft as a platform for the following Remote Sensing equipment:

a. Side Looking Airborne Radar (SLAR)
   (to be brought with technician hire);
b. Laser Profilometer
   (loan from U.S. Navy);
c. Infrared Scanner
   (loan from NOAA)
d. Mapping Camera, black/white photo 9.5" format
   (NARL);
e. I^2S Multispectral camera
   (on loan to Geophysical Institute from USFW)

2. A competent Remote Sensing Coordinator and engineer (Mr. Frank) who will develop the program, will secure, operate and maintain the above listed equipment.

VII. Sampling Methods: Describe your temporal and spatial sampling scheme and the supporting rationale. What statistical measure of sampling adequacy will be used? (Complete only if applicable.)

Monthly remote sensing missions are planned once the aircraft and equipment are fully operational. Flights will occur between Cape Lisburne and the Canadian border. Flights to other areas, i.e. Kotzebue, Norton Sound, etc., will be scheduled as requested by OCSEAP. All remote sensing requests will be specified by OCSEAP and coordinated with the OCSEAP Arctic Project Office in Fairbanks. Spatial sampling will depend on equipment used and weather (See Equipment and Use, Sect. XVIIE).

VIII. Analytical Methods: What methods of analysis are contemplated? Provide literature references. (Complete only if applicable.)

Developing and processing of all imagery for OCSEAP will be performed by RU 267 (Belon). That research unit will also index, log, catalogue, file and disseminate the remote sensing data to OCS investigators, as coordinated by the OCSEAP Arctic Project Office. Analysis of the data will be performed by individual researchers of other OCS projects, i.e. RU 88 (Weeks) - SLAR and Laser Profilometery, RU 257, 244 and others, Photography, etc.

See companion proposal (Belon, RU#267)

IX. Anticipated Problems: Discuss any anticipated major difficulties associated with the task and recommend solutions.

Certain complexities will be significant in the development of the program. Maintaining and operating extremely expensive equipment is crucial to the program's success. Obtaining, on loan, at least three of the five pieces of equipment may slow down or curtail parts of the projected program. Having the support of the Office of Naval Research is prime as the aircraft platform and other supportive equipment is Federal Government property. Working in a harsh environment will indeed have its effect on flying missions and work efforts. With a successful program, data processing limitations may reduce the flow of data to investigators.

See companion proposal.

X. Deliverable products: (identify distribution maps, numerical models, narrative reports, photography, hardware, techniques, etc. to be produced as part of this proposal.)

The products of this project will be exposed films and data from:

1. SLAR imagery
2. Laser Profilometry (Contingent on specific needs)
3. 9.5" formatted black and white aerial photography (single band and/or multispectral) of cloud free areas along the Chukchi and Beaufort Sea coasts
4. IR imagery in photographic format from thermal IR scanner

All data will be sent to the OCSEAP Arctic Project Office in Fairbanks for final processing, archiving and distribution by the Landsat Library at the University of Alaska.

A. Digital Data:

Will formatting of data into digital magnetic tape archive format be done by investigator? If yes, include funds in your budget for this activity.

Processing		Formatting	
Yes	No	Yes	No
	X		X

Data Product	Media (i.e., coding sheets, photography, tapes, punch cards)	Estimated Volume (No. of samples and volume of processed data)

1. Remote sensing data: SLAR imagery; Laser Profilometer tapes; color, black and white aerial photography; IR imagery. No data will be transformed into digital magnetic tapes.

2. No digital data is planned to be collected. Presently all data will be collected either in analog form or photographic imagery and processed at the University of Alaska.

B. Narrative Reports:

1. Aircraft Users Guide consisting of:
   a. platform schematic
   b. equipment capability
   c. power needs
   d. aircraft parts/intakes/outlets
   e. weight distribution

f. aircraft type, performance characteristics, capabilities, limitations, fuel requirements

2. Others as needed to promote the Remote Sensing Program (i.e. meeting presentations) and use of aircraft (i.e. raw imagery, photographics, log data and analog tapes)

C/D. Raw data furnished to the individual researcher or to the University of Alaska. (See Belon companion proposal RU#267); photographic plates

E. Data Submission Schedule:

Data will be submitted for by:

cruise <u>x</u>   quarter ____

The first data will be collected in <u>September 1977</u>. The data collection effort will be finished in <u>September 1978</u>.

Data will be submitted to the Project Offices for inclusion in the data base at the following times:

Collection Period	Data Submission
One mission per month September 1977 to September 1978	continuous (after each flight)

Raw data will be archived by RU 267. Field data products will be provided by the OCS projects requesting data.

XI. Information Required from Other Investigators

Describe data required from other investigators to carry out your proposed work.

Specifics of proposed C-117D flights (sensors, flight altitudes, coverage, etc.) must be supplied by the OCSEAP investigators wanting data. Requirements will be coordinated well in advance of flights by the OCSEAP Arctic Project Office in Fairbanks to ensure maximum efficiency and time utilization for greatest productivity.

XII. Quality Assurance Plans

Briefly describe your procedures for the calibration and intercomparison of instruments and methods.

Maintenance and repair of all equipment will be carried out by the NARL Remote Sensing Coordinator at Barrow, Alaska. All (SLAR) equipment will be calibrated at Fort Huachuca, Az. upon completion of installation. Other equipment will be calibrated by Mr. Frank at NARL, Barrow, before each data collection.

XIII. Special Sample and Specimen Archival Plans

If, as part of this study, samples are collected which should be kept for future reference (e.g., core samples) describe the number of samples, special storage conditions, location of the archive, annual cost of archive, etc.

RU 267 will process, index, log, catalogue and archive all raw data. The OCSEAP Arctic Project Office will disseminate this information to requesting OCS investigators.

B. AIRCRAFT SUPPORT - FIXED WING

1. Delineate proposed flight lines on a chart of the area. Indicate desired flight altitude on each line. (Note: If flights are for transportation only, chart submission is not necessary but origin and destination points should be listed)

   Flight lines will be given as per requests of other OCS investigators and coordinated by the OCSEAP Arctic Project Office, Fairbanks.

2. Describe types of observations to be made.

   Radar, Laser, photographic, IR

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times? (Key to chart prepared under Item 1 when necessary for clarification)

   to be determined

4. How many days of flight operations are required and how many flight hours per day?

   Total flight hours? **100 hours/C-117D @ $400/hr.**

5. Do you consider your investigation to the principal one for the flight thus precluding other activities or requiring other activities to piggyback or could you piggyback?

   Yes

6. What types of special equipment are required for the aircraft (non carry-on)?

   Remote Sensing Equipment

   What are the weights, dimensions, power requirements, and installation problems unique to the specific equipment.

   Installation often requires outside antennae and special "observation" hatchways

7. What are the weights, dimensions and power requirements of carry-on equipment?

   Determined before each mission

8. What type of aircraft is best suited for the purpose?

   C-117D

9. Do you recommend a source for the aircraft?

   If "yes" please name the source and the reason for your recommendation.

   NARL

10. What is the per hour charter cost of the aircraft?

    $400/hr.

11. How many people are required on board for each flight (exclusive of flight crew)?

    2 or 3

12. Where do you recommend that flights be staged from?

    Naval Arctic Research Laboratory
    Barrow, Alaska

D. QUARTERS AND SUBSISTENCE SUPPORT

1. What are your requirements for quarters and subsistence in the field area? (These requirements should be broken down by (a) location, (b) calendar period, (c) number of personnel per day and total man days per period)

   All work will be done using NARL as a base of operation. No expected field camps.

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

   NARL will provide all needed support i.e. aircraft, housing, food, etc. (A NARL C-117D will be the Remote Sensing Platform)

3. What is your estimated per man day cost for this support at each location?

   None

   How did you derive this figure, i.e., what portion represents quarters and what portion represents subsistence and is the figure based on established commercial rates at the location or on estimated costs to establish and maintain a field camp?

E. SPECIAL LOGISTICS PROBLEMS

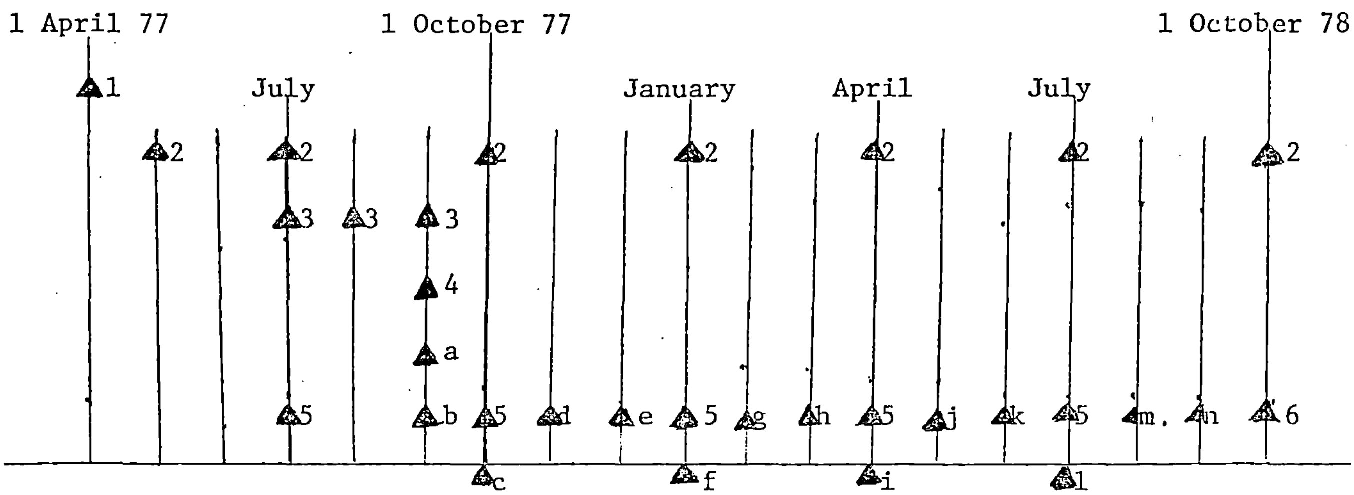
1. What special logistics problems do you anticipate under your proposal and how do you propose that the problems be solved? (Provide cost estimates and indicate whether you propose handling the problems yourself or whether you must depend on NOAA to solve them for you)

   a) Anticipated success may produce more remote-sensing data than can be processed under the companion proposal. Equipment will be available to other than OCSEAP projects, however, OCS projects will have higher priority. Therefore, a potential need to develop a NARL capability for rapid and continuous processing of film exists and will be sought through the Govt. Excess program.

   b) The equipment to be used is highly technical and expensive. Repairs will be made by the experienced and qualified Remote Sensing Coordinator. Costs for non anticipated repairs may be high. The equipment will come to NARL in working order. In all cases the handling of problems will be first attempted at NARL. Remoteness of the site may inhibit quick turnaround on needed parts.

XV. Management Plan: Briefly describe how you will manage your project. Also provide an Activity/Milestone chart.

The proposed work is a service function provided to OCSEAP as required by OCSEAP. Requests for Remote Sensing missions will be provided by the OCSEAP Arctic Project Office in Fairbanks. These requests for missions will be translated into action by the proposed NARL Remote Sensing Coordinator (RSC), Mike Frank, at Barrow. Logistics meetings between OCSEAP/Fairbanks and NARL/Barrow staff will yield projections of the approximate RS requirements of OCSEAP. These requirements may be modified during the year depending on weather, potential mechanical problems of the aircraft or RS equipment and modifications in investigator requests.



1. Remote Sensing Coordinator hire
2. Review with OCS Fairbanks
3. Component purchases
4. Operational Aircraft (C-117D 722NR)
5. Quarterly progress reports. (Annual Report 1 April)
6. Final Report contingent upon contract renewal
7. Missions

a.	1	e.	5	i.	9	m.	13
b.	2	f.	6	j.	10	n.	14
c.	3	g.	7	k.	11		
d.	4	h.	8	l.	12		

XVI. Outlook

1. The final objective of this effort will be an active Remote Sensing Platform capable of handling a variety of requests from the research community for data collection.

2. Primary Equipment installation will be completed during FY78. New sensors will be obtained and installed as required by users.

3. Program should become self-supporting as use increases.

4. Spare parts, new sensors as need arises, new methods of handling data

5. Location will remain fixed at NARL

6. Logistics requirements will be primarily flight time, housing for Remote Sensing personnel, etc.

XVII.1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled held and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g. larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the P.I. is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see par. 2).

7. Within 10 days of the completion of a cruise of data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All Publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following standard acknowledgement is acceptable.

> "This study is supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

Publications:

Laursen, G. A. 1975. Higher Fungi in Soils of Coastal Arctic Tundra Plant Communities. Ph.D. Dissertation, Virginia Polytechnic Institute and State University, Department of Biology, June 1975, 395 p: illus.

Laursen, G. A., and Miller, O. K., Jr. (in press). The distribution of Fungal Hyphae in Arctic Soil on the Tundra Biome Site, Barrow, Alaska. U.S. International Biological Program Below-ground Ecosystem Symposium.

Laursen, G. A., O. K. Miller, Jr. and H. E. Bigelow. 1976. A new Clitocybe from the Alaskan Arctic. Can. J. Bot. 54:976-

Linkins, A. E., R. K. Antibus, O. K. Miller and G. A. Laursen. (in press). Differential responses of Arctic plant roots to oil perturbation. IN Environmental Chemistry and Cycling Processes, ERDA, 2nd Mineral Cycling Symposium.

Miller, O. K., Jr., and Laursen, G. A. 1974. Below ground Fungal Biomass on U.S. Tundra Biome Sites at Barrow, Alaska. Soil Organsisms and Decomposition in Tundra. Tundra Biome Steering Committee (Stockholm), Ed. A. J. Holding et al.

Miller, O. K. and G. A. Laursen. (in press). Ecto and endomycorrhizal of Arctic plants at Barrow, Alaska. IN USIBP Tundra Biome Synthesis Vol. II, Primary Productivity.

Miller, O. K., Jr., Laursen, G. A., and Murray, B. M. 1973. Arctic and Alpine Agarics from Alaska and Canada. Can. J. Bot. 51:43-49.

_______________, Laursen, G. A., and Murray, B. M. 1974. Arctic and Alpine Agarics from Alaska and Canada. Icefield Ranges Research Project, Sci. Results Vol. 4 AM. Geographical Soc., pp. 365-369.

Abstracts:

Laursen, G. A. 1976. Higher fungi associated with meritime tundra topoenvironments of Amchitka and Adak Islands. J. Va. Acad. Sci. 54th Meetings. 28:

Laursen, G. A., Miller, O. K., Jr. 1973. Basidiomycetes in Arctic Tundra. J. Va. Acad. sci., 51st meeting. 25:3.

Laursen, G. A., Miller, O. K., Jr. 1975a. Seasonal fluctuations of fungal biomass in Alaskan Arctic tundra. The XII International Botanical Congress. Leningrad, Russia.

Laursen, G. A. and Miller, O. K., Jr. 1975b. Fungi in Tundra Soils. J. Va. Acad Sci. 52nd meeting. 26:2, p 54.

Laursen, G. A., Miller, O. K., Jr., and Manning, D. L. 1972. Notes on Arctic and Subarctic Agarics from Alaska and Adjacent Canada. J. Va. Acad. Sci., 50th meetings, 23:3 p 121.

Miller, O. K., Jr. and Laursen, G. A. 1975. The diversity of higher fungi in five major plant communities in Alaskan Arctic tundra. The XII International Botanical Congress, Leningrad, Russia.

Papers Presented at Professional Meetings:

Laursen, G. A. 1976a. Higher fungi associated with meritime tundra topoenvironments of Amchitka and Adak Island. J. Va. Acad. Sci. 54th meeting, George Mason Univ., Fairfax, Va.

Laursen, G. A. 1976b. New and interesting fungi from the Alaskan arctic. The 27th Annual AIBS, Tulane Univ., New Orleans.

Laursen, G. A., Miller, O. K., Jr. 1973a. Basidiomycetes in Arctic Tundra J. Va. Acad. Sci., 51st meeting.

____________, Miller, O. K., Jr. 1973b. Soil Organisms and Decomposition in Tundra. IBP International Decomposition Symposium, Tundra Biome Microbiology, Decomposition and Invertebrate Working Groups, Fairbanks, Alaska August.

____________, Miller, O. K., Jr. 1973c. The distribution of Fungal Hyphae in Arctic Soil on the Tundra Biome Site, Barrow, Alaska. U.S. International Biological Program Below-ground Ecosystem Symposium, Colorado State University, Fort Collins, Colorado.

____________, Miller, O. K., Jr. 1974. Higher fungi of the Alaskan Arctic tundra. The 25th Annual AIBS, Airzona State Univ., Tempe, Arizona.

____________, and Miller, O. K., Jr. 1975a. Fungi in Tundra Soils. J. Va. Acad Sci., 53rd meeting, 26:2, p 64.

Miller, O. K., Jr., and Laursen, G. A. 1973. Belowground Fungal Biomass on U.S. IBP Sites at Barrow, Alaska. IBP International Deocmposition Symposium, Fairbanks, Alaska.

Non-reviewed Reports:

Laursen, G. A. 1975. The Higher Fungi of Amchitka and Adak Islands, Alaska. Amchitka Long-Term Monitoring Program, 1975 Task Force. Rpt.

Miller, O. K., Jr. and G. A. Laursen. 1971. Project 3511 Part II: Basidiomycetes and Related Fungi in Alaskan Tundra and Taiga. The Structure and Function of the Tundra Ecosystem Vol. 1, p 148.

____________, and G. A. Laursen. 1972. Project 3511-b; Basidiomycetes of the Arctic Tundra and Selected Alpine Sites. U.S. Tundra Biome 1972 Summer Project Reports. No. 73-3, p 40.

____________, and G. A. Laursen. 1973a. Basidiomycetes of the Arctic Tundra and Selected Alpine Sites, 1971 Project and Data Set Abstracts. Tundra Biome. U.S. IBP Eas 73:3, 1. No. 953, p 35.

____________, and G. A. Laursen. 1973b. Basidiomycetes of the Arctic Tundra and Selected Alpine Sites, 1971 Project and Data Set Abstracts. Tundra Biome Data Report 73-17, p 14.

____________, and G. A. Laursen. 1973c. Project 3512 Basidiomycete Biomass and Function in the Arctic Tundra. U.S. Tundra Biome 1973 Field Project Reports. No. 73-31, p 35.

____________, and G. A. Laursen. 1975. Basidiomycetes of the Arctic Tundra and Selected Alpine Sites, 1971 Project and Data Set Abstract, Revised. Tundra Biome.

____________, and G. A. Laursen, and Calhoun, W. F. 1974. Higher Fungi in Arctic Plant Communities. U.S. IBP Tundra Biome Data Report 74-6, 90 p.

Laursen, G. A. 1976. Soil temperature and Fungi in oil treated soils. IN: Oil persistence in tundra and its impact on the belowground ecosystem. Annual Progress Report to ERDA, Project E-(40-1)-4940, O. K. Miller, Jr. (Ed) VPI & SU.

RESEARCH PROPOSAL

TO: National Oceanic and Atmospheric Administration
Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado 80302

FROM: Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

TITLE: Nutrient Dynamics and Primary Production in Alaska Beaufort Sea Coastal Waters

RU #537

CO-PRINCIPAL INVESTIGATOR: Dr. Donald M. Schell
SS #034-30-1600

CO-PRINCIPAL INVESTIGATOR: Dr. J. Brian Matthews
SS #527-74-7137

TOTAL COST OF PROPOSAL: $29,202

DURATION: 1 October 1977 to 30 September 1978

D. M. Schell
D. M. Schell
Research Fellow in Marine Science
(907) 479-7709

J. Brian Matthews
J. Brian Matthews
Associate Professor in Marine Science
(907) 479-7477

J. R. Moore
J. R. Moore, Director
Institute of Marine Science
University of Alaska
(907) 479-7531

A. B. Frol
A. B. Frol
Director of Administrative Services
(907) 479-7632

K. B. Mather
K. B. Mather
Vice-Chancellor for Research and Advanced Study
(907) 479-7282

OCS Proposal No. 20-3
July 1977

C. TECHNICAL PROPOSAL

I. Title:

Nutrient Dynamics and Primary Production in Alaska Beaufort Sea Coastal Waters

Research Unit Number: OCSEAP R.U. #

Contract Unit Number:

Proposed dates of contract: 1 October 1977 to 30 September 1978

II. Co-Principal Investigators:

Dr. D. M. Schell, Research Fellow in Marine Science, Institute of Marine Science, University of Alaska, Fairbanks, Alaska 99701
Phone (907) 479-7709

Dr. J. Brian Matthews, Associate Professor in Marine Science, Institute of Marine Science, University of Alaska, Fairbanks, Alaska 99701
Phone (907) 479-7477

III. Cost of Proposal (for FY 1978)

C. Total: $29,202

D. Distribution of effort by lease area - Beaufort Sea - 100%

IV. Background

This proposal outlines work to be performed in direct conjunction and cooperation with OCS Research Unit 467, LGL-Limited's Ecological Process Studies in the Beaufort Sea Barrier Island - Lagoon system. The proposed work below will be completely integrated with the LGL Limited-US proposal for 1977-1978 and will be a cooperative study with Dr. Richard Robarts of LGL and Dr. Don Schell of the Institute of Marine Science, University of Alaska. As such, the principal investigator will utilize LGL logistic facilities in the field and will participate in LGL sponsored workshops in which data obtained will be utilized to assist LGL modelling efforts. The background and rationale for the biological effort in the Beaufort Sea Environmental Assessment have been presented in OCSEAP R.U. No. 467 by LGL-Limited and will not be repeated here. This section will be limited instead to the role of nutrient chemistry and primary production in the nearshore ecology of the Beaufort Sea. Dr. Brian Matthews will participate in this project with advisory status on physical processes.

Photosynthetic primary production in the nearshore Beaufort Sea, as elsewhere in the biosphere, is the principle source of energy and incorporated nitrogen and phosphorus for higher trophic levels. However, unlike coastal waters in more temperate latitudes, primary production in the Arctic Ocean is rigorously controlled by extreme seasonal variations in light intensity and to a lesser extent by the physical and chemical structure of the water column. In addition, the mechanisms of algal productivity in the coastal Beaufort Sea are unlike temperate waters where water column stability is critical to the onset of the spring bloom. In the Arctic, the spring bloom commences when winter conditions are greatest as typified by maximum ice thickness and minimum water temperatures. The primary production does not begin in the water column but instead occurs as a layer of epontic algae on the underside of the ice. Studies by Alexander, *et al.* (1974) documented the ice algae layer and concluded that the appearance of ice algae populations is triggered by the attainment of critical light intensities in the spring, usually in mid-April. Little is known, however, of the extent to which ice algae cover the bottom of the nearshore ice sheet other than patchiness results from variable light attenuation caused by snow drifts on the surface of the ice. Epontic ice algae production reaches a maximum in mid-May and estimates by Clasby *et al.* (1976) based on a single sampling site off the Naval Arctic Research Laboratory at Point Barrow, indicate that the annual production at that location was approximately 5 g C/m^2-yr. Although this is a low amount by temperate standards, it represents a significant fraction of productivity in the nearshore Arctic. Ice algae production essentially ceases as the bottom of the ice sheet erodes in early June with the onset of melt. For the remainder of the summer, primary production by phytoplankton assumes the major role with additional production occurring in gravelly shallows by benthic algal communities. Instantaneous rates of production by benthic algal mats off Barrow were found to exceed the highest rates measured on ice algae or phytoplankton at the same location (Matheke and Horner, 1974) but the apparent need for a suitable substrate and critical light requirements probably relegate benthic production to a minor role in the overall annual primary production in these waters.

The nutrients required to support the annual cycle of primary production in the shallow bays and estuaries are derived from a combination of deep-water and terrestrial sources plus *in situ* regeneration. The relatively high organic and inorganic nitrogen concentrations in the run-off waters of the Colville River during summer are believed to complement the high phosphate concentrations of the Harrison Bay-Simpson Lagoon areas and contribute toward balancing an apparent nitrogen deficiency in the nearshore Beaufort Sea waters (Schell, 1975; Alexander *et al.*, 1975). *In situ* regeneration of ammonia has been measured by Alexander *et al.* (1975) in summer and Schell (1975) has measured rates of under-ice ammonification in Simpson Lagoon waters. Schell (1974) has also measured nitrification and heterotrophic utilization of dissolved organic N with consequent release of ammonia in the under-ice saline waters of the Colville River.

The past work of Schell (1975) on Dease Inlet near Point Barrow has led to the formulation of a hypothesis that the spring epontic algal bloom may derive a large fraction of its nutrient requirements through a mechanism of thermohaline convection which serves as a "nutrient pump" into shallow waters. As the ice freezes on the bottom side of the ice sheet, the salt is excluded causing a localized increase in salinity and density at the interface. This denser water drains away and is replaced by fresher water. On a macro scale, the thickening ice sheet causes an increase in the salinity beneath the ice that is most pronounced in shallow bays such as Harrison Bay or Dease Inlet and the lagoon systems. If communication is possible with offshore water, the hypersaline water drains out of the shallows along the bottom and is replaced by onshore flow beneath the ice. This onshore flow brings a fresh nutrient supply which is readily assimilated by the epontic algal community on the underside of the ice. Since ice accretion occurs until mid-May, this "nutrient pumping" process may be biologically beneficial for up to two months during the spring and the accumulated algal biomass may contain nitrogen and phosphorus in excess of that which would have been available in the water column beneath the ice had "nutrient pumping" not occurred.

Once the ice sheet begins to melt, the primary production in the nearshore is limited primarily to the deeper waters of the lagoons as these are usually overlain with extremely nutrient-deficient meltwater. Near the river mouths the picture is more complicated by positive additions of nutrient-rich river water which may be offset by severe turbidity due to transported sediments. Once the ice melts completely, wind action becomes important but data by Schell (1975) and Alexander *et al.* (1975) show that nutrient concentrations are low and extremely euryhaline situations persist in the nearshore which may inhibit primary production. Generally ice-free conditions usually persist for only August and September and primary production in the Arctic becomes significant in April. Thus an estimate of annual primary production must include the period prior to open-water conditions.

V. Objectives

The objectives below are to mesh with objectives outlined in OCSEAP R.U. 467 and are limited in this proposal to:

A. Estimate the annual primary production in the barrier island-lagoon system.

B. Relate the nutrient dynamics of the nearshore waters to annual production.

C. Determine the mechanisms of nutrient supply to the barrier island-lagoon system including erosional inputs in the open-water period and "nutrient pumping" in the spring season.

VI. General Strategy and Approach

The nutrient chemistry and primary productivity program will be consolidated with the LGL-Barrier Island-Lagoon study group with the principal investigator cooperating closely with LGL personnel. The work can be divided into three phases: (1) winter ice work prior to the onset of the spring bloom, (2) spring ice work and (3) open-water season. Each of these phases represents a period or "season" in the annual cycle of primary production and will require a sampling effort in the field.

A. Winter ice conditions

This period begins with the return of ice cover in the autumn and the diminishing of incident solar radiation to levels below that required for net positive primary production. As the ice cover thickens, the shallowest areas of the lagoon attain bottomfast ice and some local deeper basins become isolated. Further ice accretion results in rapid salinity increase in the underice water and by March and early April, nutrient concentrations reach annual maxima. At this time the nutrient concentrations of the system will be inventoried by coring the ice and sampling the under-ice water. Each core will be sectioned to obtain salinity and nutrient concentrations as well as its particulate and dissolved organic nitrogen content. The water samples obtained will be similarly analyzed with the addition of chlorophyll-*a* measurements. These data should allow a mass balance determination of the total standing crop of fixed nitrogen in the system. Nitrogen has been chosen as the indicator nutrient since past data (Schell, 1975) has led to the conclusion that the system is strongly nitrogen limited. By extending this type of sampling program over the lagoon area an integrated standing crop of nutrients can be obtained.

B. Spring ice conditions

This period encompasses the onset of the spring bloom and the growth of the epontic algal community through its maximum and decline with the beginning of the melt in June. Ice cores and water samples will be collected at several stations to measure the rate of movement of nutrients into the biomass and to assess qualitatively the transport of offshore nutrients into the nearshore under ice water column. Phytoplankton in the water column will be measured and compared to the epontic algal biomass to assess changes in relative contribution to primary production. Total mass balances of nitrogen incorporated into plant biomass relative to inorganic nitrogenous nutrients will be made at each station to enable the construction of contours of fixed N over the lagoon area. These data, when compared to estimated of water exchange due to thermohaline convection will enable estimation of the magnitude of "nutrient pumping" into the lagoon. Areal distribution of ice algae in relation to water depth and water salinity should be obtainable from this data.

C. Open-water conditions

By the time open water conditions occur in the Simpson Lagoon area, the annual season of primary production has run the major part of its course. Regenerated nutrients and terrestrially derived nutrients are now most important in the nutritional requirements of phytoplankton populations. In Simpson, Lagoon, pronounced salinity gradients occur due to river flow and, under strong wind conditions, storm surges or depressions of sea level occur with attendant severe turbidity due to eroded peat from beaches and sediment from the lagoon bottom. Primary production during this period is highly variable and subject to such a diverse collection of influences that only a general monitoring can be attempted in this program. Conventional ^{14}C-bicarbonate uptake measurements will be made periodically over the season in conjunction with an estimation of plant biomass and nutrient content of the water column. Due to the low ambient nutrient concentrations during this season with attendant high detrital and probably high bacterial populations, samples obtained for nutrient analysis will be indicative of trends only due to difficulties in sample handling. Thus primary emphasis will be placed on a combination of mass balance measurements and total standing crops in the various pools (inorganic N, dissolved organic N, particulate N) in relation to plant biomass as estimated by chlorophyll-*a* concentrations. These data, when coupled with instantaneous primary production measurements, should allow an estimate of turnover times for the individual pools.

Detrital input to the nutrient pool in Simpson Lagoon will be estimated by techniques similar to those in Schell (1975) using updated erosional data as made available by other personnel in the OCSEAP program. It is realized that due to the close proximity of the study area to the mouth of the Colville River and the immediate effects of wind direction and force coupled with river flow and sediment load, detrital input to the nutrient pools of Simpson Lagoon is probably highly variable both temporally and spatially and can only be very roughly estimated in an effort of the scope of this project. It is arguable, however, that since a major part of the primary production of this area occurs well before the river even begins to flow each year (the Colville freezes to the bottom and all flow ceases each winter, (Arnborg *et al.*, 1966)) the detrital and erosional input of nutrients is probably not felt immediately, but is manifested the following spring when the organic N has been regenerated as nitrate and ammonia by bacterial populations over the winter months.

VII. Sampling Methods

A. Winter and spring conditions

Ice cores will be obtained with power driven SIPRE corers and sectioned, bagged, labeled and maintained in a frozen condition. Water samples will be taken with a van Dorn bottle through an auger hole in the ice. The water will be stored in plastic bottles in the field. Nutrient samples will be filtered through glass fiber filters and stored frozen until analysis. The filters will be retained for particulate nitrogen analysis.

B. Open-water conditions

Stations accessible by small boat will be sampled with a van Dorn bottle and the water treated as above. For erosional input data, selected beach sites will be profiled from freshly eroded surfaces. Soil samples will be held frozen until analyzed for organic N, moisture and mineral content.

VIII. Analytical Methods

All nutrient chemistry will be performed on Technicon Autoanalyzer systems using standard methods developed for the analyzer. Particulate N will be determined using a Coleman Nitrogen Analyzer. Chlorophyll-*a* will be estimated using a Turner fluorometer on whole water samples or on meltwater containing the algal layer from the bottom of ice cores (Lorenzen, 1966). The fluorometer will be calibrated against chlorophyll samples obtained from aliquots of core meltwater which have been measured using the trichromatic method of Strickland and Parsons (1968). Although the fluorometer is not as precise as the method of Strickland and Parsons, it has two advantages which outweigh the slight analytical deficiencies: (1) it allows instantaneous measurement on a small sample of water, and (2) it can be used in a field camp because of its simplicity and small size thus allowing the processing of a larger number of samples and minimizing the handling Actual field sampling of the ice algae layer will involve taking replicate cores at each station and visually inspecting each core to ascertain a clean sectioning of the water-ice interface. To test the coring technique for loss due to wash-off of algae in withdrawing the sample from the drill hole, a calibration test will be made employing diver-obtained samples. As part of the LGL fisheries studies, divers will be used through the ice and they will assist by cutting undisturbed samples of the ice algae layer next to samples obtained with a corer. By measuring the difference between cored and diver-obtained samples of ice algae, an empirical correction can be obtained. Diver observation and sampling will be used to quantitate patchiness in ice algae density.

IX. Anticipated Problems

Within the framework of sampling and analytical chemistry, no major problems are anticipated. Logistic considerations are all-important, however, in establishing the spatial and temporal framework of the water and ice sampling program. Persistent fog and overcast can curtail ice sampling and heavy weather precludes small boat operations. A degree of flexibility will be maintained to allow an opportunistic approach toward sample station locations and density.

X. Deliverable Products

A. All data products forthcoming from this study will be submitted to the OCSEAP Data Management Group in the accepted format. Efforts will be made to consolidate all published and unpublished data available in a manner best suited for coastal management purposes. These data will include digital products. See also Data Products Schedule in LGL proposal (RU 467)

Nutrient concentrations - nitrate + nitrite -N, ammonia, phosphate, dissolved organic nitrogen

Particulate material - particulate nitrogen

Salinities - water samples and ice core samples

Pigment concentrations - chlorophyll data

B. Narrative reports:

None anticipated other than Quarterly and Annual Reports.

C. Visual Data:

Nutrient data and ice algae density will be presented on maps where sufficient sampling density allows.

D. Other non-digital data:

None anticipated

E. Data submission schedule:

See Data Products Schedule in LGL proposal (RU 467)

XI. Information Required from Other Investigators

Close cooperation with members at the LGL-Barrier Island-Lagoon Study Group will allow ready exchange of information when required. Arrangements concerning this exchange have been made.

XII. Quality Assurance

The Institute of Marine Science employs well standardized and calibrated analytical equipment for routine nutrient and pigment analyses. Internal standards will be used to insure no deviation from normal processing has occurred in samples acquired in OCSEAP programs. Field replication of samples and calibration of cores by divers will ascertain precision in sampling methods.

XIII. Special Sample and Voucher Specimen Archival Plans

Not applicable.

XIV. Logistic Requirements

All logistics will be coordinated through OCS Research Unit 467, the LGL-Limited's Beaufort Sea Barrier Island-Lagoon Ecological Process Studies, 1978.

XV. Data Management Plan

Overall management of logistics and field operations will be the responsibility of the LGL-Limited staff. The principal investigators of this project will be responsible for the field research program described above and will have co-principal investigator status with LGL investigator Richard Roberts. Dr. Schell will be responsible for the nutrient, pigment, and ^{14}C-primary productivity analyses and data reduction.

Perdiem expense and logistic expenses in the field will be the responsibility of the OCSEAP Arctic Project Office. Attendance at any OCSEAP sponsored workshops will be supported by the contracting agency.

XVI. Outlook

A. Extensions

Pending successful completion of the survey program described above, logical extension of the work would have to include:

1. Kinetic studies of nutrient uptake by ice algae and phytoplankton at ambient concentrations using ^{15}N-labeled nitrate and ammonia.
2. Nutrient regeneration studies involving ammonification and nitrification processes beneath winter ice. Such data would allow estimation of the fraction of available nutrients which had been regenerated *in situ*.
3. Determine the hydrographic requirements and significance of thermohaline convective flow beneath the ice and its relation to nutrient transport vs. *in situ* regenerative processes. Such data would be essential in predicting the effects of dredging or causeway construction on the nutrient dynamics of the nearshore zone.

B. Data products

Final results obtained from the above studies should yield information which will enable testing of hypotheses generated concerning nutrient cycles in cold, shallow marine environments. Extension of these hypotheses to the coastal waters of the Beaufort and Chukchi Seas would be a desirable development. The data would allow increased sophistication and applicability to the ecosystem models resulting from current studies and such models would be the most useful data products.

C. Projected costs

The projected costs below include equipment costs but exclude logistic support:

FY 1979 - $60,000
FY 1980 $50,000

D. Major equipment

No purchases anticipated. Current meters, mass spectrometer time, expanded chemical analysis capability and technical assistance would be provided by the Institute of Marine Science at appropriate cost.

E. Location of future field effort

Simpson Lagoon
Harrison Bay
Dease Inlet
Elson Lagoon

F. Logistic requirements

Expansion of this program to include the Harrison Bay, Dease Inlet-Elson Lagoon area would require helicopter support in the spring and shallow draft boat support in summer. A preliminary estimate for FY 1979 is 25 hours helicopter support and 7 days of Alumiak support. Coordination of these efforts with the LGL-Limited-US program would be effected.

XVII. Contractual Statements

1. A schedule for data submission for each task order has been, and will continue to be, submitted and updated each quarter.

2. This statement is in accordance with our base contract, and we will continue to comply.

3. See Section XIII of this proposal. The University of Alaska will continue to negotiate a Voucher Specimen Policy with NOAA/OCS. We will comply with the then agreed to policy.

4. See Section XV of this proposal. The University of Alaska agrees that the Principal Investigators can travel to the Project Office at least twice during the contract year, provided that such travel is in accordance with University of Alaska travel policy and consistent with other University duties of the Principal Investigator.

5. Data will be provided in the form and format agreed to by the University and NOAA/OCS in the negotiating of the Data Management Plans for each of the tasks falling under the jurisdiction of this office.

6. As per Article 9 of the base contract, the University of Alaska agrees to the following: "...all archivable data is to be submitted by the contractor to the Contract Data Manager within 120 days after acquisition. Certain data sets such as plankton counts or volumes are not available until sortin of samples is complete. The data so obtained are archivable 120 days following the actual sorting or other laboratory procedure."

7. Within 10 days of the completion of a cruise or data gathering effort a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager by the Chief Scientist. If the Chief Scientist represents the contracts covered by this office, the form will be sent through this office.

8. This is in accordance with base contract with which we shall comply.

9. Three copies of all publications or presentation abstracts or manuscripts pertaining to technical or scientific material developed under OCSEAP funding will be submitted to the COTR sixty days prior to publication or presentation. Copies of all news releases mentioning OCS or using information gathered by OCS funding will be sent to the COTR.

10. The following acknowledgement of sponsorship will be used:

> "This study was supported under contract 03-5-022-56 between the University of Alaska and NOAA, Department of Commerce through the Outer Continental Shelf Environmental Assessment Program to which funds were provided by the Bureau of Land Management, Department of Interior."

MILESTONE CHART

Δ Planned Completion Date

Δ Actual Completion Date

RU #: ____________ PI: Donald M. Schell

Major Milestones: Reporting, data management and other significant contractual requirements, periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978													
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D		
Quarterly reports			Δ			Δ			Δ			Δ					
Data Submission								Δ	Δ			Δ					
Spring ice coring (field work)						Δ			Δ								
Meltwater nutrient sampling										Δ							
Open water sampling										Δ	–	Δ					
Modelling and integration workshop			Δ				Δ										
Completion of analytical work													Δ				
Final report															Δ		

5/20/77

XVIII. References

Alexander, V., R. Horner and R. C. Clasby. 1974. Metabolism of arctic sea ice organisms. IMS Report 74-4. Institute of Marine Science, University of Alaska, Fairbanks.

Alexander, V., C. Coulon and J. Chang. 1975. Studies of primary productivity and phytoplankton organisms in the Colville River system. *In: Environmental Studies of an Arctic Estuarine System - Final Report.* Environmental Protection Agency Report EPA 660/3-76-026.

Arnborg, L., H. J. Walker and J. Peippo. 1966. Water discharge in the Colville River, Alaska, 1962. Geografiska Annaler 48A:195-210.

Clasby, R. C., V. Alexander and R. Horner. 1976. Primary productivity of sea-ice algae. *In: Assessment of the Arctic Marine Environment: Selected Topics.* Institute of Marine Science, University of Alaska, Fairbanks.

Matheke, G. E. M. and R. Horner. 1974. Primary productivity of the benthic microalgae in the Chukchi Sea near Barrow, Alaska. *J. Fish. Res. Board Can.* 31(11):1779-1786.

Schell, D. M. 1974. Regeneration of nitrogenous nutrients in arctic Alaskan estuarine waters. *In: The Coast and Shelf of the Beaufort Sea.* J. C. Reed and J. E. Sater (eds.). Arctic Institute of North America, Arlington, Virginia.

Schell, D. M. 1975. Seasonal variation in the nutrient chemistry and conservative constituents in coastal Alaskan Beaufort Sea waters. *In: Environmental Studies of an Arctic Estuarine System - Final Report.* Environmental Protection Agency Report EPA 660/3-75-026.

Publications: Kinney, P. J., D. M. Schell, V. Alexander, S. Naidu, C. P. McRoy and D. C. Burrell. 1971. Nearshore and estuarine environments of the Alaskan Arctic coast: parameters for engineering solutions. Symposium Proc. on Port and Ocean Engineering under Arctic Conditions. Technical University of Norway.

Schell, D. M. 1971. The uptake and regeneration of dissolved organic nitrogen in southeastern Alaska marine waters. Ph.D. Dissertation, University of Alaska, Fairbanks.

Alexander, V. and D. M. Schell. 1973. Seasonal and spatial variation of nitrogen fixation in the Barrow, Alaska tundra. Arctic and Alpine Research 5:77-88.

Schell, D. M. and V. Alexander. 1973. Nitrogen fixation in arctic coastal tundra in relation to vegetation and microrelief. Arctic 26:130-137.

Schell, D. M. 1974. Uptake and regeneration of dissolved free amino acids in southeastern Alaskan marine waters. Limnol. and Oceanogr. 19:260-270.

Schell, D. M. 1974. Regeneration of nitrogenous nutrients in arctic Alaskan estuarine waters. *In* The Coast and Shelf of the Beaufort Sea, J. C. Reed and J. E. Sater, eds. The Arctic Inst. of North America, Arlington, Virginia. 649-663 pp.

Alexander, V., M. Billington and D. Schell. 1974. The influence of abiotic factors on nitrogen fixation rates in the Barrow, Alaska arctic tundra. Rep. Kevo Subarctic Res. Stat. 11:3-11.

Schell, D. M., J. Caperon and D. Ziemann. In press. The nutrient regime of south Kaneohe Bay, Oahu, Hawaii. Submitted to Pacific Science.

Schell, D. M., J. Hirota, E. D. Laws and J. Caperon. In press. Ammonia regeneration in Kaneohe Bay, Oahu, Hawaii. Submitted to Pacific Science.

Schell, D. M. In press. Chemical and isotopic methods in nitrification studies. Proceedings of the ASM conference on nitrification and reduction of nitrogen oxides, Athens, Georgia, Sept. 1976.

Alexander, V., M. Billington and D. M. Schell. In press. Nitrogen fixation in arctic and alpine tundra. *In* Primary Production Synthesis for the IBP Tundra Biome, L. Tieszen, ed.

2/16/77

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

TO:	Outer Continental Shelf Environmental Assessment Program National Oceanic & Atmospheric Administration
TYPE OF SUPPORT REQUESTED:	Contract
TITLE OF PROJECT:	Norton Sound/Chukchi Sea Oceanographic Processes
PRINCIPAL INVESTIGATORS:	L. K. Coachman, Professor
	K. Aagaard, Research Associate Professor and
ASSOC. PRINCIPAL INVESTIGATOR:	T. H. Kinder, Research Associate Department of Oceanography College of Arts & Sciences University of Washington Seattle, Washington 98195 Telephone - area code 206, 543-5047
AMOUNT REQUESTED:	$113,694
DESIRED PERIOD:	1 October 1977 - 30 September 1978
UNIVERSITY OFFICE TO BE CONTACTED REGARDING CONTRACT NEGOTIATION:	Grant & Contract Services 1 Administration Building, AD-24 University of Washington Seattle, Washington 98195 Telephone - area code 206, 543-4043

DATE: 23 June 1977

L K Coachman
Principal Investigator

Knut Aagaard
Co-Principal Investigator

T H Kinder
Associate Principal Investigator

F A Richards
Francis A. Richards
Associate Chairman for Research
Department of Oceanography

Joe S. Creager, Associate Dean
College of Arts & Sciences

OFFICIAL AUTHORIZED TO GIVE UNIVERSITY APPROVAL:

Donald R. Baldwin, Director
Grant & Contract Services
1 Administration Building, AD-24

REF: P77-52

A. Norton Sound/Chukchi Sea Oceanographic Processes (N-COP)

Research Unit: 541

Principal Investigators:
L. K. Coachman
R. L. Charnell
J. D. Schumacher
K. Aagaard
R. D. Muench
T. H. Kinder

Total Cost:	Pacific Marine Environmental Laboratory	$111,000
	University of Washington	114,000
	Total	$225,000

Institution:

Pacific Marine Environmental Laboratory
National Oceanic and Atmospheric Administration
3711 15th Avenue N. E.
Seattle, Washington 98105

Department of Oceanography
University of Washington, WB-10
Seattle, Washington 98195

Date: 30 June, 1977

Required Signatures:

R. D. Muench, Research Oceanographer, PMEL
Principal Investigator

R. L. Charnell, Research Oceanographer, PMEL
OCSEAP/PMEL Coordinator

J. R. Apel, Director, PMEL

R. Cunningham, Administative Officer, PMEL

B. Qualifications of the Proposer

Both institutions (University of Washington and Pacific Marine Environmental Laboratory) and all principal investigators have worked on this research unit during the past year. Their qualifications remain unchanged, with the exception of an additional year of experience working on this project.

C. Technical Proposal

I. Norton Sound/Chukchi Sea Oceanographic Processes (N-COP) Task Number B2
Research Unit 541. Contract Number: 03-05-022-67.
1 October 1977 - 30 September 1978.

II. Principal Investigators:

Dr. L. K. Coachman, Coordinator
Department of Oceanography
University of Washington, WB-10
Seattle, WA 98195

Dr. Knut Aagaard
Department of Oceanography
University of Washington, WB-10
Seattle, WA 98195

Mr. R. L. Charnell
NOAA/PMEL
3711 - 15th Avenue Northeast
Seattle, WA 98105

Dr. Robin D. Muench
NOAA/PMEL
3711 - 15th Avenue Northeast
Seattle, WA 98105

Dr. J. D. Schumacher
NOAA/PMEL
3711 - 15th Avenue Northeast
Seattle, WA 98105

Dr. T. H. Kinder
Department of Oceanography
University of Washington, WB-10
Seattle, WA 98195

III. Cost of Proposal:

A. Science $225,000

B. Logistics*

C. Total $225,000

D. Distribution of Effort (Approximate)

Chukchi Sea	33%
Norton Sound	67%

IV. Background:

This proposal covers activities by the University of Washington and PMEL in the Norton Sound and Chukchi Sea areas. Efforts in these areas will be divided 2:1 (see III D, above).

An analysis and description of the regional physical regime based on data available through 1973 [Coachman, L. K., K. Aagaard and R. B. Tripp, Bering Strait:

* Logistics are managed and funded entirely through the OCSEAP Project Office.

The Regional Physical Oceanography, University of Washington Press, 1975] has been useful in defining needs for further study which are being addressed in this program. Preliminary N-COP results appear in the First Annual Report dated 31 March 1977.

V. Objectives:

Based on the knowledge we now have, the following major questions pertinent to tasks B-2 (primary) and in support of B-4, B-5, B-11, B-12, D-4, D-11, D-12, E-2, A-2, A-12, A-23, A-24 (and others requiring knowledge of the time-dependent circulation) will be addressed:

1. Elucidation of the fluctuations in transport of the predominantly north flow through the system;

2. Verification and temporal and spatial description of the bifurcation of northward flow which takes place west of Pt. Hope;

3. Definition of temporal and spatial scales of the variability ubiquitous to the system and acquisition of data for a dynamical description;

4. Definition of circulations prevailing in Norton and Kotzebue sounds. These relatively shallow sounds on the east side of the system have been largely ignored in previous studies, the general circulation patterns within them are not well known; and

5. Clarification of interaction in the zone between the shelf regime of the northeastern (N-COP study area) and the southeastern Bering Sea (B-BOP study area).

VI. General Strategy and Approach

Major unknowns in the regional circulation are the time-dependent flow and smaller scale spatial variability; many of the mean, large-scale flow features are known. Upon recovery of the 19 instrument moorings during the summer 1977 field season, we will begin analysis of these records and our CTD data to address our objectives (see V, above). This analysis will be the major thrust of our FY 78 work.

To continue this work and to link the N-COP work and the OCSEAP work being done in Bristol Bay (B-BOP, RU 141), we plan a field program of 9 instrument moorings and 2 CTD surveys. We plan to deploy the instruments in September 1976 in cooperation with RU 141. Three moorings, one located in Bering Strait, one south of Cape Rodney in the entrance to Norton Sound, and one southeast of St. Lawrence Island (see figure) will continue to monitor conditions in the northeastern Bering Sea. Three additional moorings will be placed between St. Lawrence Island and Nunivak Island to examine the region which connnects the study region of N-COP and B-BOP. These moorings will be retrieved in July-August 1978, and will thus contain 10-12 month long records. We plan to conduct CTD surveys both during the deployment of the moorings in September 1977, and during their recovery in July-August 1978. These surveys will include attempts to define the Yukon River's plume. These activities will be closely coordinated with concurrent deployments of moorings and CTD surveys in the B-BOP study area (see RU 141 proposal).

A combined effort in RU's 541 and 141, including investigating the region between the domains of these two contracts, is important because these shelf regimes may not be independent. We have studied the regions north of St. Lawrence Island and south of Nunivak Island separately, and we are beginning to understand some aspects of these flow regimes. We want to know if the two regions are sufficiently independent of each other to be considered separately, or whether consideration of the two regions as a single entity is more fruitful. Examination of the data recovered in 1977 and the data from the proposed FY 78 field programs should help to answer this question.

Additionally, we plan to obtain CTD data from Norton Sound during the winter. Our attempts to obtain these unique data last year were thwarted by unusual ice conditions. We therefore propose a program identical to that attempted in FY 77. The measurements will be made from a helicopter based at Nome. Covering the approximately 30-station grid should take about one week of actual flying. We have talked with Cacchione and Drake of U.S.G.S., Menlo Park, who are eager to make transmissometer and suspended sediment measurements in Norton Sound during winter. It appears quite feasible to combine these with the CTD work, and we propose doing so as it makes effective use of logistics.

VII. Sampling Methods

CTD observation from vessels will be carried out using the Plessey 9040 CTD units as in past OCSEAP work. The helicopter-borne operation will utilize a portable STD unit. Currents will be measured using Aanderaa recording meters in moored arrays as for previous work carried out under the research unit.

VIII. Analytical Methods

N/A

IX. Anticipated Problems

As always, logistical problems will require considerable attention. The principal uncertainty is the ice, and most sensitive part of the field program is the winter CTD work from helicopters. The apparent solution is for both project office and investigators to remain flexible, and to modify plans as weather and ice require.

X. Deliverable Products

A. Digital data:

1. Pressure gauge (format 017)
   Current meters (format 015)
   CTD measurements (format 022)

2. List of digital products--see attached Data Products Schedule.

Data Products Schedule

Data Type (i.e. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
CTD	tape	200 shallow stations	022	yes	various	(1)
Pressuge gauge	tape	3 Aanderaa TG records	017	yes	various	(1)
Current meter	tape	23 Aanderaa RCM-4 records	015	yes	various	(1)

Note: (1) Submission will be about 120 days after collection. Because the data returns discretely in large quantitie because the data requires extensive processing after collection, and because many people have the responsibility of processing data under more than one OCSEAP contract, the 120 day target date will probably not be met in all cases if the data is to have high quality. We will sacrifice timely submission to maintain the quality of the data. Also see Milestone Chart.

B. Narrative Reports

We have written a manuscript on Norton Sound (submitted to the Journal of Geophysical Research) and one on Kotzebue Sound (as a technical report). Work on these reports will continue, and similar reports will be written as appropriate.

C. Visual Data -- Visual data will usually be included in quarterly, annual and narrative reports.

D. Other non-digital data -- N/A

E. Data Submission Schedule -- see attached Data Products Schedule and Milestone Chart.

XI. Data Required from Other Investigation

We desire light hydrocarbon plume data from RU 153, and satellite imagery from RU 289.

XII. Quality Assurance Plan

CTD data will be calibrated against a near-bottom water sample, analyzed for salinity against Copenhagen (standard) sea water using an induction salinometer, and for temperature using reversing thermometers. Current meters and pressure gauges will be calibrated at the Corps of Engineers Bonneville facility, or at NWRCC Bellevue, as required.

XIII. Special Sample and Voucher Specimen Archival Plan: N/A

XIV. Logistics

A. Ship Support

1. See Figure 1.

2. Operations at moored array sites will consist of deployment/recovery. Array design will be similar to that presently used. Additionally, approximately 100 CTD stations will be occupied. Exact positions will be furnished for Project Instructions.

3. Optimum chronology of observations is given in TABLE 1. Departures from these times on the order of one week would be acceptable.

4. See TABLE I.

5. All investigations are principal for the operation. All mooring operations require daylight. A deployment requires about 1 hour, as does a recovery. CTD work may be undertaken anytime, typical on station time is 15-20 minutes.

6. Standard electronics test equipment CTD system, 7-track digital recorder; salinometer Nansen bottles, reversing thermometers, Survey Technicians and deck crew (for array deployments).

7. Anchors will be railroad wheel configurations (about 2,500 lbs.). Subsurface floating will be either 28 or 41 inch spheres.

8. No

9. No

10. Yes. NOAA

11. N/A

12. Two people. Participants have not been designated yet.

B. AIRCRAFT SUPPORT - FIXED WING N/A

C. AIRCRAFT SUPPORT - HELICOPTER

1. See Attached chart for Norton Sound CTD grid. As time and weather permit, we will occupy Norton Sound stations and those east of St. Lawrence Island.

2. STD casts.

3. February-March 1978. This depends critically on ice conditions.

4. 8 lines of stations, 360 miles. Total flight hours depends on weather and ice conditions.

5. 2-3.

6. Portable STD unit, see RY 151.

7. Bell 205 with muff heater, see RU 151. Floats are required.

8. Charter or NOAA.

9. --

10. Nome.

11. Yes, VLF navigation, e.g. GLOBAL, ONTRAC.

Quarters and Subsistence Support

1. (a) Nome
   (b) February-March 1978
   (c) 2-3 personnel

TABLE I

Logistics Requirements

(RU 141/541 combined)

LEG	Date	Days	Operation
I	Late February 78	12	Occupy about 100 CTD stations near ice edge and in the density inversion region
II	Mid July 78	22	Occupy approximately 300 CTD stations and recovery all arrays in RU 141 and RU 541

With perfect weather and ice conditions, the survey can be completed in under ten days, e. g., ∿ 25 M-D. Experience suggests that the required time will be greater, and not very predictable.

2. No.

3. Current commercial rates at Nome.

XV. Management Plan

The project coordinator will coordinate activities of all personnel on the contract to meet deadlines on the Milestone Chart, to address objectives of the contract, to conform to the principles of sound scientific research and to ensure responsible fiscal management.

XVI. Outlook

Assuming that the FY 78 proposal is done successfully, the bulk of the data derived from this contract will be in hand only at the end of the project, i. e., October 1978. Thus, we require a minimum of one year beyond FY 78 to reduce and analyze the data even if we undertake no further field work.

1. Final results and data products

Same as for this proposal: quarterly reports, annual reports, technical reports (PMEL or UW), and journal articles will be used to report our findings, as appropriate.

2. Significant milestones:

Submit CTD, pressure gauge, and current meter data: winter 1979.

Preliminary analysis, annual report: 1 April 1979.

More extensive analysis, e.g., technical report or journal articles: autumn, 1979.

Each analysis of data inspires new questions, and suggests new field work to address these questions. The data we hope to recover during summer 1977 will, when analyzed, probably suggest fruitful field programs. It is now premature to guess these programs or their cost.

3. Cost by fiscal year:

FY 79: Funding at a similar salary level and data analysis level as during FY 78, plus funding for field work.

After FY 79: Funding for analysis of the previous year's data, plus funding for field work.

4. Equipment costs:

The major equipment costs would be replacement of lost current meters, pressure gauges, and acoustic releases, and refurbishment of these instruments. These costs would be proportional to the level of scheduled field work.

5. Location of future field efforts:

   The area between St. Lawrence Island and Nunivak Island may be fruitfully studied.

6. Logistics requirements: simila: to FY 78.

XVII. Standard Statements:

1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly rpeorts will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office, the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see para. 2).

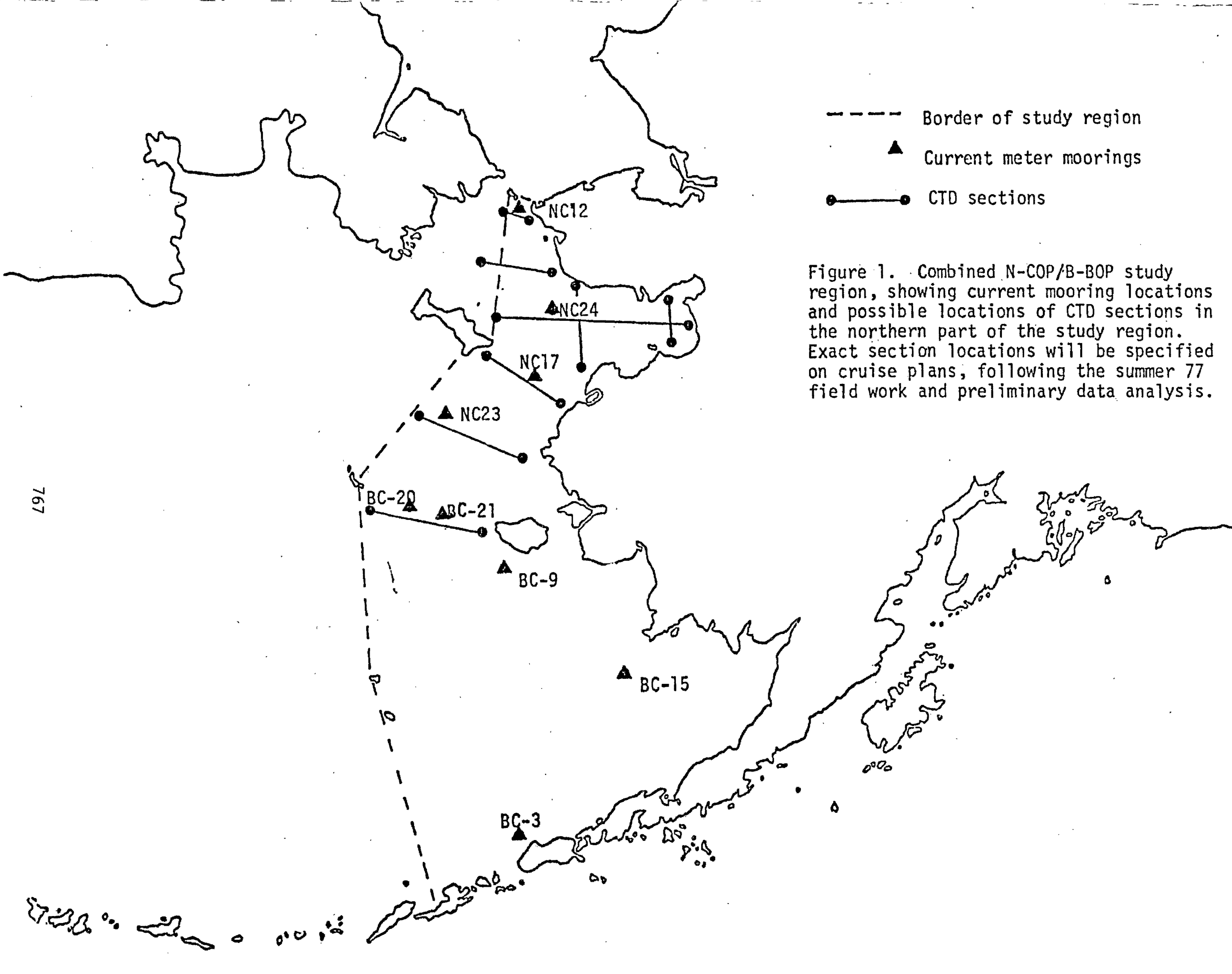


Figure 1. Combined N-COP/B-BOP study region, showing current mooring locations and possible locations of CTD sections in the northern part of the study region. Exact section locations will be specified on cruise plans, following the summer 77 field work and preliminary data analysis.

MILESTONE CHART

RU #: 541 PI: Coachman

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Recover 19 moorings, deploy FY 78 moorings, do CTD survey -- September 1977															
Submit CTD data			x												
Submit current meter data				x											
Submit pressure gauge data				x											
Conduct CTD survey of Norton Sound					x	x									
Submit CTD data										x					
Recover FY 78 moorings and conduct extensive CTD survey.										x	x				
Submit CTD data														x	
Submit current meter data														x	
Submit pressure gauge data														x	

1.0 TITLE PAGE SAI 1-022-71-781-21

IMPLEMENTATION OF SAI'S MARINE DATA MANAGEMENT AND ANALYSIS SYSTEM IN SUPPORT OF OCS ACTIVITIES

TECHNICAL PROPOSAL

Research Unit #545

TOTAL COST: $30,000

REQUIRED SIGNATURES:

Principal Investigator:

Name: M. J. Hameedi M. J. Hameedi

Address: 2760 29th Street, Boulder, Colorado 80302

Telephone Number: (303) 449-7500 Date: 22 June 1977

Required Organization Approval: JG Gratt for EJ McGrath

Name: E. J. McGrath

Address: 1200 Prospect St., La Jolla, CA 92038

Telephone Number: (714) 459-0211 Date: 22 June 1977

Organization Financial Officer: D. A. James for A. Dow

Name: A. Dow

Address: 1200 Prospect St., La Jolla, CA 92038

Telephone Number: (714) 459-0211 Date: 22 June 1977

SCIENCE APPLICATIONS, LA JOLLA, CALIFORNIA
ALBUQUERQUE • ANN ARBOR • ARLINGTON • ATLANTA • BOSTON • CHICAGO • HUNTSVILLE
LOS ANGELES • McLEAN • PALO ALTO • SANTA BARBARA • SUNNYVALE • TUCSON

P.O. Box 2351, 1200 Prospect Street, La Jolla, California 92037

3.0 TECHNICAL PROPOSAL

3.1 PROPOSAL IDENTIFICATION

3.1.1 Title: Implementation of SAI's Marine Data Management and Analysis System in Support of OCS Activities

3.1.2 Proposed Dates of Contract: July 1, 1977 through September 30, 1978

3.2 PRINCIPAL INVESTIGATOR

Dr. M. Jawed Hameedi

3.3 COST OF PROPOSAL

3.3.1 Science (Total): $30,000

3.4 BACKGROUND

The primary objective of NOAA's Outer Continental Shelf Environmental Assessment Program (NOAA/OCSEAP) is to provide background information for management decisions that may be necessary to protect the Alaskan OCS from damage during oil and gas exploration and development. Nine areas of the Alaskan OCS are under consideration for development. The approved Five-Year Plan indicates that the program must develop meaningful data, in a useable form and in a timely manner, so that any required corrective actions can be taken before serious or irreversible impacts occur.

Since May 1976, SAI staff has assisted the NOAA/OCSEAP Program Office in meeting its primary objective by performing a multitude of tasks, ranging from summarizing, integrating, and synthesizing data and results from OCSEAP studies to preparing briefing documents and management plans.

The NOAA/OCSEAP integration task requires that SAI... "develop the methodology and scientific implementation systems necessary to enable the synthesis of data and information products resulting from the Alaskan Outer Continental Program." In addition, the NOAA offices in both Boulder, Colorado and Washington, D.C., are required to receive and store data using the most efficient available computing and data management techniques. Emphasis is placed on "most efficient" because of the large quantity and diversity of the OCSEAP data base. NOAA must provide several types of integrated analyses in preparing their reports for BLM. This integrated data analysis approach requires a data management system oriented toward analysis and is capable of handling data of different disciplines and formats without programmer involvement. SAI has developed a system which meets these requirements. The system has been in use in the Southern California Bight Program for over one year, and both BLM and SAI are impressed with what it has accomplished. A comparable system will be used by SAI in the South Atlantic Bight Program. This system implemented on NOAA computers would, through its interactive nature, enhance the data analysis activities throughout the Alaskan OCS Program.

3.5 OBJECTIVE

Working closely with OCSEAP/EDS liaison officer, Wayne Fischer, SAI will implement its Marine Data Management and Analysis System on the NOAA computer in Washington, D.C., and train NOAA personnel in its use. The computer codes, both the data management and the statistical analyses, will be customized for NOAA and its computers. SAI will have the following responsibilities:

- Program Modification to Achieve NOAA/BLM Goals
- Program Maintenance
- Training of NOAA Personnel: Executive and User Level
- Program Preparation (coding necessary to meet NOAA's new computer system)
- Program Implementation (code loading on NOAA's computer).

3.5.1 Methodology

SAI will assist the NOAA OCSEAP office by the implementation of the SAI Marine Data Management System and the training of NOAA personnel in its capabilities and use. The implementation will involve obtaining from NOAA users a list of capabilities they wish the system to have. Variances from existing system capabilities will be noted and made on the system code before implementation on NOAA computers. Preparation of the code will involve examination of NOAA computer systems, identification of NOAA's computer system capabilities. Program implementation will involve one programmer full time for a short period to load and test the code on the NOAA system.

Training of NOAA personnel will be done at the NOAA facility by SAI personnel. Training will be at two levels. The first, Executive Level, in which the overall system capabilities will be discussed in addition to each statistical, cartographical, and data display subprogram, the limitations and capabilities will be discussed. The second level, User Level, will consist of a one-week "hands-on" user course of the system. The program itself will be covered in detail along with its use.

3.5.2 Statement of Work

- SAI will make all necessary modifications and preparation changes in the system.
- SAI will provide qualified trained personnel instruction at NOAA designated locations to insure adequate training of NOAA personnel in the use of the system.

- SAI will provide an "on-call" programmer to make any necessary "maintenance changes" in the system.
- SAI will implement the data management system at a location specified by NOAA.

3.5.3 SAI's Marine Data Management and Analysis System

In order for the NOAA OCSEAP program to meet its scientific objectives, a data management system must be developed which not only provides adequate responsiveness to the scientists doing the work but one which also provides management with the necessary information to effectively manage the program's diverse activities. The system that is proposed is one which has been field tested and verified by SAI in the Southern California Bight Program and will also be utilized in the South Atlantic Bight Program. Important features of the system include:

- All data filtered for error on entry.
- Data set and sub-set storage system which encourages frequent analysis.
- File management system oriented toward oceanographic data and analysis.
- System is indifferent to I/O mode.
- System allows retrieval and analysis by use of a map of the region, calibrated to a digitable (complete digitation is unnecessary).
- The system is designed to provide for dynamic hydrographic modelling.
- The system is interactively linked to an automated sample tracking system.

The advantages to OCSEAP/NODC are:

- A high quality minimized error data base
- Thorough analysis of the data by scientists conducting the work
- A high degree of interaction among the project members
- More effective program management through links to data management
- Easy access and manipulation of the data by OCSEAP/BLM personnel, if desired.

3.5.3.1 Approach

Introduction

The Data Management activities are divided into four phases: preparation, field sampling, sample analysis and analysis/reporting. With the exception of the first, none of these phases are discrete in time from the others. Moreover, with the exception of the last phase, all require essentially the same level of effort from the data management staff. Table 3.1 shows an example of these phases and their subcomponents.

Description of the Data Management Phases

Preparation Phase. During the preparation phase, activities involving the formating and variable list of each summary tape for each subcontractor are initiated. This includes making the contacts with other research programs operating in the same region to obtain data from them, and gathering historical data from other scientists.

During this phase the Original Packaging, Cataloging and Storage (OPCS) document is updated so that it reflects accurately the disposition of each year's data.

Another important task requires the data management staff to contact sources of additional historical data sets. Once obtained, this data is entered in the system in a form which will facilitate statistical merging, when possible, with the newly-collected data. To facilitate this process, there is a procedure developed which is centered around a map of the region. The map is placed on a digitable, and the system is calibrated so that to obtain data from any loaded data set for a particular region all that is required is that the region be circled using the digitables control pen. A sloppy list then appears on the screen showing the user which variables from which data sets are available for that region. The user selects the desired variables using a light pen and the data can then be placed in another file for analysis, mapped or statistically analyzed directly. The procedure is very effective in bringing in either historical data, or data from the present project from different descriptives. Finally, the DTC card formats are reviewed for their suitability to the program. Additional statistics are identified and programming commenced as required.

Table 3.1 SAI/BLM South Atlantic Bight Program: Data and Analysis Requirements

File Set	Type of Analysis for Each File	Interpretative Value
Currents (Surface and Subsurface)		
• Surface current Tracer information	• Historical data overlays with current data.	• Allows comparisons with present study with previous studies to observe possible long term trends, and integration where gaps exist to develop synoptic pictures.
• Photomosaics	• Overlays of current and historical data with photomosaics.	• Facilities comparison of field data with satellite data and fills gaps in current flow mapping.
• Aircraft tracks and plots	• Current reactor mapping.	• Provides statistical/visual summarization of the data.
• Subsurface currents	• Parameter-parameter plots.	• Provides "point in time space" visual of parameter change with another parameter or with depth.
• Current speed and direction	• Filtering	• Several types of filtering employed. a. Row data filtered and summary types prepared b. Summary data filtered for error and consistency to maintain data base quality Interpretation value.
• Conductivity, pressure temperature	• Correlations	• Correlations - parametric and non-parametric employed to provide necessary conceptualization of flow field, historical agreement.
Hydrography	• Discriminant	• Discriminant analysis will be used to detect anomalous patterns in the flow field, seasonal variability and changes in chracteristic flows attributable to meteorological changes.
• Temperature	• Spectral analysis	• Spectral analysis will be used in preparation of the summary data tape to obtain necessary low pass time series.
• Salinity		
• Pressure		
• Tide		
• Dissolved oxygen		
• Nutrients		
• Chloraphyll a		
• Transmisivity		
• Suspends particulates		
• Satellite - turbidity		
Meteorology		
• Wind velocity		
• Humidity		
• Barometric pressure		
• Inversions		
• Cloud cover		

The DTC program is one which allows the program manager to access virtually any raw data inventory information or data information from a TSO terminal in his office. The program he uses answers a series of managerial oriented questions about the state of his program; such as, what data has been collected, what collected data is in the pre-process stage, what data has been received, and what is the quality of the received data from each investigator?

Field Data Retrieval Phase

The dominant activity for the data management staff during this phase of the program is working with field staff in each sub-program to identify correct procedures for formatting. It is critical to the quality of the data that formats be comprehensive and flexible, else difficulties arise in storage and program development. As the field data is received at each investigator's facility, it is preprocessed and a summary tape with the pertinent data is prepared. This summary tape will be sent to EDS/NODC for analysis and synthesis with data from the other programs.

Another activity during this phase is the sample tracking activity, discussed in a later section in more detail.

Raw Data Analysis Phase

Activities in this phase overlap extensively with those in the Field Sampling and Analysis/Reporting phases. During this phase three major sub-activities are taking place:

- The subcontractor's laboratories are preparing summary tapes and submitting them for review and entered in the system for storage.
- The data are reviewed for consistency, readability and obvious quality before acceptance.
- Corrections are being identified by the laboratories and made in the data base temporary file.

During this phase the program statistician is also travelling to each of the labs, meeting with each and suggesting ways in which he can use data from other program areas through statistics to enhance analysis for the final report. During this time the analytical and data integration capability will also be made available to each investigator.

Analysis and Reporting Phase

The activities in this phase involve analysis of the data for three purposes: (1) the PI's final report; (2) the Data Manager's interdisciplinary analysis to insure good communication between proper areas and therefore good science; and (3) the examination of the data for statistical "outlayers." Past experience has indicated that PI's tend to want to use the data collected from the other program areas, much of the work involved in (2) is transferred to (1), and therefore (1) represents the most time consuming of these activities. The analysis performed for each of the PI's involves taking the data which has been "cleared for statistical analysis," that is, those data sets in which all corrections have been made, and applying the previously agreed-upon statistics to them. Sometimes the results obtained are unclear or inconsistent which good science and additional analyses are required by the PI to aid in the interpretation of the results. Therefore, analysis of the data is not always a single interation procedure, but may require several iterations before enough information is revealed to allow an explanatory discussion to be developed. The other important activity is that of "statistical filtering" of the data to identify statistical "outlayers" which could be the result of a poor or incomplete analysis. While this procedure cannot be used for all data, it can be applied to much of the data, particularly the chemical data. The first is determination of the "statistical distribution" and therefore what, if any, transformations may be required for it to meet the assumptions of the statistics being applied to it. The second is a linear regression program linked to a sophisticated graphics package, which allows easy manipulation to determine the effects of eliminating "outlayers." Both of these procedures have proved useful in other programs and will be invaluable to the proposed work. This applies to parametric statistics only.

In this phase, a data tape reporting all new data collected in the current year's program can be prepared, thus completing data archiving responsibilities.

Field Data Tracking and Data Analysis

These activities are closely linked to the data management function. The field data tracking system allows the data manager to identify all those who handled a particular sample in the event of any problem. It also provides him with valuable information on the quantity and timing of data arrival at the data center and therefore, allows him to plan his staff activities accordingly. The data synthesis function is closely linked to that of the data manager because the nature, and content, of the statistical analyses frequently determine the way in which the data files are set up in the computer's memory, thereby determining the ease of access and the responsiveness of the system during the analysis phase.

3.5.3.2 Available Analyses and Their Application

It is apparent that a viable data base management program must be able to accept data in any format and store it in a file system structured to meet the demands of the NOAA/OCSEAP program. The corresponding software used in generating the required graphs and charts and in performing the required statistical analyses must also be programmed to read the files in whatever format they are stored, eliminating the necessity of rewriting the software format or manually handling the system's data. The system should also be capable of handling a massive amount of information, with much diversity.

Fortunately, this problem is not new. Most compilers can handle the variable format and most 64K memory machines can handle even the most sophisticated statistical analyses of data when accompanied by a disk system.

The SAI system package has the following partial list of sub-programs. A brief description of each follows:

- IFMP — Interim File Maintenance Processor
- TAPEDT — Raw Data Tape Copy
- GRFIT — Histogram Generator
- PLOTIT — X, Y Plot Generator
- MAPIT — Map Generator
- DIVCAL — Diversity Calculation
- CONSPC — Community Description by Mirror Image Plots
- GSCLUS — Ecosystem Description by Clustering
- CONVAR — Community Change Study by Canonical Variate Analysis
- CORIT — Correlation of Two Variables
- CORITZ2 — Combined Linear Regression/Correlation and Editing Procedure

- MCORIT1 Multiple Linear Regression/Correlation and Editing Procedure
- MCORIT2 Multiple Non-Linear Regression/Correlation and Editing Procedure
- MAPRETV Digitized Tablet Data Retrieval
- DISCRIM Discriminant Analysis

3.5.3.3 Discussion of the Software Ensemble

- IFMP - Interim File Maintenance Processor: The program deals with the volatile files in conducting maintenance functions such as deleting, adding and changing data records. The instruction to the program may be read either from cards or from a remote terminal. Execution of this program results in a new tape with all indicated changes. The old tape is not used as an output tape so that a historical record is maintained.

The purpose of this program to the data base manager is to update his existing tape file system. The option to make the corresponding changes on disk files is also included.

- TAPEDT - Raw Data Tape Copy: This program is intended to be used primarily by the data base manager to accept an input tape in raw or interim-raw format, edit it in accordance with instruction from cards, or terminal, and create an edited output tape. It can also be used to edit tapes in other formats since the record size is variable and multiple files are allowed.

The purpose of this program to the data base manager is to write a tape in a "requestor-specified" format, or a tape which may be required to perform any of the following analyses.

- GRFIT - Histogram Plotter: This program accepts a tape generated by TAPEDT and prepares a histogram plot. The plot appears as the one presented below, indicating the specie abundance relationship for an intertidal community, shown here on a lognormal assessment of the community (Figure 3.1). A CALCOMP plotter and the accompanying software is required for use of this program.

- PLOTIT - X, Y Plot Generator: The program accepts a tape generated by TAPEDT and prepares an X, Y printerplot of the data. The program will plot as many as 10 lines on the same axis set.

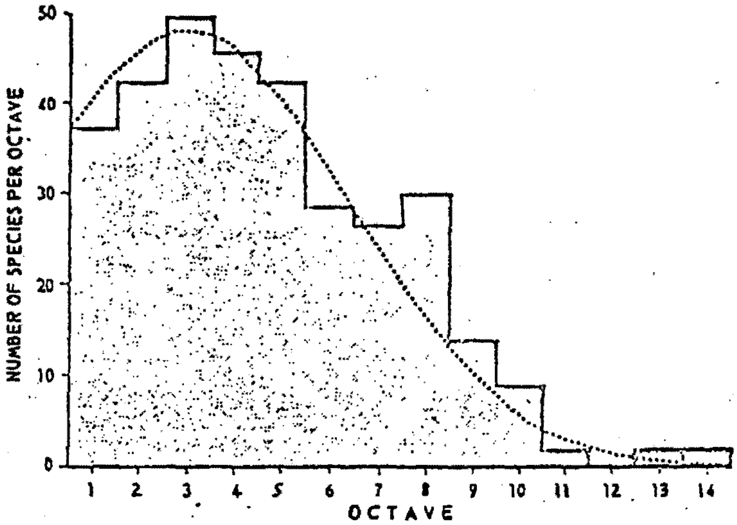


Figure 3.1 GRFIT Histogram

- DIVCAL - Diversity Calculation: This program accepts a tape generated by TAPEDT and conducts four calculations on the community composition. The indices are: (1) a dominance index; (2) a species richness index; (3) eveness index; and (4) a diversity index.

- CONSPC - Community Description by Mirror Image (Kite Diagram) Plot: This program accepts a tape generated by TAPEDT and calculates a community description utilizing mirror image plots (Figure 3.2). This type of analysis is favored by intertidal biologists to graphically show seasonal changes in community structure. A CALCOMP plotter with accompanying subroutines is required for the program.

- GSCLUS - Community Description by Clustering Analysis: This program accepts a tape generated by TAPEDT and calculates a community description in terms of clustering levels using the specie association criteria set forth by Sneath and Sokal (1974).

3.5.3.4 The Advanced Statistical Package

- GSCLUS1 - The Dendrogram for GSCLUS: This program would accept the tape written by GSCLUS and prepare a dendrogram plot. (See Figure 3.3 for a hypothetical example.) This program requires a CALCOMP plotter with accompanying software package.

- MAPIT - Map Generator: This program accepts a tape from TAPEDT on which is written station locations. It then generates a map in relation to the coastal outline, for any subregion within the study area.

- COVAR - Community Change Study by Canonical Variate Analysis: This program accepts a tape from TAPEDT and conducts a community analysis using the methods of canonical variate analysis. This is a method of ordination in which matrix methods are used to minimize the variance between species abundance in the community and measured abiotic factors. Using this method, particular species groups (communities) can be associated with specific environmental factors. Conversely, omission of particular species within those groups, and their abundance, can be associated with certain abiotic factors.

- CORIT - Correlation of Two Variables: This program performs correlation analysis on data written onto tape by TAPEDT.

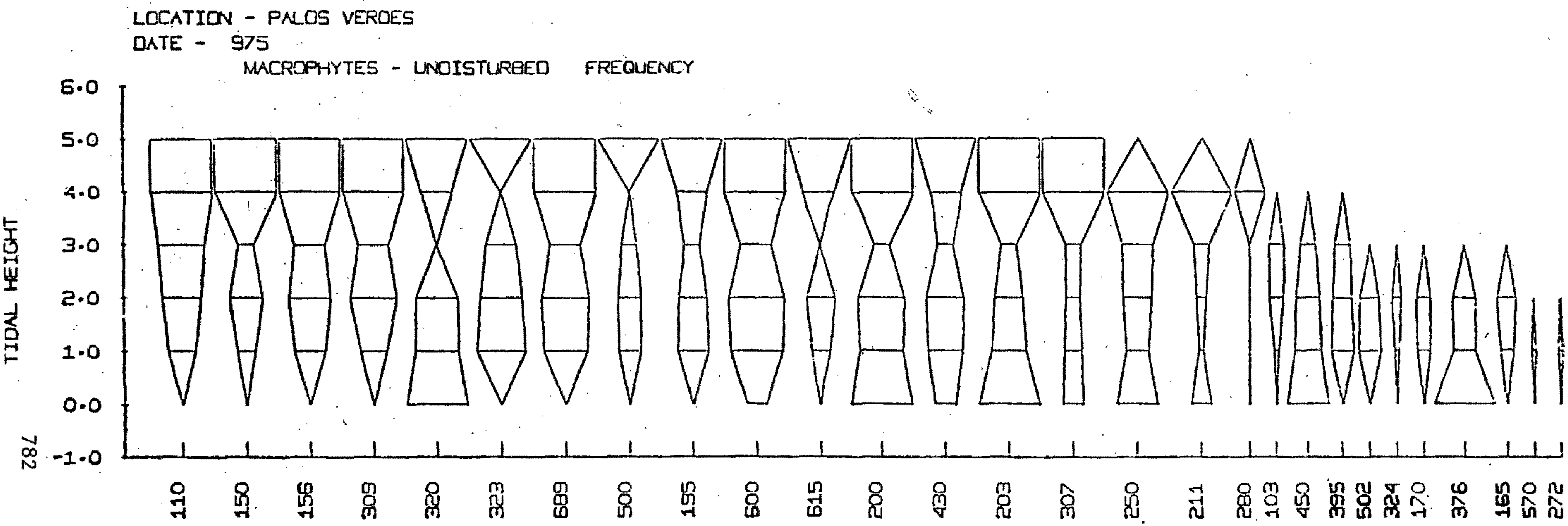


Figure 3.2 CONSPC Kite Diagram

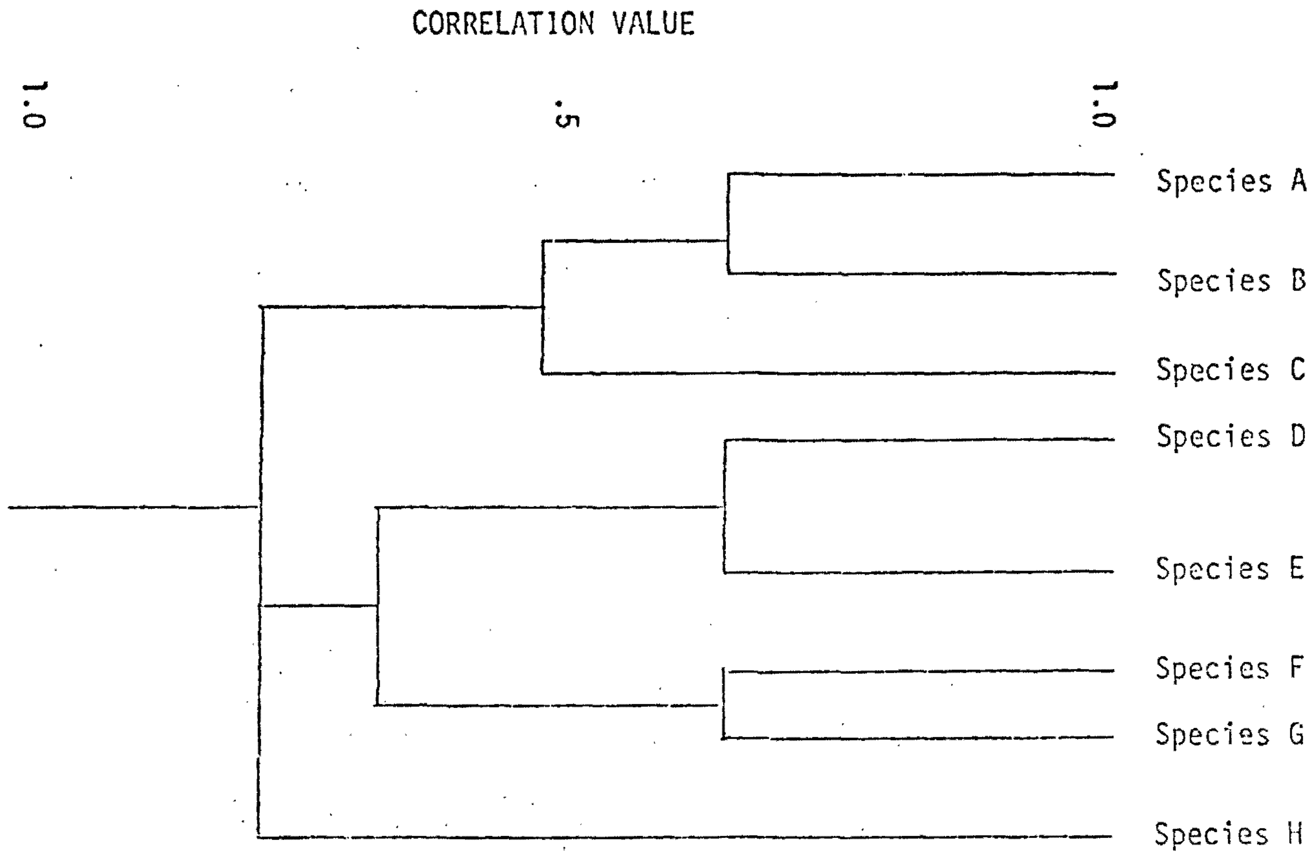


Figure 3.3 GSCLUS1 Dendrogram

• CORIT2 - Combined Linear Regression/Correlation and Editing Procedure: This program performs correlation and regression analysis on data written onto disk or tape by TAPEDT. The user is presented with a list of display options for files. He selects those he wishes to examine, and they are displayed on an X, Y plot. He then may request the analysis to be run, resulting in the r^2 value being displayed on the plot and the parameters of the linear regression line also displayed (Figure 3.4). He may choose to delete a point and recalculate. This he does via light-pen control. All data associated with the deleted point is also displayed. He may continue the process of deletion and re-addition until satisfied with the analysis.

The program is particularly useful to the data manager in examining the data for possible incorrect analysis in the labor or contamination in the field.

• MCORIT1 - Multiple Linear Regression/Correlation and Editing Procedure: This program performs stepwise multiple regression/correlation analysis on data written onto disk or tape by TAPEDT. It has all of the options indicated for CORIT2, except that only 3 variables may be displayed at a time.

Its use is similar to CORIT2, but it is a more powerful technique and is used for data sets where confounding may be more significant. The user has the choice of either a direct or transform solution.

• MCORIT2 - Multiple Non-Linear Regression/Correlation and Editing Procedure: This program performs multiple non-linear regression/correlation analysis on data written onto disk or tape by TAPEDT. It has all of the options indicated for MCORIT1. Its use is the same.

• MAPRETV - Digitized Tablet Data Retrieval: This program uses a digitized tablet, overlayed with a map of the region of interest to retrieve data stored on disk or tape. The data is accessed by keying in a particular map number. This map is then placed on the tablet and the tablet pen is used to outline regions of interest. All stations touched or encircled by the user are then placed either in analysis arrays (see following sections), written on tape, disk, cards or displayed on the scope or terminal, or any combination of these as the user wishes.

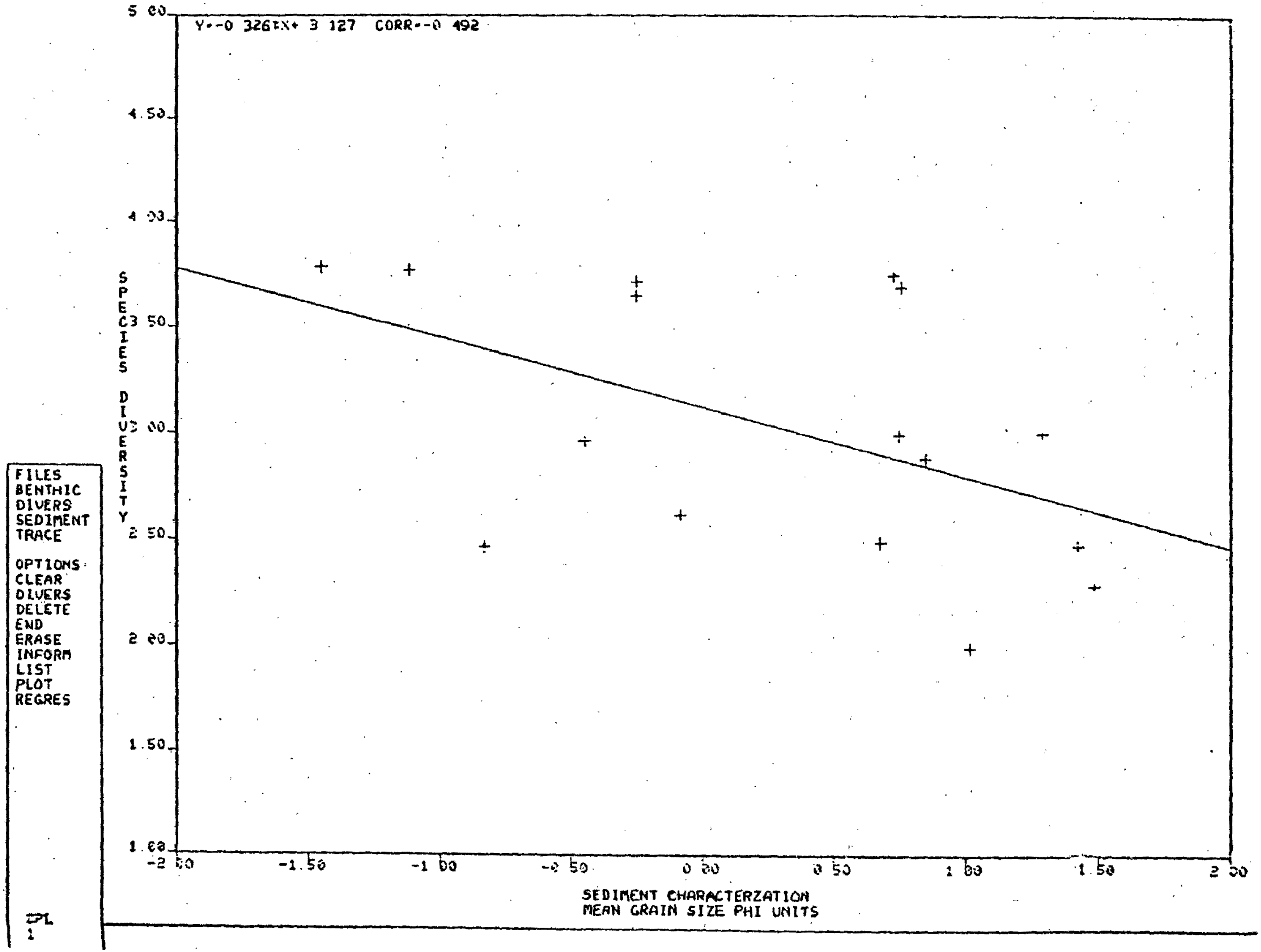


Figure 3.4 CORIT2 Regression

- DISCRIM - Discriminant Analysis: This program performs discriminant analysis on data written by TAPEDT or IFMP. Discriminant analysis is used where there are a few closely related parameters in which identification must be as certain as possible. This analysis is also designed to work in conjunction with COVAR so that discrimination of the canonical variates may also be achieved.

3.6 ANTICIPATED PROBLEMS

The quantity and complexity of data generated by OCSEAP and related programs is steadily increasing. SAI believes that if the most useful and comprehensive synthesis is to be realized, increasing attention should be directed towards expansion of data management capabilities. Implementation of the proposed marine data management and analysis system will help achieve this goal.

3.7 QUALITY ASSURANCE PLANS

3.7.1 Planned Costs and Schedules

In addition to the cost and schedule reporting provided by SAI (Figure 3.5), the SAI internal management information provides the following computer reports that will be directly useful for maintaining costs control:

- Management Information Service 74 - Detail of Direct Cost Biweekly - actual expenditures
- Management Information Service 85 - Monthly Budget Analysis

A detailed accounting system of all expenditures, actual and encumbered, is also maintained by the Project Administrator. The combination of these systems allows the project management staff to monitor the expenditures of contract resources closely and maintain cost control.

3.7.2 Deliverables

SAI staff will work in close conjunction with OCSEAP staff in preparing deliverables to insure the product is consistent with what was envisioned. Internal SAI review will insure the products are of the highest quality and flexibility.

SCIENCE APPLICATIONS, INC.
PROJECT AUTHORIZATION NOTICE

Charge No.

Co.	Div.	Type	Serial	Sub.

Title ______________________________

P.I. ______________________ Duration ______________________ Date Opened ______________________

Contract Type ______________________ Proposal Ref. ______________________ Approved ______________________

Agency/Customer ______________________ Contact ______________________ Contract No. ______________________

Contract Representative ______________________ Current Funding ______________________ GFE ______________________

TOTAL COST CURVE ($000'S)

Period Ending																			
ACT	Current																		
	Cumul.																		
PLAN	Current																		
	Cumul.																		

Statement of Work/Comments: ______________________

Figure 3.5 Cost and Schedule Control Form

3.8 MANAGEMENT PLAN

The proposed management plan (Figure 3.6) consists of a flexible concept that SAI has used successfully in a large number of technical support programs. Specifically, we propose:

- Technically qualified PI, with sufficient vested authority and flexibility to be fully responsive to NOAA/EDS needs.
- Qualified staff, each of whom is a specialist in interdisciplinary data management, computer applications and programming.
- A visible project status in SAI. The PI will report directly to Dr. L. B. Gratt who is responsible to the SAI president through Dr. E. G. McGrath for performance. Dr. Gratt has the authority to commit corporate resources to the project as required.

The project schedule outlined in Figure 3.7 illustrates the expected period of performance for each suggested task.

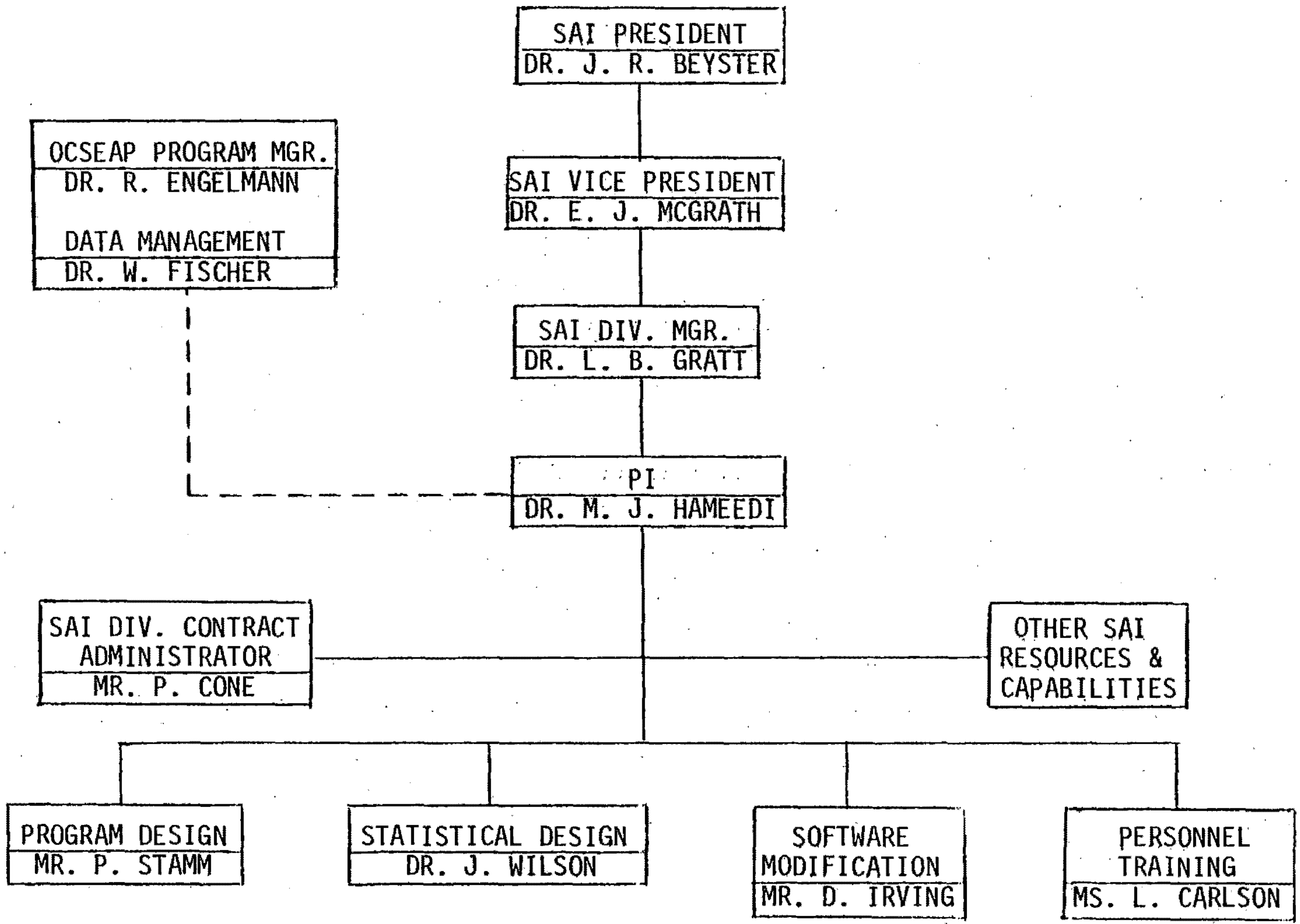


Figure 3.6 Project Management

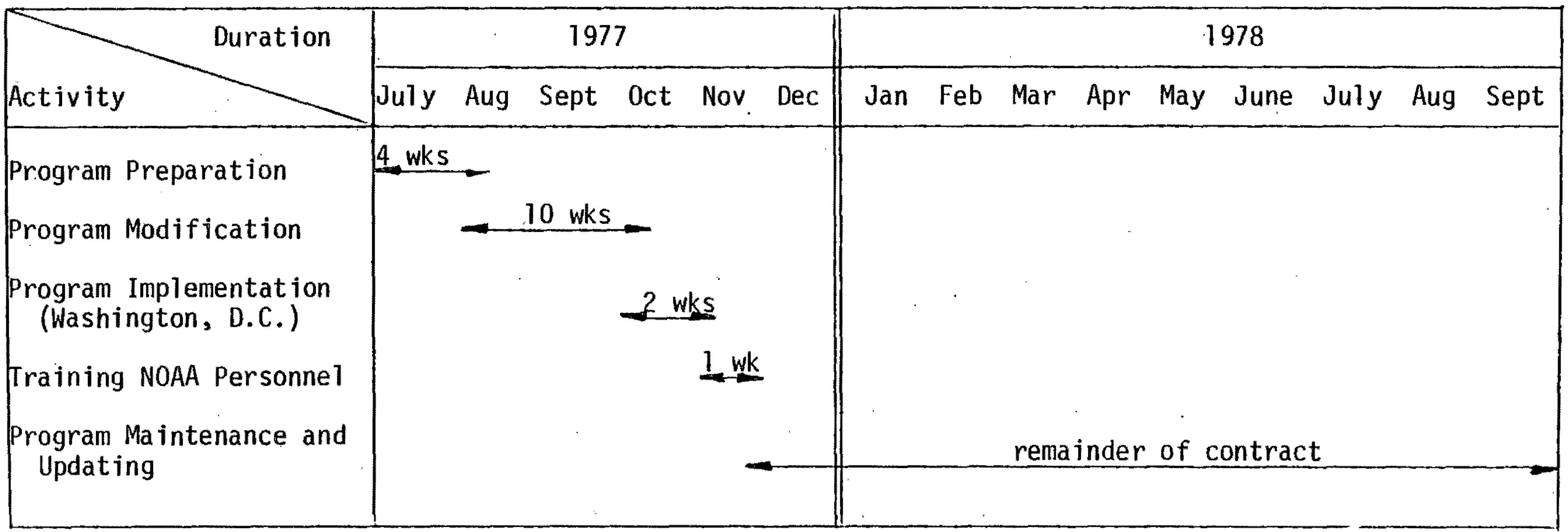


Figure 3.7 Project Schedule

Southeastern Bering Sea Circulation

Research Unit: 549

Principal Investigators: J. D. Schumacher
L. K. Coachman
T. H. Kinder
R. L. Charnell

Total Cost: $156,000

Date: 1 October 1977 - 30 September 1978

Pacific Marine Environmental Laboratory
3711 15th Avenue N. E.
Seattle, Washington 98105

Required Signatures:

James D Schumacher
J. D. Schumacher, Principal Investigator, PMEL

R. L. Charnell
R. L. Charnell, Research Oceanographer, PMEL
OCSEAP Program Coordinator

John R. Apel
J. R. Apel, Director, PMEL

R. Cunningham
R. Cunningham, Administrative Officer, PMEL

Technical Proposal Form

I. Southeastern Bering Sea Circulation
RU 549
Contract Number:
Proposed Dates of Contract: 1 October 1977 - 30 September 1978

II. Principal Investigators

Dr. James D. Schumacher
Dr. L. K. Coachman
Dr. Thomas Kinder
Mr. R. Charnell

III. Cost of Proposal

C. Total $156,000
D. Distribution of Effort by Lease Area: Bristol Bay, 55%
St. George Basin, 45%

IV. Background

1. Coordination with Other RUs:
Coordination will be continued with RU 435

2. Relation to Previous Research:

From current meter, pressure gauge and CTD data collected during FY 76 and FY 77 programs several conclusions regarding circulation have been made (see FY 76, FY 77 Annual Reports). A dominant feature is the lack of mean flow except along the shelfbreak and during relatively short (1 to 3 days) pulses. The temporal and spatial distribution of such pulses requires further investigation in order to delineate their formation. We believe there is a conditional response of shelf water to storm center location. In order to address this objective, extensive analysis of available meteorological data and a field program designed to examine the spatial extent of such pulses will be undertaken.

Periodic ice formation and the balance between buoyancy and mixing results in a well mixed band of coastal water, and a sharply defined two-layered region seaward of the 50 m isobath. Further, interactions between the shelf water and slope waters over the shelfbreak results in density inversions. During FY 78 a prime objective is to investigate processes involved in creating the observed hydrographic structure by analyzing the vast quantity of CTD available upon completion of FY 77 field operations. Additionally, it is paramount to examine the density structure under ice cover. This experiment will be undertaken during February 1978.

V. Objectives: The general objective will be to provide information leading to an improved understanding of the hydrography, circulation and dominant driving mechanisms in the southeastern Bering Sea. Specifically, these objectives are:

(1) To obtain and analyze current and pressure gauge records.
(2) To synthesize current data and investigate meteorological forcing.
(3) To obtain a better understanding of the formation mechanisms and role in mixing of large scale density inversions.
(4) To obtain a better understanding of the hydrographic structure (e.g. the front separating coastal waters and the two layered domain)
(5) Data will be available for modeling efforts conducted under RU 435.

VI. General Strategy and Approach: To obtain direct measurements that yield current meter, pressure gauge and CTD data to characterize hydrographic structure and circulation. This will be carried out by maintaining the program discussed in Section VII.

VII. Program Design: To link the B-BOP work and OCSEAP work being done in N-COP (RU 541), we plan a field program of 9 instrument moorings and 2 CTD surveys. We plan to deploy the instruments in September 1977 in cooperation with RU 541. Three moorings will continue to monitor conditions in Bristol Bay. Three additional moorings will be placed between St. Lawrence Island and Nunivak Island to examine the region which connects the study region of N-COP and B-BOP. These moorings will be retrieved in July-August 1978, and will thus contain 10-12 month long records. We plan to conduct CTD surveys both during the deployment of the moorings in September 1977, and during their recovery in July-August 1978. These activities will be closely coordinated with concurrent deployments of moorings and CTD surveys in the N-COP study area (see RU 541 proposal), and the selection of mooring sites will be made with the requirements of RU 435 in mind.

A combined effort between RUs 541 and 141, including investigating the region between the domains of these two contracts, is important because these shelf regimes may not be independent. To date, we have studied the regions north of St. Lawrence Island and south of Nunivak Island separately, and we are beginning to understand some aspects of these flow regimes. We want to know if the two regions are independent of each other or whether considering the two regions as a single entity is more fruitful. Examination of the data recovered in 1977 and the data from the proposed FY 78 field programs should help answer this question.

The locations for moored arrays are shown in Figure 1. Arrays BC-3, BC-15, and BC-9 have been occupied previously and will provide long-term time series. Arrays BC-20 and BC-21 will be equipped with bottom pressure gauges to address objective 4. Additionally, the current records obtained will provide a measure of flow continuity between this study area and RU 541. This will allow an examination of the temporal and spatial distribution of flow pulses (see FY 75 Annual Report). These arrays are to be deployed in September 1977. Coincident with deployment/recovery operations, CTD stations will be occupied to elucidate water mass distributions and vertical structure. In particular, the northwestward extension of the front between the two-layered shelf water and well mixed coastal water will be examined.

During early February 1978, CTD operations will be conducted using helicopter support and through-the-ice techniques. Approximately 25 stations will be occupied along sections 1-5 (see Figure 1). These CTD data will provide an initial determination of vertical structure under ice conditions. Concomitant with helicopter operations, shipboard CTD will be collected along the ice edge and throughout the interaction region where density inversions have been observed. This experiment will investigate the temporal character of an inversion and attempt to more clearly define the spatial extent of such features.

At this time, we do not plan to use surface drift cards in Unimak Pass and surrounding areas until similar activities around Kodiak Island (RU 138) have been evaluated. Upon completion of such evaluation we may apply an appropriate program in the Bristol Bay area.

VIII. Analytical Procedures

N/A

IX. Anticipated Problems: CTD helicopter operations are dependent on ice conditions and weather, thus both investigators and the Project Office must be flexible and modify plans as conditions dictate

X. Products:

1. Digital Data:

A. Current meter, pressure gauge and CTD data acquired will be digitized in accordance with existing procedures in formats defined by the OCSEAP data base in NODC. Formats are 022, 017, 015.

B. See attached Data Products Schedule.

C. Narrative Reports: Reports will discuss relationships between currents, sea level and meteorological conditions inferred from acquired data. Additional CTD observations and data of opportunity, as available, will be analyzed for new information on processes of mixing and transport of deep Bering Sea water onto the shelf. Reports will also include documentation of experimental design and methods of analysis.

Data Products Schedule

Data Type (i.e. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Current meter	Tape	66 months	File type 015	Yes	9/77 to 7/78	10/78
CTD	Tape	25 stations	" " 017	"	3/78	6/78
CTD	Tape	200 stations	" " "	"	7/78	10/78

D. Visual Data: Currents, pressures, and meteorological data will be graphically displayed in the Narrative reports, including:

- Appropriately filtered time plots of tidal and non-tidal currents.
- Charts of progressive vector diagrams.
- Stick diagrams of currents, together with winds and pressure variations.
- Charts showing hydrographic properties and locations of water mass mixing areas.
- Data Submission Schedule: See Data Products Schedule

XI. Information Required from Other Investigators:

Close coordination will be carried out with D. Hansen (AOML) and J. Leendertse (RU 435). Additionally, satellite photographs of ice distribution will be required from Dr. T. Royer, UA.

XII. Quality Assurance Plans:

All equipment is and will continue to be calibrated at NWRCC as per OCSEAP requirements already established.

XIII. Special Sample and Voucher Specimen Archival Plan

N/A

XIV. Logistics Requirements:

A. Ship Support

1. See Figure 1.
2. Operations at moored array sites will consist of deployment/recovery. Array design will be similar to that presently used. Additionally, approximately 300 CTD stations will be occupied. The exact positions will be furnished for Project Instructions.
3. Optimum chronology of observations is given in TABLE 1. Departures from these times on the order of one week would be acceptable.
4. See TABLE I.
5. All investigations are principal for the operation. All mooring operations require daylight. A deployment requires about 1 hour, as does a recovery. CTD work may be undertaken anytime, typical on station time is 15-20 minutes.

6. Standard electronics test equipment CTD system, 7-track digital recorder; salinometer Nansen bottles, reversing thermometers, Survey Technicians and deck crew (for array deployments).

7. Anchors will be railroad wheel configurations (about 2,500 lbs.). Subsurface floating will be either 28 or 41 inch spheres.

8. No

9. No

10. Yes. NOAA

11. N/A

12: A. Two people. Participants have not been designated yet.

B. AIRCRAFT SUPPORT - FIXED WING N/A

C. AIRCRAFT SUPPORT - HELICOPTER

1. See Figure 2

2. CTD observation through ice.

3. Operations totally dependent on ice cover. It seems that later February would afford the highest probability of success.

4. 14 days (7 actual flying days)

5. Two

6. Portable CTD equipment presently being designed and constructed, final weight is planned to be about 500 lbs.

7. UHIH

8. NOAA. These helicopters have been used for similar operations in RU 141 E.

9. N/A

10. Nunivak Island, Cape Newenham

11. No

XV. Management Plan:

PIs will maintain a plan which is an extension of that used in FY 76/77 programs. Additionally, R. Charnell will be designated as OCSEAP Program Manager for PMEL and will be the focus for management. See attached Milestone Chart.

TABLE I

Logistics Requirements

LEG	Date	Days	Operation
I	Late February 78	12	Occupy about 100 CTD stations near ice edge and in the density inversion region
II	Mid July 78	22	Occupy approximately 200 CTD stations and recovery all arrays in RU 141 and RU 541

XVI. Outlook:

Assuming that the FY 78 proposal is successfully completed, the bulk of data collected during this contract year will be in hand only at the end of the project. Thus, analysis of FY 78 results will require a minimum of one year. Further, field operations at level similar to FY 78 may be required to elucidate such features as (1) circulation in the Unimak Pass region (2) seasonal characteristics of the front between the well mixed coastal water and the two layered waters and (3) circulation along the shelf break.

XVII. 1. Updated Activity/Milestone/Data Management Charts will be submitted quarterly.

2. Quarterly reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, held, and shipped to an official OCSEAP-designated repository in conformity with OCSEAP voucher specimen policy. Vouchering will include life history stages (e.g., larvae, juveniles, adults) when these are used, and sexes where these are morphologically distinguishable.

4. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel and per diem for these trips will be borne by the Project Office.

5. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

6. Data will be submitted within 120 days of the completion of a cruise or 3 month data collection period, unless a written waiver has been received from the Project Office. This does not apply to report requirements (see para. 2).

7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

8. Title for all property purchased with OCSEAP funds remains with the U. S. Government pending disposition at contract termination.

9. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard.

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP Office."

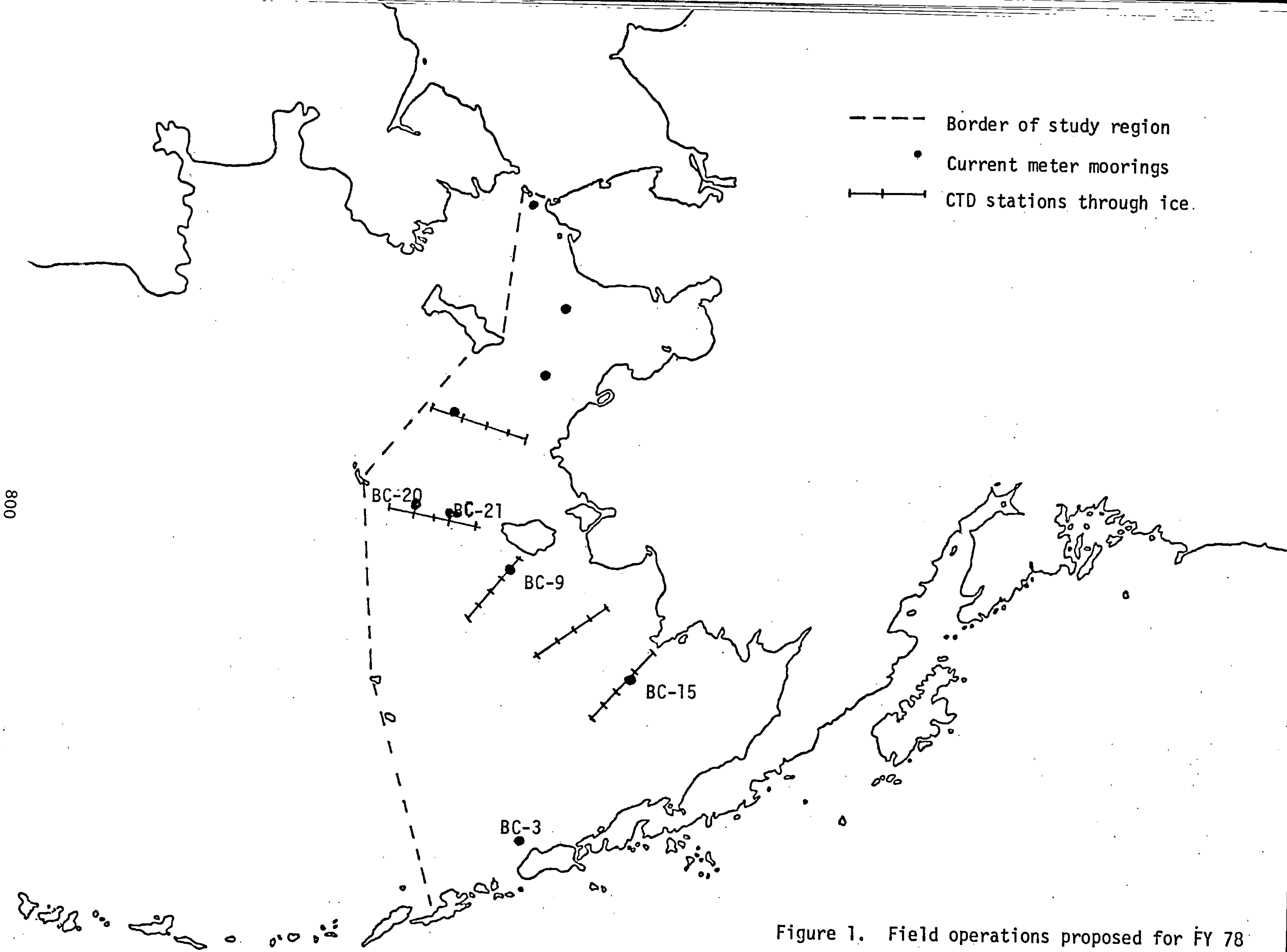


Figure 1. Field operations proposed for FY 78

MILESTONE CHART

RU #: 141 PI: J. Schumacher

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Submit CTD data from Sept. 77 cruise			Δ												
First Quarter Report			Δ												
Through ice CTD helicopter operations					├┤										
CTD Cruise LEG I (in conuunction w/above ops.)					├┤										
FY 78 Annual Report						Δ									
Submit CTD data from helicopter/LEG I operations								Δ							
LEG II cruise: CTDs/moored array recovery										├┤					
3rd Quarter Report									Δ						
Submit CTD, current meter, and pressure gauge data from LEG II													Δ		
4th Quarter Report												Δ			

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Outer Continental Shelf Environmental
Assessment Program
Bering Sea-Gulf of Alaska Project Office
P. O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

RFx41-549-915

Date: 8 NOV 1977

To : Rudy Engelmann
OCSEAP/Alaska Program Office Rx4

From: Herbert E. Bruce
OCSEAP/Juneau Project Office RFx41

Subj: Acceptance of Proposal for R.U. 549 (PMEL) and R.U. 141 (University of Washington).

The Proposal, "Bristol Bay Oceanographic Process" by Dr. Larry Coachman of University of Washington and Dr. James Schumacher of PMEL has been reviewed by the Juneau Project Office. It is recommended that it be accepted at the funding levels of $94,900 for R.U. 141 and $156,000 for R.U. 549. According to the attached letters amending the original proposal to meet the new budget figures, there will be some reduction in data analysis and field work made necessary by the budget cut.

It is requested that the contracting office proceed with details of a contract with the University of Washington and that PMEL be notified of their funding for FY 78.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES

October 5, 1977

Herbert E. Bruce, Director, OCSEAP Project Office, Juneau

RC

Robert Charnell, PMEL OCSEAP Coordinator

RU ~~141~~ 549, FY 78, Proposal Revision No. 2

The delay in responding to your August 19, 1977 letter requesting additional proposal revision is due to your letter never having been received by any principal investigator either at the University of Washington or here at PMEL; at my request your office kindly provided a Telefax copy yesterday. This delay should not be construed as a lack of interest in our participation in this program. We want to assure you that researchers, both at PMEL and UW, are enthusastic about continuing our investigation of Bristol Bay.

It is unfortunate that emphasis in the OCSEAP program is to be directed away from Bristol Bay. We have been successful in collecting a valuable data set and an interesting picture of physical oceanography is beginning to emerge. However, we accept your judgement and agree to continue our work in this area at a reduced level. It is my understanding, from conversations with Mauri Pelto, that the new budget of $252.0K is to be distributed between the University and PMEL as follows:

RU 141 (U. of Washington)	$96.0 K
RU 549 (PMEL)	$156.0 K

This represents a large reduction in our proposed effort for FY 78. As you suggest, the most logical way to attain the new funding level is to reduce the field effort. With each year of this project, a greater portion of support monies has gone into analysis of data previously collected with a subsequent reduction in support for field activities. A major portion of field activities for FY 78 was begun with deployments during FY 77 and must be continued with their recovery. Analysis of data collected in a field program next summer would not be done until the following fiscal year and hence is not a significant portion of this year's proposed budget. It was proposed that field work in Bristol Bay be combined with field work for N-COP; thus only one cruise can be dropped to help reduce field costs in Bristol Bay. These facts suggest that the proposed cost reductions cannot be met solely by a reduction of remaining field effort. Consequently, we will have to reduce the rate of data analysis during the coming year and hope to make up for this loss during the subsequent year. This probably means no field work in Bristol Bay during FY 79 so that we may have the time to complete analysis and prepare the appropriate reports.

The reduced funding level will severely limit our field work flexibility and means that we will be unable to support Dr. Leendertse's program with deployments during next summer. This is unfortunate; I hope you will be able to support his program with separate funding negotiated during the year.

In summary, PMEL and the University of Washington agree to continue physical oceanography research work in Bristol Bay at a revised level of $252.0K. This funding reduction is achieved by:

1) reducing field work during summer 1978 (including cancellation of the September Discoverer cruise)
2) lowering the rate of data analysis
3) eliminating field support for Dr. Leendertse's program

Both PMEL and UW agree to these revisions; you will receive a separate letter from the University after it has gotten the necessary approvals.

I want to reiterate the interest of our research team in continuing activities in Bristol Bay. I hope this revised program meets with your approval and that our delay in responding to your letter has not jeopardized our relationship. I expect you share my interest in completing negotiations on this contract as speedily as possible.

cc: LK Coachman
JD Schumacher
JR Apel

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

5 October 1977

Department of Oceanography
Cable Address: UNWADO

Dr. Herbert Bruce
OCSEAP
Bering Sea-Gulf of Alaska Project Office
P.O. Box 1808
Juneau, Alaska 99802

Ref: RU 141

Dear Dr. Bruce:

The delay in responding to your letter of August 19, 1977 is a result of never having received the mentioned letter. We are extremely interested in continuing our investigation of the Bristol Bay region.

We accept the fact that there are other priorities which necessitate a cut in funding of the Bristol Bay Oceanographic Program. However, this represents a reduction to our proposed effort for FY 78. The proposed cost reductions will have to be met as follows:

1. Eliminate the September 1978 *Discoverer* cruise,
2. Reducing level of effort towards data analysis,
3. Eliminating field support for Dr. Leendertse's program, and
4. Curtail program to provide plots of CTD data in form of data reports, which Mauri Pelto and I thought very useful to other investigators.

I have outlined the $26,600 reduction in funding as follows:

		Original Proposal	To be Allotted
A.	Salaries	29,611	22,463.20
B.	Benefits	5,067	3,573
C.	Supplies	18,300	15,800
D.	Equipment	2,500	1,250
E.	Travel	8,600	5,900
F.	Computer	9,000	4,000
G.	Other Direct Costs	34,380	30,232.80
H.	Total Direct Costs	107,458	83,219
I.	Indirect Costs	14,042	11,681
	TOTAL	121,500	94,900

The reductions were derived as follows:

		Reduction	
A.	Salaries	7,147.80	Man months: 0.5 LKC(P.I.); 3.0 Oceanographer; 1.0 RBT
B.	Benefits	1,494	
C.	Supplies	2,500	Calibration of instrumentation was deleted
D.	Equipment	1,250	
E.	Travel	2,700	31% of travel associated with field program
F.	Computer	5,000	56% of analysis of data deleted
G.	Other Direct Costs	4,147.20	57% of freight budget plus one man-month of programmer and 1.5 man-month of technician deleted
H.	Total Direct Costs	24,239	
I.	Indirect Costs	3,717	Since our total direct costs now drop below 100K we now pay a higher rate while we are in the field. Hence, we now have to pay an additional $1,356 in this category

A cut of 26.6K is a 22% reduction from the original proposal. However, when you look at the reduction in terms of man-months (which is the only way one can eliminate that kind of money), the effect is as follows:

A total of 21 man-months (5 man-months in the field) were proposed to accomplish the project. I have eliminated 7 man-months (5 analysis; 2 field work) which is in essence a 33% reduction in effort.

We agree with PMEL to continue a physical oceanography program in Bristol Bay at this reduced level will attempt to provide the highest level of effort in accomplishing this program.

Sincerely,

Richard D. Tripp

for L. K. Coachman
Professor and
Principal Investigator

RBT:LKC:af

Research Unit #556

I. TITLE: Trace metals in the bottom sediments of the Southern Bering Sea

II. PRINCIPAL INVESTIGATOR: Walter E. Dean, Jr.
Branch of Regional Geochemistry
U.S. Geological Survey
Denver, Colorado

III. COST OF PROPOSAL: FY 78 TOTAL

15,000 15,000

IV. PERIOD OF WORK: October 1, 1977 - September 30, 1978

Principal Investigator

Name Walter E. Dean, Jr. Walter E. Dean, Jr. Date 7/11/77
Address U.S. Geological Survey, Box 25046 Federal Center, MS 925, Denver, CO 80225
Telephone Number (303) 234-2310

Required Organizational Approval

Name Richard J. Ebens Date 7/11/77
Address U.S. Geological Survey, Box 25046 Federal Center, MS 925, Denver, CO 80225
Telephone Number (303) 234-3715

Organizational Financial Officer

Name Date
Address
Telephone Number

TECHNICAL PROPOSAL

I. TRACE METALS IN THE BOTTOM SEDIMENTS OF THE SOUTHERN BERING SEA (task A-3)

II. PRINCIPAL INVESTIGATOR

Walter E. Dean, Jr.

III. COST OF PROPOSAL

Total 15,000

IV. GENERAL STRATEGY

Samples for the proposed research will be collected during August and September, 1977 aboard the U.S.G.S. R/V Sea Sounder which will be conducting investigations by Gardner and Vallier (RU 206) on slope instability in the same area. The 1977 area of investigation will concentrate on the continental slope and large submarine canyons adjacent to the St. George Basin on the outer continental shelf, and will extend knowledge gained on the distribution and concentrations of trace metals in sediments obtained in the St. George Basin on U.S.G.S. Cruise S76-4, August and September, 1976 (see map included under the section - Other Data). Preliminary results of analyses of major, minor, and trace elements in surface sediments collected on the outer continental shelf last year indicate three main sources of sediment: the Aleutian Islands, the Pribilof Islands, and the Alaskan mainland. The preliminary results also indicate that trace and minor elements are valuable indicators of the dynamics of sediment transport. For example, trace elements suggest that the dominant flow of sediments is from the Aleutians controlled by strong currents through the Unimak Pass. These data suggest that the Pribilof submarine canyon is active in channeling sediments but that the Bering submarine canyon may not be presently active in controlling sediment distribution. On the 1976 cruise, only a few samples were collected in the canyons, and none were collected on the continental slope adjacent to the St. George Basin. Data on sediments from the canyons and continental slope areas will be necessary to more completely characterize sediment dispersal patterns and their influences on the distribution and concentration of trace metals in an integrated shelf-slope-canyon dynamic system.

Samples will be processed aboard ship, and should be ready for submittal to the U.S.G.S. analytical laboratories by October, 1977. Allowing a reasonable 6 months for analyses, results should be available by the end of March, 1978. Statistical analyses and computer graphic presentations of the analytical results will require another six months so that final results should be available by September 30, 1978.

V. SAMPLING METHODS

Sampling methods used on the 1977 southern Bering Sea Cruise will be essentially the same as those used on the 1976 cruise. A sampling grid will be established by the intersections of, and by points along, seismic reflection lines. The first series of lines, perpendicular to the slope, will be run during the first half of the cruise. The second series of lines, parallel to the slope, will be run between sampling stations on the second half of the cruise. Positions of the second series of seismic lines, and consequently the positions of the stations, will be predetermined as much as possible based on the seismic results on the first half of the cruise.

Stations on the 1976 southern Bering Sea cruise were on the order of 30/km. At most stations, duplicate samples of surface sediment were collected and analyzed. All of the analyses of the 1976 samples have not yet been received, but a preliminary analysis of variance of the results received reveals that there is very little variation in chemical composition of sediments within a station (geographic scale on the order of several hundred meters, within limits of navigation and dynamic positioning of the ship), and that most of the variance is between stations (geographic scale on the order of 30 km). Based on these results, duplicate samples will not be collected on the 1977 cruise, resulting in a marked reduction in analytical load. A number of analytical replicates will still be submitted in order to obtain a measure of analytical variance (precision).

Samples will be collected by means of one or a combination of plastic-lined gravity and piston corers or a "chemically clean" Soutar vanVeen grab sampler. Choice of sampler is governed mainly by the nature of the bottom material; the gravity and piston corers are used in soft, fine-grained sediments and the vanVeen in hard, sandy sediments. Samples for chemical analyses will be collected from the top 3 cm of vanVeen samples, and from the top 10 cm of gravity and piston cores. All samples will be dried at 90°C in a forced-air drying oven in the sediment laboratory aboard ship, and stored in clean polyethylene containers.

VI. ANALYTICAL METHODS

The elements Al, Ca, Fe, K, P, Si, S, Ti, Mn, Sn, Se, Ge, As, Sb, Te, and Bi will be analyzed by X-ray fluorescence spectrometry (Wahlberg, 1976). The elements B, Ba, Co, Cr, Cu, Ni, Pb, Sc, Sr, V, Y, Mo, Nb, Yb, Ga, and Zr will be analyzed by semiquantitative optical emission spectroscopy (Meyers, Havens, and Dunton, 1961). Na, Mg, Li, and Zn will be determined by atomic absorption spectrophotometry on a single solution obtained by dissolving the sediment sample in nitric, hydrofluoric, and perchloric acids (Huffman and Dinnin, 1976). Cd will also be analyzed by atomic absorption on a solution obtained by digestion of the sediment sample with nitric acid (Nakagawa and Harms, 1968). Hg will be analyzed by a flameless atomic absorption technique in which mercury is vaporized in an induction furnace and the vapor amalgamated onto silver. The silver amalgamator is then heated and the vapor collected in an absorption chamber where its concentration is measured (Vaughn, 1967). All analyses will be performed by the Branch of Analytical Laboratories, Denver.

Statistical analyses of the analytical results will be done using programs already existing in the U.S.G.S. STATPAC System maintained by the Branch of Regional Geochemistry, Denver (Miesch, 1976; Van Trump and Miesch, 1977). Programs which will be used include basic moment statistics, analysis of variance, correlation analysis, R-mode factor analysis, and Q-mode factor analysis. Computer graphics of results will be done using basic software routines on a Calcomp plotter interfaced with the Honeywell computer, Denver Federal Center.

References:

Huffman, Claude, Jr., and Dinnin, J. I., 1976, Analysis of rocks and soils by atomic absorption and other methods, in Miesch, A. T., Geochemical survey of Missouri - methods of sampling, laboratory analysis, and statistical reduction of data: U.S. Geol. Survey Prof. Paper 954-A, p. A12-A14.

Myers, A. T., Havens, R. G., and Dunton, P. J., 1961, A spectrochemical method for the semiquantitative analysis of rocks, minerals, and ores: U.S. Geol. Survey Bull. 1084-I, p. 207-229.

Miesch, A. T., 1976, Geochemical survey of Missouri - methods of sampling, laboratory analysis, and statistical reduction of data: U.S. Geol. Survey Prof. Paper 954-A, 39 p.

Nakagawa, H. M., and Harms, T. F., 1968, Atomic absorption determination of cadmium in geologic materials, in Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600-D, p. D207-D209.

Van Trump, George, Jr., and Miesch, A. T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geosciences (in press).

Vaughn, W. W., 1967, A simple mercury vapor detector for geochemical prospecting: U.S. Geol. Survey Circ. 540, 8 p.

Wahlberg, J. S., 1976, Analysis of rocks and soils by X-ray fluorescence, in Miesch, A. T., Geochemical survey of Missouri - methods of sampling, laboratory analysis, and statistical reduction of data: U.S. Geol. Survey Prof. Paper 954-A, p. A11-A12.

VII. EXPECTED RESULTS

Results of the proposed investigation, together with results of analyses of samples collected in the summer of 1976, should provide sufficient data on the chemical composition of bottom sediments in the shelf-slope-canyon system in the vicinity of the St. George Basin, southern Bering Sea, to characterize the dynamics of sediment dispersal in this region, and the influences of sediment dispersal on the distribution of trace metals. These data should provide an estimate of the regional components (baselines) of geochemical variability in surface sediments on the outer continental shelf and continental slope in the southern Bering Sea. These data will also be used to determine the magnitude of local variability in surface sediments on the shelf and slope in order to provide a "meterstick" with which to measure future variations from the geochemical baselines.

VIII. ANTICIPATED PROBLEMS

None

IX. DATA PRODUCTS

Processing - yes

Formatting - Data obtained by the proposed research will be in the U.S.G.S. STATPAC format which is a two-dimensional matrix of samples (rows) and element concentrations (columns). Additional information provided as output from the U.S.G.S. RASS system includes sample descriptions, latitude and longitude of sample stations, and any additional information supplied by the submitter at the time of sample submittal.

Data Product	Media	Estimated Volume
Element concentration values Station locations Depth Sediment type Environment of deposition Size fraction	coding sheets data tables punched cards and/or magnetic tapes	50 sample stations concentration values for 38 elements in 75 samples
Maps of element concentrations	maps	

X. PRODUCTS

1. Narrative reports of trace element composition and distribution in sediments collected during the proposed investigation integrated with results obtained on analyses of samples collected on the 1976 U.S.G.S. Cruise S76-4.

2. Tables of raw data as well as output from U.S.G.S. STATPAC programs including analysis of variance, basic moment statistics, R-mode factor analysis, and Q-mode factor analysis.

3. Visual data in the form of contour maps of concentrations for most of the 38 elements for which we anticipate obtaining data.

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

Although the information obtained by the proposed research could stand alone, an attempt will be made to integrate the following information: 1. results of analyses for organic carbon, grain size, and mineralogy obtained on the same samples by the U.S.G.S. Marine Geology laboratories in Menlo Park, California (Gardner and Vallier, RU206); 2. sub-bottom seismic reflection data obtained as part of the underway geophysical program of the R/V Sea Sounder (Gardner and Vallier, RU206); 3. results of trace element analyses of bottom sediments from the northern Bering Sea (Nelson, RU413).

XII. CALIBRATION AND INTERCOMPARISON

A total of 24 samples of surface sediments from the St. George Basin, collected on the 1976 cruise, have been sent to Dave Robertson of Battelle Northwest Laboratories (RU506) for analysis of trace elements by Neutron Activation. Results of these analyses will be used for intercalibration with results obtained by other methods by the U.S.G.S. Analytical Laboratories.

XIII. DATA SCHEDUAL

Data will be submitted for cruise.

The first data will be collected in August, 1977. The data collection effort will be finished in September, 1978.

Data will be submitted to the Field Project Offices for inclusion in the data base in October, 1978.

XIV. SPECIAL SAMPLE AND SPECIMEN ARCHIVAL PLANS

All raw bulk samples will be archived at the U.S.G.S. Office of Marine Geology, Menlo Park, California. In addition, bulk samples ground for chemical analyses will be archived in the U.S.G.S. Branch of Regional Geochemistry, Denver, Colorado, and will be available for sampling by other investigators. No cost of archiving will be charged.

XV. LOGISTIC REQUIREMENTS

Ship support will be provided by the Office of Marine Geology, U.S.G.S., Menlo Park, California (Gardner and Vallier, RU206).

XVI. MANAGEMENT PLAN

Management and activities are explained by the activity/milestone chart below:

	FY 77		FY 78												FY 79
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Sample collection	s--	f													
Sample analysis			s--	--	--	--	--	f							
Statistical analyses of data								s--	--	--	--	f			
Preparation of element maps									s--	--	--	--	f		
Preparation of tables based on statistical analyses										s--	--	--	f		
Report writing												s--	--	--	f

s - beginning of activity
f - end of activity
-- - period of time over which an activity occurs

Bibliography

(A) Dean, W.E., Jr. and Anderson, R.Y., 1965, Pennsylvanian flysch sedimentation, Marathon Region, Texas: in New Mexico Geological Society Guidebook to southwestern New Mexico 11, p. 238 (abs.).

(A) ________, 1966, Correlation of laminae within the Permian Castile formation, Delaware Basin, Texas and New Mexico: in New Mexico Geological Society Guidebook, 17th Annual Field Conference, p. 119-120x (abs.).

(P) Kirkland, D.W., Bradbury, J.P., Dean, W.E., Jr., 1966, Origin of the Carmen Island salt deposits, Baja, California, Mexico: Jour. Geology, v. 74, p. 932-938.

(P) Dean, W.E., Jr., and Anderson, R.Y., 1967, Correlation of turbidite strata in the Pennsylvanian Haymond Formation, Marathon Region, Texas: Jour. Geology, v. 75, p. 59-75.

(A) Dean, W.E., Jr., Anderson, R.Y., and Cruft, E.F., 1967, Chemical variations in the varved Permian Castile Anhydrite, Delaware Basin, Texas: Geol. Soc. America Program, 1967 Annual Meeting, New Orleans, p. 44-45 (abs.).

(A) Dean, W.E., Jr., 1969, Freshwater iron-manganese "nodules" in Oneida Lake, New York: Geol. Soc. America Program, 1969 Annual Meeting, Atlantic City, p. 45 (abs.).

(P) Dean, W.E., Jr., 1970, Ferromanganese oxidate crusts, Oneida Lake, New York: 13th Annual Great Lakes Research Conf. Proceedings, p. 217-226.

(P) Anderson, R.Y., Dean, W.E., Jr., Kirkland, D.W., and Snider, H.I., 1972, Permian Castile varved evaporite sequence, West Texas and New Mexico: Geol. Soc. Am. Bull., v. 83, p. 59-86.

(A) Dean, W.E., Jr., and Megard, R.O., 1973, Control of phytoplankton photosynthesis on precipitation of $CaCO_3$: Geol. Society of America Abstracts with Programs, v. 5, p. 594-595 (abs.).

(P) Dean, W.E., Ghosh, S.K., Krishnaswami, S., and Moore, W.S., 1973, Geochemistry and accretion rates of freshwater ferromanganese nodules: in International Symposium on the Origin and Distribution of manganese nodules in the Pacific, National Science Foundation, International Decade for Ocean Exploration.

(P) Dean, W.E., Jr., 1974, Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods: Jour. Sed. Pet., v. 44, p. 242-248.

(P) Gorham, E., Lund, J.W.G., Sanger, J.E., and Dean, W.E., Jr., 1974, Some relationships between algal standing crop, water chemistry, and sediment chemistry in the English lakes: Limnol. Oceanog., v. 19, p. 601-617.

(P) Dean, W.E., and Anderson, R.Y., 1974, Trace and minor element variations in the Permian Castile Formation, Delaware Basin, Texas and New Mexico, revealed by varve calibration: Fourth International Symposium on Salt, Cleveland, Northern Ohio Geological Society, v. 1, p. 275-285.

(P) Dean, W.E., and Tung, A.L., 1974, Trace and minor elements in anhydrite and halite, Supai Formation (Permian), east central Arizona: Fourth International Symposium on Salt, Cleveland, Northern Ohio Geological Society, v. 1, p. 287-301.

(P) Dean, W.E., Jr., and Anderson, R.Y., 1974, Application of correlation coefficient techniques in time series analysis: Jour. Intern. Assc. Math. Geol., v. 6, p. 363-372.

(A) Eggleston, J.R., and Dean, W.E., 1974, Microstructure of freshwater stromatolites revealed by scanning electron microscopy: Geol. Soc. Am. Abs. with Programs (annual meeting, Miami Beach), v. 6.

(A) Ghosh, S.K., and Dean, W.E., 1974, Factors contributing to precipitation of major, minor, and trace elements in ferromanganese nodules and associated sediments, Oneida Lake, N.Y.: Geol. Soc. Am. Abs. with Programs (annual meeting, Miami Beach), v. 6.

(P) Shilts, W.W., and Dean, W.E., 1975, Permafrost features under Arctic lakes, District of Keewatin, Northwest Territories: Can. Jour. Earth Sci., v. 12, p. 649-662.

(P) Shilts, W.W., and Dean, W.E., 1975, Periglacial features in eastern arctic lakes, District of Keewatin, N.W.T.: Verh. Int. Ver. Limnol., v. 19, p. 3212-3220.

(P) Dean, W.E., 1975, Shallow-water versus deep-water evaporites: discussion: Am. Assoc. Petrol. Geol. Bull., v. 59, p. 534-535.

(P) Dean, W.E., and Eggleston, J.R., 1975, Comparative anatomy of marine and freshwater algal reefs, Bermuda and Central New York: Geol. Soc. Amer. Bull., v. 86, p. 665-676.

(P) Dean, W.E., Davies, G.R., and Anderson, R.Y., 1975, Sedimentologic significance of nodular and laminated anhydrite: Geology, v. 3, p. 367-372.

(A) Ghosh, S.K., and Dean, W.E., 1975, Geochemistry of sediments and interstitial waters, Oneida Lake, New York: Geol. Soc. Amer. abs. with Programs (Northeast Section meeting, Syracuse, N.Y.), v. 7.

(A) Effler, S.W., and Dean, W.E., 1975, Chemical stratigraphy of Onondaga Lake sediments: Geol. Soc. Amer. Abs. with Programs (Northeast Section meeting, Syracuse, N.Y.), v. 7.

(A) Dean, W.E., and others, 1975, Cyclic sedimentation in the eastern North Atlantic - Deep Sea Drilling Project, Leg 41: Geol. Soc. Amer. Abs. with Programs (annual meeting, Salt Lake City), v. 7.

(P) Shilts, W. W., and Dean, W. E., and Klassen, R. A., 1976, Physical, chemical, and stratigraphic aspects of sedimentation in lake basins of the eastern arctic shield: Geol. Survey of Canada Paper 76-1A, p. 245-254.

(P) Dean, W. E., and Gorham, Eville, 1976, Major components of Minnesota lake sediments: Limnol. Oceanog., v. 21, p. 259-284.

(P) Eggleston, J. R., and Dean, W. E., 1976, Freshwater stromatolitic bioherms in Green Lake, New York, in Walter, M. R., ed.. Stromatolites: Elsevier Publ. Co., p. 479-488.

(P) Dean, W. E., and Gorham, E., 1976, Classification of Minnesota lakes by Q- and R-mode factor analysis of sediment mineralogy and geochemistry, in Merriam D. F., ed., Quantitative Techniques for the Analysis of Sediments: Oxford, Pergamon Press, p. 61-71.

(O) Ringrose, C. D., Klusman, R. P., and Dean, W. E., 1976, Soil chemistry in the Piceance Creek Basin, in U.S. Geological Survey, Geochemical survey of the western energy regions: U.S. Geol. Survey Open-file Rept. No. 76-729, p. 101-111.

(O) Dean, W. E., 1976, Geochemistry of Green River oil shale, in U.S. Geological Survey, Geochemical survey of the western energy regions: U.S. Geol. Survey Open-file Rept. No. 76-729, p. 48-56.

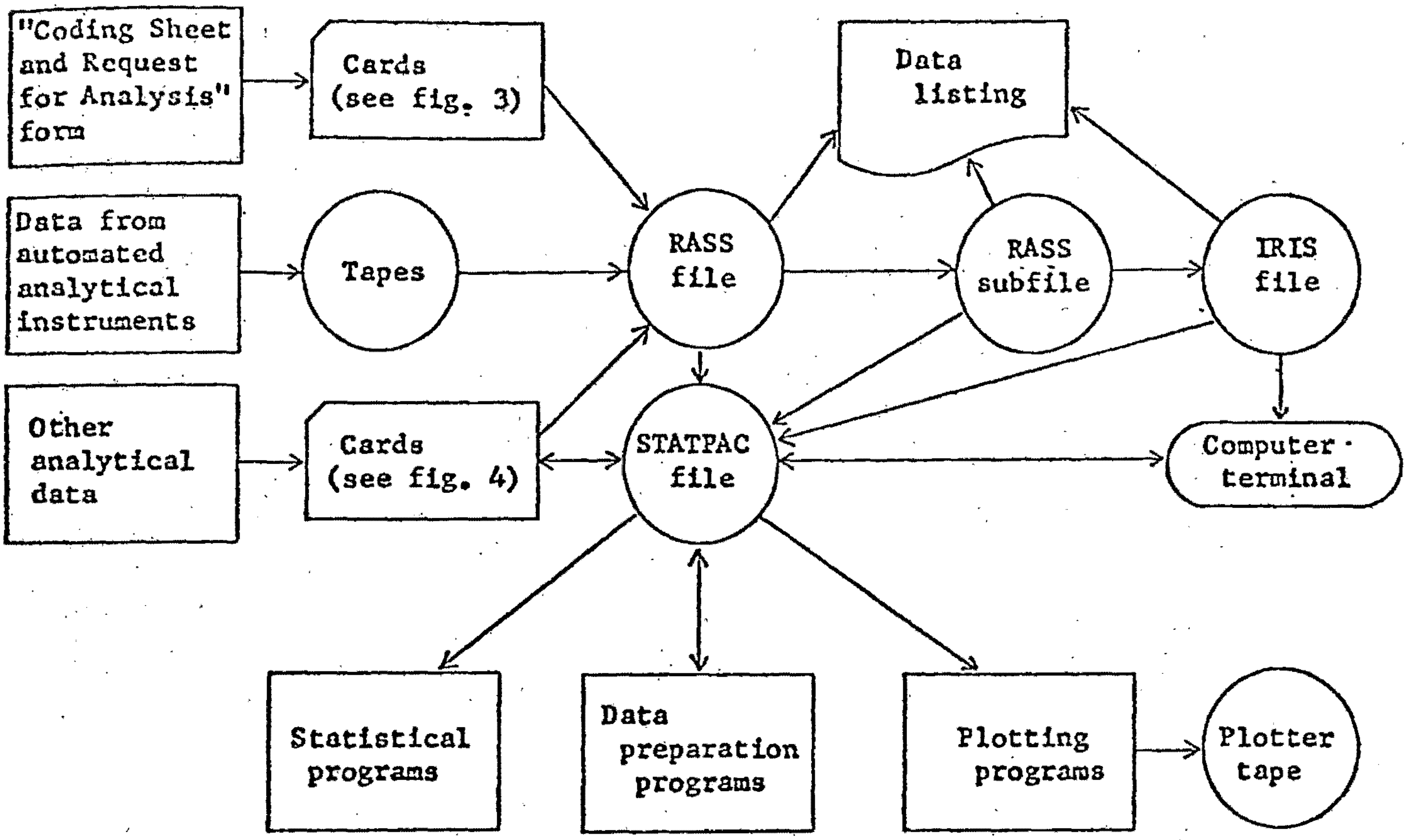
(A) Dean, W. E., and Schreiber, B. C., 1976, Authigenic barite in the eastern north Atlantic, Leg 41, Deep Sea Drilling Project (abs.): Geol. Soc. America, Abstracts with Programs, v. 8, no. 6, p. 830-831.

(A) Moore, W. S., Dean, W. E., and Krishnaswami, S., 1976, Episodic growth of ferromanganese nodules in Oneida Lake, New York (abs.): Geol. Soc. America, Abstracts with Programs, v. 8, no. 6, p. 1016-1017.

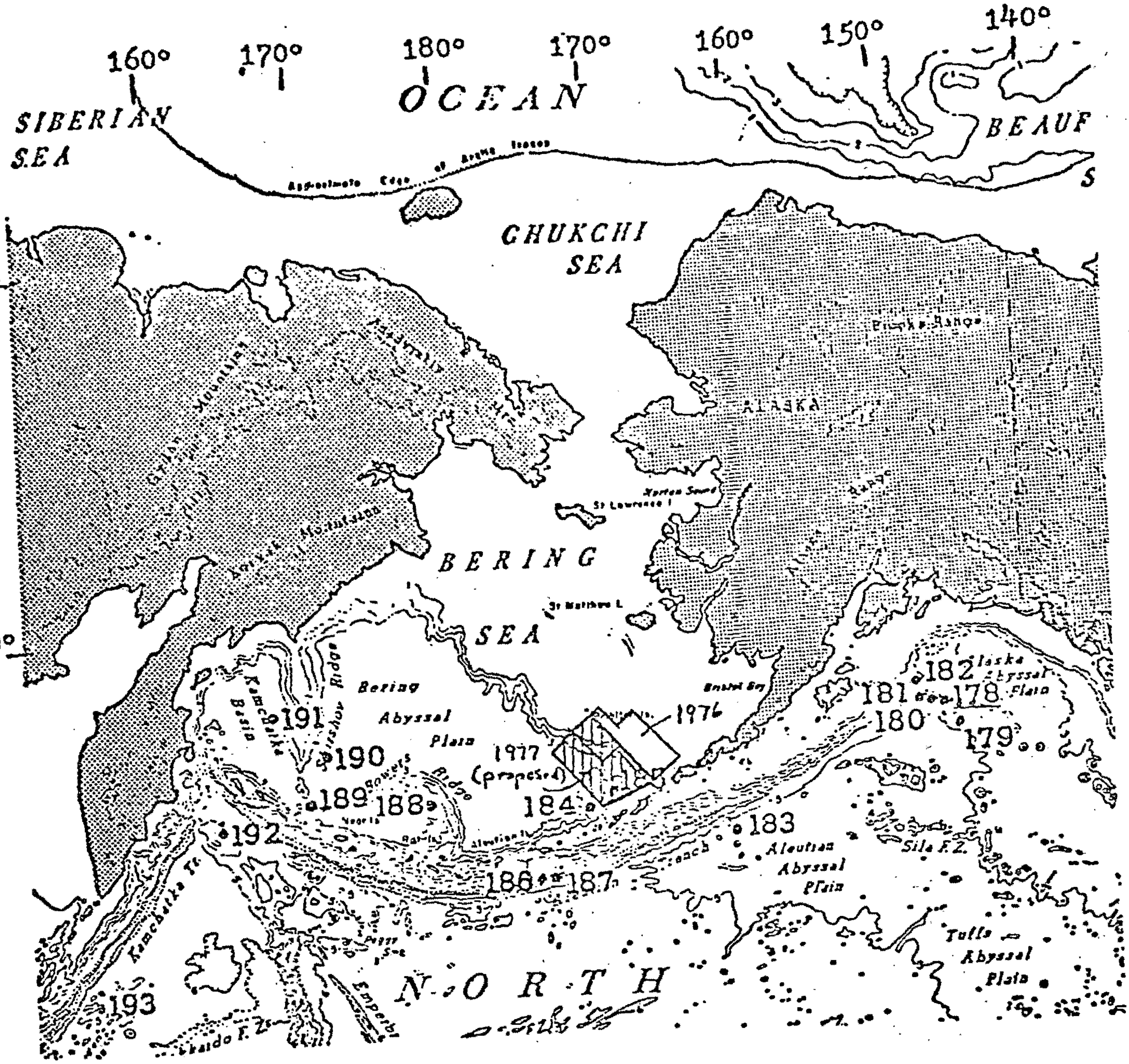
(P) Dean, W. E., and Schreiber, B. C., 1977, Authigenic barite, Leg 41, Deep Sea Drilling Project, in Lancelot, Y., Seibold, E., et al., Initial Reports of the Deep Sea Drilling Project, v. 41, Washington, U.S. Govt. Printing Office.

(P) Dean, W. E., Gardner, J. V., Jansa, L. F., Cepek, P., and Seibold, E., 1977, Cyclic sedimentation along the continental margin of northwest Africa, in Lancelot, Y., Seibold, E., et al., Initial Reports of the Deep Sea Drilling Project, v. 41, Washington, U.S. Govt. Printing Office.

(P) Gardner, J. V., Dean, W. E., and Jansa, L. F., 1977, Sediments recovered from the northwest African continental margin, Leg 41, Deep Sea Drilling Project, in Lancelot, Y., and Seibold, E., et al., Initial Reports of the Deep Sea Drilling Project, v. 41, Washington, U.S. Govt. Printing Office.



Generalized diagram of the U.S.G.S. RASS-STATPAC System (from VanTrump, George, Jr., and Miesch, A. T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geosciences (in press)



Locations of proposed investigations for 1976 and 1977, outer continental shelf and continental slope, southern Bering Sea, Alaska. Numbers are Deep Sea Drilling Project sites.

PROPOSAL TO OCSEAP

TITLE: Analysis, Storage and Dispersement of Marine Coastal Sediment Reference Samples

RESEARCH UNIT: 557

PRINCIPAL INVESTIGATOR: Dr. William D. MacLeod, Jr.
(SSN: 353-24-6186)

TOTAL COST: $20,100

PERIOD OF WORK: Fiscal year 1978

INSTITUTION AND DEPARTMENT: NOAA National Analytical Facility
Environmental Conservation Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112

SUBMITTED BY:

William D. MacLeod, Manager, NOAA National Analytical Facility
Environmental Conservation Division, NWAFC, NMFS, NOAA
2725 Montlake Boulevard East
Seattle, Washington 98112

Phone: (206) 442-4240; FTS 399-4240

APPROVED BY:

Donald C. Malins, Director, Environmental Conservation Division
NWAFC, NMFS, NOAA
2725 Montlake Boulevard East
Seattle, Washington 98112

Phone: (206) 442-7737; FTS 399-7737

Title: Analysis, Storage, and Dispersement of Marine Coastal Sediment Reference Samples

Objective: Receive and analyze prehomogenized marine coastal sediment samples to be used as a reference and intercalibration material for heavy hydrocarbon analysis; distribute these samples to cooperating principal investigators and collate analytical reports from them.

Principal Investigator: Dr. William D. MacLeod, Manager
NOAA National Analytical Facility (NAF)
Environmental Conservation Division
Northwest and Alaska Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98112

Introduction: Standard reference material is needed to evaluate the efficiency and reliability of analytical procedures and techniques employed by various investigators and laboratories in hydrocarbon analyses. In this NAF study, aliquots of the homogenized samples previously prepared will be analyzed for alkanes and arenes using glass capillary gas chromatography (GC), UV fluorescence, and mass spectrometry (MS); major compounds will be identified by GC/MS. Upon verification that the homogeneity of the proposed reference sediment is acceptable within experimental error (*ca.* ± 25% rel. std. dev.), samples of the reference material will be distributed to various hydrocarbon analytical labs for analyses. NAF will collate the reports of the analytical results from these laboratories and place them in a statistical context for the NOAA/BLM outer continental shelf program.

Work Plan

1. The laboratory will receive approximately 500 frozen sediment aliquots (100-150g wet weight each) and store them frozen until analyzed or distributed. Samples stored longer than 6 weeks will be held in a freezer at -50°C or less.

2. A synthetic standard mixture of 6 *n*-alkanes, one isoprenoidal alkane, and 3 arenes will be prepared and 10 aliquots will be selected and processed through the sediment analysis procedure (spiked reagent blank). The relative standard deviations for the 10 GC peaks and the 3 UV fluorescence maxima will be calculated. Relative standard deviations should not exceed ± 20% for any parameter.

3. Ten sediment aliquots will be randomly selected and analyzed for:
   (a) percent water, total organic extract, total saturated hydrocarbons and total unsaturated hydrocarbons by microgravimetry.
   (b) individual *n*-alkanes from C_{14} to C_{32}, pristane and phytane in the saturated hydrocarbon fraction; selected aromatic hydrocarbons (*o*-xylene, isopropylbenzene, *n*-propylbenzene, indan, 1,2,3,4-tetramethylbenzene, naphthalene, benzothiophene, 2-methylnaphthalene, 1-methylnaphthalene, biphenyl, 2-6-dimethylnaphthalene, 2,3,4-trimethylnaphthalene, fluorene, dibenzothiophene, phenanthrene, anthracene, 1-methylphenanthrene, fluoranthene, and pyrene) in the unsaturated hydrocarbon fraction; analysis will be by glass capillary GC and GC/MS. Concentrations will be reported in units of weight per gram dry sediment.

4. Investigate similar tenfold replicate analyses of "2-,3-, and 4-ring" arenes in the total organic extract by UV fluorescence spectrometry; concentrations will be determined relative to a synthetic standard mixture of naphthalene, phenanthrene, and pyrene.

5. Relative standard deviations and means will be determined for all analyses. If the relative standard deviations of 30 of the 40 GC measurements do not exceed ± 25%, satisfactory aliquot homogeneity is indicated, and NAF will distribute samples of the reference sediment as directed by OCSEAP. Shipping costs will be arranged for separately by OCSEAP.

6. NAF will receive reports of these analyses from the participating laboratories and collate the results with assistance from center statisticians. The results and findings will then be forwarded to OCSEAP.

7. NAF will compare extraction efficiency, ease and reliability of several methods for analysis of hydrocarbons in sediment, e.g.,:
   (a) NAF's tumbled extraction with $MeCl_2$/MeOH
   (b) Quinn's direct extraction with boiling Toluene/MeOH
   (c) Calder's Soxhlet extraction with $MeCl_2$/MeOH
   (d) Shaw's Soxhlet extraction with Benzene/MeOH

   Aliquots of the above homogenized sediment will be analyzed in triplicate for comparison purposes after laboratory personnel are thoroughly familiar with the respective procedures.

Archival of Voucher Specimens of Biological Materials
Collected under the Outer Continental Shelf
Environmental Assessment Program
(OCSEAP) Support

Solicitation No. NOAA 11-78

Research Unit #563

Principal Investigator: William N. Eschmeyer

Total Cost of Project: $ 51,247

Institution: California Academy of Sciences

Departments: Ichthyology, Invertebrate Zoology, Botany, others as needed

Principal Investigator:

William N. Eschmeyer

Dr. William N. Eschmeyer
Director of Research
California Academy of Sciences
Golden Gate Park
San Francisco, CA 94118
(415) 221-5100 (ext. 220)

Other signatures:

George E. Lindsay

George E. Lindsay
Director
California Academy of Sciences
(415) 221-5100 (ext. 224)

Nancy B. Dykes

Nancy B. Dykes
Business Manager
California Academy of Sciences
(415) 221-5100 (ext. 280)

TECHNICAL PROPOSAL

Archival of Voucher Specimens of Biological Materials
Collected under the Outer Continental Shelf
Environmental Assessment Program
(OCSEAP) Support

Solicitation Number: NOAA 11-78

Research Unit Number: 563

Contract Number:

Proposed Date of Contract: May 1, 1978 through April 30, 1979, possible renewal for a like period

II. Principal Investigator: Dr. William N. Eschmeyer, Director of Research and Chairman, Department of Ichthyology, California Academy of Sciences.

Collaborators (same institution):

a. Dr. Welton Lee, Chairman and Curator, Department of Invertebrate Zoology

b. Dr. Tomio Iwamoto, Associate Curator, Department of Ichthyology

c. Dr. Dennis Breedlove, Chairman and Associate Curator, Department of Botany

d. Dr. Sylvia Earle, Curator, Department of Botany (Algae)

e. Dr. Peter Rodda, Chairman and Curator, Department of Geology (including Diatoms and Mollusks)

Invertebrate Coordinator: Dustin Chivers, Senior Scientific Assistant, Department of Invertebrate Zoology

III. COST OF PROPOSAL

$51,247

IV. BACKGROUND

The California Academy of Sciences, founded in 1853, is a non-profit research and educational natural history museum consisting of scientific departments, support departments, an aquarium, planetarium, and display halls. The primary purposes of the Academy are to acquire and maintain scientific collections of specimens, to carry on research on these specimens, to make the collections available to the scientific community, and to interpret the natural world through educational activities, displays, and publications.

A primary concern is permanence of the institution receiving the contract. Natural history museums are stable centers for collections of scientific specimens, more so than most university collections which are subject to changing emphases of biology departments and the strengths of individual scientists (note the recent transfer of all of the Stanford University natural history collections, the collections of Hopkins Marine Station, and the transfer of the University of California invertebrate collections to the California Academy of Sciences). The Academy has demonstrated long-term support for its collections.

All of the Academy departmental research collections are in the top 10 in the United States, with most in the top 2 to 6 nationally. Two departments that will receive the bulk of the OCSEAP material are discussed briefly below. Besides these, the Academy's Department of Botany, which includes the recently transferred Dudley Herbarium from Stanford University, would house terrestrial plants and marine algae resulting from the project. Included in the Department of Geology is one of the world's finest diatom collections and library, with much Alaskan material resulting from the activities of G Dallas Hanna; should diatom collections result from the OCSEAP program they could be processed into this collection. The Academy's dry mollusk collection also is part of the Department of Geology and, with the recent inclusion of the Stanford collection, is one of the world's finest; dry mollusks would be placed in this collection and those in preserving fluids in the Department of Invertebrate Zoology. The Academy's Department of Ornithology and Mammalogy also would accept specimens from this contract if any should become available, and this department is especially strong in western North American species, including emphasis on marine mammals.

The latest Annual Report for the Academy is submitted as additional information but not included as part of the proposal.

Department of Ichthyology

The collection of fishes at the California Academy of Sciences has been ranked as the second most important fish specimen resource in the United States by the Advisory Committee for the Development of a National Plan for Ichthyology (Copeia, 1976, no. 3, pp. 625-642). It contains over 1 million specimens, in 175,000 lots, representing about 14,000 nominal species, and primary and secondary type specimens representing about 3,000 species. It is worldwide in scope, with especially important collections from North America, Japan, Asia, the central and western Pacific and South America. The collection is housed in facilities which were expanded in 1967 and 1968 with the assistance of the National Science Foundation. Additional space will be made available in early 1978. The collection is widely and intensively used, both nationally and internationally by scientists and students. It is of considerable historical importance because of its age, the large number of publications based on it, the large number of type specimens, and its continued use by scientists and students. It provides a data base to governmental agencies concerned with environmental quality and endangered species, and it serves as a principal source of research materials for scientists and students. The collection has received considerable financial support from the National Science Foundation, for remodeling in 1967, for incorporation of the Vanderbilt and Stanford University collections, and is currently supported by an NSF curatorial support grant.

The present staff includes the following:

Dr. William N. Eschmeyer, Chairman and Curator
Dr. Tomio Iwamoto, Associate Curator
Dr. Warren Freihofer, Associate Curator
Mrs. Lillian J. Dempster, Associate Curator (parttime)
Mr. W. I. Follett, Curator Emeritus
Ms. Pearl M. Sonoda, Senior Scientific Assistant
Mr. James Gordon, Curatorial Assistant
Mr. William C. Ruark, Curatorial Assistant
Mrs. Betty A. Powell, Secretary

The fish fauna off California is very similar to that off Alaska, with the exception of areas west of the Aleutians. The Academy holds extensive collections from off western U.S. as well as Japanese specimens. Specimens from Alaska are not well represented in fish collections. The Academy's Alaskan holdings include specimens collected by the ALBATROSS 1906 North Pacific Cruise (Japan, Aleutian Islands, and Kamchatka), specimens collected from 1949-52 by a number of Stanford scientists and students working out of Point Barrow, and other smaller collections.

The Department of Ichthyology has had experience processing large collections, such as the incorporation of the 40,000-bottle Vanderbilt Foundation collection and the 75,000-bottle Stanford collection into the departmental collection. It serves as a repository for specimens from scientists, and from Federal and State agencies and some private ones, such as the Department of Fish and Game of California, several universities, NMFS Seattle Laboratory rockfish project, ERDA Farallon Islands dump site project, and some private consulting firms in the Bay Area.

Additional information is provided on this department by submission of portions of a funded NSF grant entitled, "Support for the care and use of the Collection of fishes at the California Academy of Sciences." One copy is provided, and it is not considered a formal part of this proposal.

Department of Invertebrate Zoology

The Department of Invertebrate Zoology has developed into one of the major repositories of preserved invertebrates in North America. It has extensive collections from Baja California, Central America, the Galapagos Islands, Alaska, British Columbia, and Southeast Asia. Alaskan holdings of importance include the U.S. fur seal investigations of 1919-21, the Department of Naval Research Pt. Barrow project in the 1950's, the U.S. Department of Interior Alaska Earthquake Study of 1965, the G.E. MacGinitie Naval Research project 162-911 that resulted in the publication, "Distribution and ecology of the marine invertebrates of Pt. Barrow, Alaska" (Smithson. Publ. vol 128), specimens collected by the Stanford University expedition in 1951, and many collections resulting from G. D. Hanna's work on Alaskan mollusks and his long-standing involvement in Alaskan biology.

This department also has had extensive experience serving as a voucher specimen repository for a variety of agencies. Recent additions include deposition of specimens by the California Department of Fish and Game (Fort Ross to Pt. Lobos, Point Arena Reactor Site Study), Monterey Bay Benthos Study by Hopkins Marine Station, Moss Landing Monterey Bay Study for the City of Watsonville, Santa Cruz Intertidal Study, Stanford Research Institute collections, EPA Farallon Radioactive Dump Site Study, Brown and Caldwell, Inc. Gulf of the Farallons study and Five-county Study of Sewage Disposal Sites, U.S. Geological Survey of South San Francisco Bay, U.S. Bureau of Reclamation Delta-Mendota Canal Study, U.S. Army Corp of Engineers Mouth of the Columbia River Baseline Study, the San Francisco International Airport Outfall Study, etc.

The Department of Invertebrate Zoology staff consists of the following:

Dr. Welton Lee, Chairman and Curator
Mr. Dustin D. Chivers, Senior Scientific Assistant
Dalene R. Drake, Curatorial Assistant

The Department is augmented by 4 Associates, 2 Field Associates, and other personnel working on specific grants, such as the San Francisco Bay Project which was funded by Sea-grant and several private foundations. This project involves the preparation of voucher specimen collections from this region, preparation of literature files, and the preparation of identification manuals.

The Department's facilities and collections are growing rapidly, and its collections form one of the largest and best curated invertebrate collections in the western United States. Numerous private and governmental agencies have recognized it as a desirable archival depository, and they have turned over extensive and biologically significant collections and associated data bases to the Academy for long term curation.

V. OBJECTIVES

1. Establish and maintain a fully cataloged museum collection of biological voucher specimens collected under the auspices of the Alaskan OCS Environmental Studies Program.

2. Specify appropriate collection and preservation techniques for various marine taxa.

3. Coordinate the shipment of preserved materials from other principal investigators to the archive.

4. Provide quarterly ADP formatted data summaries on the status and content of the collections.

VI. GENERAL STRATEGY AND APPROACH

1. Voucher Policy

In conjunction with the designated OCSEAP representatives, the voucher policy will be finalized. The draft voucher policy is well done and needs only minor modification in our opinion (for example, propylene phenoxetol and propylene glycol are probably not essential for field preservation of most general plankton collections). The curators of each pertinent Academy department will participate in preparing the voucher policy.

If the voucher specimen labels have not been printed, we suggest the addition of "number of specimens" in the lot. If it was thought desirable by the Project Coordinator, we would add catalog numbers directly to the voucher specimen labels, in which case provision for this could be made on the labels.

Instructions and tips on packing and shipping specimens to the archive will be prepared, along with a listing of any additional information desired by the archive from principal investigators (such as preserving solution from which specimens were removed, how to prepare invoices of specimens if needed, etc.)

2. Processing of Specimens

Location of work--In the spring of 1978, a 1152-sq. ft. room will be modified for use by the Department of Ichthyology. Funds are on hand for this rennovation, which includes construction of a workroom with sink and installation of 1727 sq. ft. of metal shelving. The Department of Ichthyology will not need most of this room for several years, and it is proposed that this area be used for the initial processing of specimens from this project.

Initial curation of specimens (in project workroom)--
a. Acknowledge receipt of each shipment
b. Unpack shipment, check against invoice
c. Transfer to final preserving solution and container
d. Examine quality of identifications and labeling (by appropriate Academy curator).

e. Catalog specimens in appropriate departmental collection. This provides each lot or sample with a unique number.
f. Enter data in computer (see 4 below).
g. Place on shelves in systematic order in the project workroom.

Provide sender of shipment and NOAA coordinator with a printout of contents of shipment after processing and cataloging.

Confirm identifications--Academy scientists and visiting scientists will be encouraged to examine the project material in their area of specialty to confirm identifications and correct identifications, adding an appropriate identification label documenting their identification. Note that we have included some funding in the proposal for reimbursement of expenses of specialists for confirming identifications in their area of specialty. We have had these funds available for visitors upgrading identifications in the general collections. The contribution to any one investigator is small, and some graduate students have been paid hourly to spend additional time during a visit to upgrade identifications in their area of specialty.

Subsequent integration with appropriate departmental collection--It is desirable that during the project, or initial portion of the project, that the specimens resulting from this project be kept isolated to facilitate their study. At a later date they will be transferred to the departmental scientific collections. (Proper care of the voucher specimens is insured if they are in the general collections where, for example, alcohol levels are checked routinely or botanical collections are fumigated regularly, and the voucher specimens are available for subsequent study by visiting scientists.)

It is tentatively proposed to distinctively mark the containers resulting from this project. For example, each of the 40,000 bottles of the Vanderbilt fish collection were marked before their incorporation into the Academy fish collection in 1968. Also, a note will be placed on the label or in the bottle indicating that these voucher specimens may not be loaned.

3. Personnel Strategy (See Appendix for additional information on key project personnel)

The principal investigator has strong interests in the fish fauna from the area involved and will, besides supervising the project, participate actively in aspects of the project dealing with fishes. He will devote 25% of his time to the project. (Should this proposal be funded, he will relinquish the chairmanship of the Department of Ichthyology to provide time for the project.)

The Senior Assistant and Invertebrate Coordinator has had extensive experience in identification and curation of invertebrates, especially from the N. Pacific, and he will supervise the processing of invertebrate groups as well as oversee purchase of all supplies and equipment.

Curatorial assistants will be hired as soon as shipments in sufficient volume are received. We want to employ two halftime assistants, one specializing in fishes and one in invertebrates. It is expected that existing Academy curatorial assistants will be interested in switching to this project, and halftime of their current position will be filled by new personnel.

For certain specialty groups and anticipated low-volume ones, such as algae or terrestrial plants, we propose using appropriate Academy technicians and reimbursing their departments for time spent on this project through the inclusion of hourly funds in the budget.

3. ADP Strategy

"Computerizing" large specimen collections is in its infancy, and most such attempts have been heavily funded as experimental studies. Use of large computers and generalized cumbersome programs have not been as satisfactory as the use of mini computers with immediate access and with data entry by departmental curatorial assistants rather than computer technicians. At the present time the Academy's Department of Herpetology has a mini computer that perhaps could be used for the present project with the addition of more memory units, but the Academy is currently examining larger mini computers with remote terminals, and it is anticipated that purchase of such equipment will be made in the near future. Should the purchase of a central Academy computer system not be accomplished in time for the present project, it is proposed that a self-contained mini (such as an HP 1000 or IBM 5110) be leased for this project.

Formatting will be done as prescribed in the RFP, with the Principal Investigator and Dr. Alan Leviton of the Academy's Department of Herpetology representing the Academy.

All project personnel will be trained in data entry. If a separate catalog label is prepared it will be done concomitantly with data entry.

The data base probably will be kept on disks and will be converted to tapes for quarterly submission.

VII. SAMPLING METHODS

Not applicable.

VIII. ANALYTIC METHODS

Not applicable.

IX. ANTICIPATED PROBLEMS

Despite the well thought out and specified voucher policy provided by NOAA to principal investigators involved in activities resulting in voucher specimens, we anticipate that a few investigators will not follow this policy and will ship to the archive extraneous materials collected during their study. Working through the NOAA Coordinator, we would want to assist in selecting proper voucher specimens in these cases.

We do not anticipate additional problems unless the amount of material to be deposited far exceeds the volume we anticipate at this writing.

X. DELIVERABLE PRODUCTS

A. Digital Data

To be worked out with NOAA's Environmental Data Service. Digital tapes to be submitted quarterly as required.

Parameters

These will be established with the NOAA Project Coordinator. The format minimally should provide for data retrieval by taxon, NODC Code number, catalog number, geographic location, and project, but also should provide more detailed information as needed by principal investigators, such as lists of vouchers by vessel station numbers, etc.

For each voucher specimen lot we would enter all the information on p. 16 of the RFP, along with the number of specimens in the lot, the catalog number, and provisions for future reidentifications. We also would add our own internal filing code to assist in subsequent retrieval of voucher specimens from the collections. This consists of entry of the department and its filing category (family number in fishes, numerical systematic file number in invertebrates).

List of digital products

See attached Data Products Schedule.

B. Narrative Reports

1. Finalized voucher policy, including preserving techniques.

2. Voucher specimens by project or by each shipment, indicating catalog numbers and reidentifications; to be provided to Project Coordinator and individual principal investigators so that they may include archive voucher catalog numbers in their reports and publications.

3. Other reports as specified in the RFP.

C. Visual Data

None seem to be needed.

D. Other Non-digital Data

None requested.

E. Submission Schedule

As specified in the RFP. See attached schedule (Appendix).

XI. INFORMATION FROM OTHER INVESTIGATORS

We anticipate the need to communicate with principal investigators shipping voucher specimens to the archive. Some labels may lack sufficient data, discrepancies will no doubt occur occasionally, etc. We would like to correspond directly to clarify these problems as they arise. From certain contractors (or from the NOAA Data Base) we might desire lists of stations and associated data, especially from extensive vessel cruises resulting in numerous voucher specimens, so that we may check data on labels, clarify labels that are not completely legible, etc.

Normally when museums or scientists send specimens they prepare a "specimen invoice" and the recipient verifies receipt of the specimens. For the present project, perhaps the principal investigator sending the voucher specimens to the archive will not need to prepare an invoice as long as the specimens are properly labeled and the archive returns a printout of the material received as soon as it is processed.

XII. QUALITY ASSURANCE PLANS

1. Permanence. As discussed under BACKGROUND INFORMATION, the Academy is a stable natural history museum capable of providing long-term care to the voucher specimens deposited in the Academy scientific specimen collections.

2. ADP Committment. As outlined earlier, computer data management of natural history collections is best accomplished on mini computers or direct access terminals, with data entry made by departmental curatorial assistants. We believe the ADP strategy described under item VI(3) will insure prompt submission of accurate data tapes to the NOAA Data Center.

3. Scientific Competence. This is assurred by the training and experience of the organization and its staff, the on-site scientific associates, and the scientific visitors that will confirm identifications while utilizing the extensive Academy collections for systematic research purposes.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLANS

Not applicable.

XIV. MANAGEMENT PLAN

The principal investigator (Eschmeyer) will supervise all aspects of the project, including the preparation of reports, and will report directly to the NOAA Project Coordinator. He will supervise the processing of all fish voucher specimens and conduct all correspondence and related items. He will devote at least 25% of his time to the project.

The Senior Assistant and Invertebrate Coordinator (Chivers) will supervise the processing of non-fish groups and will be responsible for ordering all curatorial supplies and equipment needed for the project.

Curatorial assistants will be drawn from present Academy staff, with replacements for their vacated duties. They will be employed on this project as soon as the level of shipments of voucher specimens warrants. Provision for hourly workers for specialty groups is made.

All project personnel will be trained for data entry into the computer.

See also item VI. GENERAL STRATEGY AND APPROACH.

XV. OUTLOOK

Once voucher specimens are deposited, we will retain and curate them indefinitely. We anticipate that we would be able to provide at little or no cost an updated data base to accommodate reidentifications and changing systematic nomenclature that occur long after the project is terminated.

At the termination of the proposed initial 3-year contract, the cost of an extension would depend on the amount of voucher material still to be deposited by principal investigators. If the voucher material outstanding is extensive, we anticipate that the cost of continuation would be about $30,000 per year until the bulk of the material is deposited. We anticipate little or no subsequent expense, and processing of miscellaneous collections could be done at Academy expense, as is done with small collections from Federal and State agencies and from scientists and other contributors of scientific collections.

We also would like to offer for consideration that the archival center eventually receive for permanent storage certain information generated by principal investigators and subcontractors that might not be deposided or stored elsewhere, such as original field logs from vessel collections.

XVI. STANDARD STATEMENTS

1. Updated Activity/Milestone/ Data Management Charts will be submitted quarterly.

2. Quarterly Reports will be submitted in sufficient time during the contract year to be in OCSEAP hands by the first day of January, July, and October, Annual reports by April 1. The Final Report will be submitted within 90 days of the termination of the contract.

3. At the option of the Project Office the PI is prepared to travel to the Project Office at least twice during the contract year to review project status and progress. Such reviews will be scheduled on dates mutually satisfactory to both parties. It is understood that costs of the travel will be borne by the Project Office.

4. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

5. Data will be submitted within 120 days of the completion of a 3 month data collection period, unless a written waiver has been received from the Project Office.

6. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending deposition at contract termination.

7. Three (3) copies of all publication or presentation manuscripts pertaining to technical or scientific material developed under OCSEAP funds will be submitted to the appropriate Project Office at least sixty (60) days prior to release for information and for forwarding to BLM. The release of such material within a period of less than sixty (60) days shall be made only with prior written consent of the Project Office. News releases will first be cleared with the appropriate Project Office.

8. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship. The following acknowledgment is standard:

> "This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

XVII. OTHER INFORMATION

The principal investigator, William N. Eschmeyer, shall actively lead and supervise the proposed work, and shall take full responsibility for timely completion of all objectives, independent of the percentage of his salary requested in the budget.

ta Type e. Intertidal, nthic Organisms, c.)	Media (Cards, cod-ing sheets, tapes, disks)	Estimated Volume (Volume of processed data)	OCSEAP Format (If known)	Processing and Formating done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)	Submissior (Month/Yea
Voucher specimen data	Disks, converted to tapes for submission	Unknown	To be established	Yes, in conjunction with NOAA	May 1977 to end of project and as long thereafter as desired	Beginning Sept. 1978; quarterly thereafter

MILESTONE CHART

RU #: 563 PI: William N. Eschmeyer

Δ Actual Completion

Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Finalize voucher policy							Δ	Δ							
Prepare shipping instructions for principal investigators sending specimens to the archive							Δ	Δ							
Order equipment and supplies							Δ	Δ	Δ						
Establish data format							Δ	Δ	Δ	Δ					
Process voucher specimens									Δ	Δ	Δ	TO	END	OF	PROJECT
ADP first operational										Δ					
Confirm identifications, upgrade where possible									Δ	Δ		TO	END	OF	PROJECT
Submission of first data tape to NOAA, quarterly thereafter												Δ			

Publications:

1963. A deepwater trawl capture of two swordfish (Xiphias gladius) in the Gulf of Mexico. Copeia, 1963 (3): 590.

1965. Western Atlantic scorpionfishes of the genus Scorpaena, including four new species. Bull. Mar. Sci., 15 (1): 84-164.

Three new scorpionfishes of the genera Pontinus, Phenacoscorpius and Idiastion from the western Atlantic Ocean. Bull. Mar. Sci. 15 (3): 521-534.

Station data errors for fishes collected by the steamer BLAKE. Copeia, 1965 (2): 236-238

A method for preserving color in biological specimens. BioScience, 15 (5): 361. (With R. A. Waller)

1966. The scorpinofish subfamily Setarchinae, including the genus Ectreposebastes. Bull. Mar. Sci. 16 (2): 349-375. (With B.B. Collett).

1967. A systematic review of the scorpionfishes of the Atlantic Ocean. Dissertation, University of Miami, Florida. 241 pp.

1968. The identity of the 'British' scorpionfish Helicolenus microphthalmus. J. Linn. Soc. (Zool.), 47 (312): 309-314. (With A. Wheeler)

Four advanced larval specimens of the blue marlin, Makaira nigricans, from the western Atlantic Ocean. Copeia, 1968 (2): 414-417. (With H. R. Bullis)

1969. Scorpaenodes muciparus Alcock and a new species of Scorpaenodes from the Indian Ocean, with comments on the limits of the genus. Occ. Pap. Calif. Acad. Sci., no. 76, 11 pp.

A systematic review of the scorpionfishes of the Atlantic Ocean (Pisces: Scorpaenidae). Occ. Pap. Calif. Acad. Sci., no. 79, 130 pp.

1970. Status and provenance of the scorpaenid fish, Scorpaena microlepis Gunter. Copeia, 1970 (1): 193-196.

1971. One Tree Island. Pacific Discovery, 24 (4): 12-33.

Two new Atlantic scorpionfishes. Proc. Calif. Acad. Sci., 37 (17): 501-508.

Three new species os scorpionfishes (family Scorpaenidae) from Easter Island. Proc. Calif. Acad. Sci. 37 (19): 515-527. (With G. R. Allen)

1972. A new species of the scorpionfish genus Helicolenus from the North Pacific Ocean. Proc. Calif. Acad. Sci., 29 (4): 47-53. (With T. Abe)

Sebastes mouchezi, a senior synonym of Helicolenus tristanensis, with comments on Sebastes capensis and zoogeographical considerations. Copeia, 1971 (3): 576-579, 1 fig. (With J. C. Hureau).

Two new scorpionfishes (genus Scorpaenodes) from the Indo-West Pacific, with comments on Scorpaenodes muciparus. Proc. Calif. Acad. Sci., 29 (5): 55-64, 1 fig. (With K. V. Rama Rao)

1973. The hidden world of coral reefs. Saturday Review of the Sciences, Apr., 1973, pp. 51-54.

Two new species of the scorpionfish genus Rhinopias, with comments on related genera and species. Proc. Calif. Acad. Sci., 39 (15): 285-310, 10 figs. (with Y. Hirosaki and T. Abe.)

Two new stonefishes (Pisces, Scorpaenidae) from the Indo-West Pacific, with a synopsis of the subfamily Synanceiinae. Proc. Calif. Acad. Sci., 39 (18): 337-382, 13 figs. (With K. V. Rama Rao)

Range extensions for the scorpionfish Scorpaena isthmensis. Florida Sci. 36 (2-4): 209-211. (With J. D. McEachran)

1974. Fish on stamps. Pacific Discovery, 27 (5): 1-8.

Location of holotypes of Japanese fishes (Jordan and Starks, 1906) and types of Hawaiian fishes (Jordan and Evermann, 1903). Copeia, 1974, no. 2: 566-569. (With V. G. Springer)

1975. The scorpaenid fishes of the Hawaiian Islands, including new species and new records (Pisces: Scorpaenidae). Proc. Calif. Acad. Sci., 40 (11): 265-334, 25 figs. (With J. E. Randall)

1976. The Indo-West Pacific scorpionfish genus Ocosia Jordan and Starks (Scorpaenidae, Tetraroginae), with description of three new species. Matsya, 1: 1-16, 7 figs. (With S. G. Poss)

Review of the scorpionfish genus Maxillicosta (Pisces: Scorpaenidae), with a description of three new species from the Australian-New Zealand region. Bull. Mar. Sci. 26 (4): 433-449. (With S. Poss)

1977. Systematics and biology of the deep-sea fish family Gibberichthyidae, A senior synonym of the family Kasidoroidae. Proc. Calif. Acad. Sci. 41 (6): 215-231. (With D. de Sylva)