Environmental Assessment of the Alaskan Continental Shelf

Program Work Statements

FY 1978

Volume I

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. I

June
1978

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WORK STATEMENTS

FOR FISCAL YEAR 1978

(October 1, 1977 - September 30, 1978)

VOLUME I

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ENVIRONMENTAL RESEARCH LABORATORIES

BOULDER, COLORADO 80303

June 1978

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VOLUME I

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

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Classification of Research Units as to Tasks

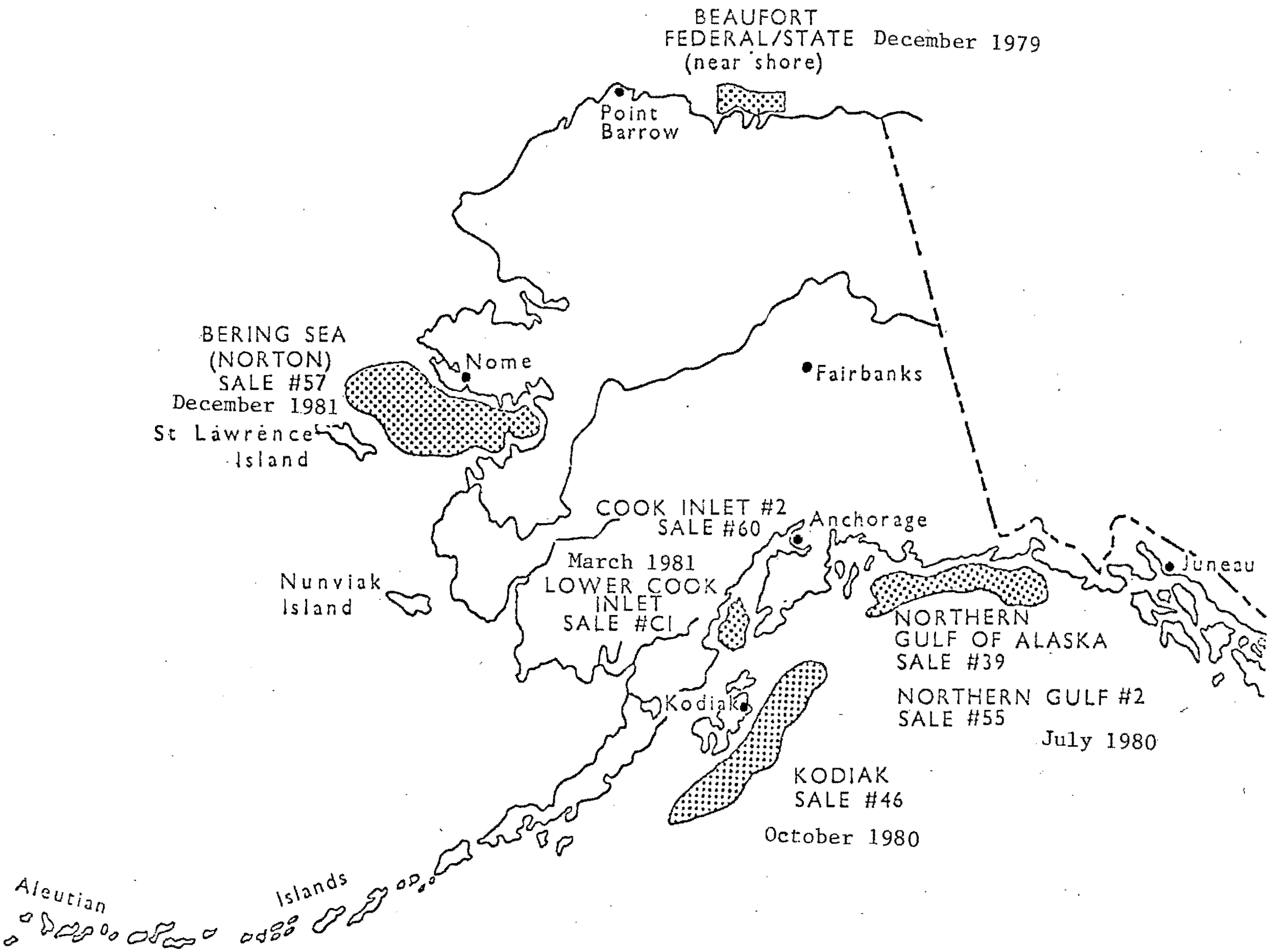
A	C	D	E		F	Data Management
43	16	48	3	232	71	350
152	59	91	5	237	72	351
153	87	138	6	243	73	362
162	88	140	19	248	77	370
275	98	141	29	332	96	468
480	105	208	67	337	389	497
500	204	217	68	341	423	527
506	205	250	69	356	454	545
556	206	257	78	359	460	563
	210	265	83	417	467	
	212	267	108	424		
	251	289	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

IDENTIFICATION, DOCUMENTATION AND DELINEATION OF COASTAL MIGRATORY BIRD HABITAT IN ALASKA

Avifaunal Investigations of the Walrus Islands and Kamishak Bay

Research Unit #3

Principal Investigator

Paul D. Arneson

Alaska Department of Fish and Game

Game Division

June 3, 1977

TECHNICAL PROPOSAL

I. Title: Identification, documentation and delineation of coastal migratory bird habitat in Alaska.

Avifaunal investigations of the Walrus Islands and Kamishak Bay.

Research Unit #3

Contract No. 03-5-022-69

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

II. Principal Investigator: Paul D. Arneson

III. Cost of Proposal:

Total: $71,000

Distribution of Effort
50% (winter) Lower Cook Inlet (Kamishak Bay)
50% (summer) Bristol Bay (Walrus Islands)

IV. Background:

Seabird populations breeding in the Walrus Islands number approximately 1,000,000 birds. The largest colony is on North Twin Island with an estimated 535,000 birds. None of these colonies have been closely scrutinized from the ground. Bird populations on the islands will be a good indicator of environmental degradation by future oil and gas development in the Bristol Bay area. Studies would complement those of George Hunt, RU #83, in the Pribilof Islands and previous studies at Cape Peirce.

Past bird surveys and research in Lower Cook Inlet have not documented bird use of a possible "null zone" south of Augustine Island in Kamishak Bay. Previously RU #3 obtained information only on nearshore bird use. It has been determined that Kamishak Bay will likely serve as a repository for oil pollution in Cook Inlet. It is therefore important to determine bird use of the area prior to oil development. Winter is the season when the least bird research is conducted and yet can be quite critical to bird populations. Ice can concentrate and contain birds and oil causing greater potential for disaster to bird populations. Also, weather in winter is more inclement, increasing probabilities of oil pollution. This study would be tied in with any oceanographic research in Kamishak Bay plus those projects sampling food organisms of birds. This would help determine the reason for specific bird distributions as found in aerial bird surveys.

V. Objectives: **

Walrus Islands

1. To determine phenology of events from arrival to departure of birds.
2. To determine the distribution and abundance of birds.
3. To obtain baseline information on reproductive biology of birds.
4. To describe habitat utilization during the breeding season.
5. To obtain food habit and foraging distance information.

Kamishak Bay, Lower Cook Inlet

1. To determine the winter distribution and abundance of marine birds in relation to ice conditions and other environmental parameters.

VI. Approach: *

Walrus Islands

The field season will be initiated in late April or May to determine arrival dates of seabirds to their colonies. Birds distribution and habitat utilization will be determined prior to nesting. As nesting commences, dates of nest initiation, clutch size, hatching success and fledging success will be determined.

Concurrently, sea watches and transects by raft will be conducted to determine distribution and foraging areas of birds of the Walrus Islands. If possible, radial transects could be flown to determine foraging distances from the colonies. Food habits of seabirds will be determined by collecting selected individuals or by direct observation on the breeding grounds or at the nest site. Various other parameters will be recorded including weather conditions, plant species composition of the colonies, and beached bird information.

Kamishak Bay-Lower Cook Inlet

Aerial surveys will be utilized to determine winter bird distribution and abundance in Kamishak Bay. Because cost prohibits use of aircraft equipped with global navigation systems, line of sight transects will be conducted. Partial shoreline or ice edge surveys will be conducted between transects and also from the Forelands down to Kamishak-Kachemak Bays.

Ice conditions will be noted and bird numbers by species will be recorded. The birds' distribution in relation to prevailing ice conditions will be assessed.

VII. Sampling Methods: *

Walrus Islands

Observations will commence at about the time birds first arrive on the study area. Dates will be recorded as each new species arrives. Sea watches will be conducted on a regular basis to determine the magnitude of migration in the area. The specific colony or colonies to be studied in detail will be determined after a preliminary reconnaissance to the area this summer.

* See Amendment 1

** See Amendments 1 & 2

At the study colonies, dates of nest initiation for each species, clutch size, hatching success, fledging success and departure dates will be determined. Methods used will be the same as those used by other OCSEAP P.I.'s so that data is directly comparable.

Kamishak Bay-Lower Cook Inlet

Transects conducted in Lower Cook Inlet will be of standard width (100 or 200 meters on each side of the aircraft) and of known length so that area and therefore densities of birds will be determined. Birds' location in relation to ice flows and the possible gyre south of Augustine will be recorded.

The first survey will be conducted at the start of severe weather. Two more sampling periods will be conducted as winter progresses and a final survey will be flown at winter's end. Changes in bird distribution as a result of changes in ice conditions will therefore be determined.

VIII. Methods of Analysis

Data from the bird colony study will be analyzed similarly to other OCSEAP colony studies. Tables of breeding biology information and chronology of bird movements will be prepared. Maps of nest locations and general bird distribution and foraging areas will be presented.

For the Kamishak Bay study, species lists with bird densities and their locations will be prepared.

No statistical analysis is anticipated.

IX. Anticipated Problems: *

Not having ready access to colonies best suited for study may pose the biggest problem. The largest colonies are on the Twins and both islands are uninhabitable. Access will be by raft from nearby Crooked Island but frequent inclement weather may preclude visitations on a regular basis.

Extreme weather conditions (either very mild or severe) in Kamishak Bay will affect bird distribution and therefore bias the results of a one-year study.

X. Deliverable Products: *

A. Digital Data:

1. Parameters checked in File Type 033, 035 and 038 on the following pages will be collected and submitted.

2. List of digital products. See attached Data Products Schedule.

B. Narrative Reports:

I will attempt to publish a report on general bird distribution of the Walrus Islands.

* See Amendment 1

C & D. Visual Data and other Non-Digital Data:

No additional visual material other than what appears in required reports is anticipated.

E. Data Submission Schedule:

Data will be submitted within 90 days of the collection as per the attached Milestone Chart. Data submissions will be for four aerial surveys in Lower Cook Inlet and one after the summer field season in the Walrus Islands.

XI. Information Required from Other Investigators:

No data from other investigators is essential for the completion of my task. Arrangements will be made to procure data of use as background information for the project.

XII. Quality Assurance Plans:

Well in advance of any field work contact will be made with other OCSEAP investigators (particularly Hunt RU#83, and Lensink/Bartonek RU #337 and 341) to be certain techniques used will be identical. Few intricate scientific instruments needing absolute accuracy are anticipated. Instruments purchased will be of high quality and tested for accuracy.

XIII. Special Sample Plans:

Approximately 150 samples (largely stomach contents) will be collected and sorted in alcohol at the Alaska Dept. Fish and Game, Anchorage.

XIV. Logistic Requirements: *

See attached forms.

XV. Management Plan:

All proposed work will be under direct supervision of the principal investigator, Paul Arneson. He will be responsible for bird surveys in Lower Cook Inlet and the bird colony project in Walrus Islands.

Qualified temporary field assistants and other personnel of the Alaska Department of Fish and Game will help with data gathering and transcription and laboratory analysis.

The principal investigator will be reaponsible for writing quarterly, annual and final reports and for data submission in EDS format. Data from surveys should be transcribed and keypunched within 60-90 days after the completion of each survey.

See attached milestone chart for activity schedule.

* See Amendment 1

XVI. Outlook:

As has been proven by past OCSEAP bird colony studies, much variation in bird productivity occurs from year to year. To determine baseline information about a given colony, sites should be studied a minimum of two years and preferably more to document natural, annual variation in productivity and mortality. To fully assess banded bird information (including recolonization), a several year study is necessary. Final results would include year to year comparisons prior to oil and gas development. Milestones would be identical to those of the proposed FY 78 project. Costs would be comparable to FY 78 because the increase in salaries and operational costs would be offset by less need for equipment monies. No additional major equipment is anticipated unless replacements are necessary. Logistics requirements would also be similar to those of FY 78 unless more radial aerial transects were necessary to determine foraging distances.

A comparison of two or more year's data would also be beneficial in determining bird use of the "null" zone of Kamishak Bay and Lower Cook Inlet because of suspected large yearly differences. Milestones would be identidal to FY 78 while costs would slightly increase due to increased salaries and aircraft charter rates. Logistics requirements would be similar to FY 78.

XVII. The following statements will be adhered to:

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).

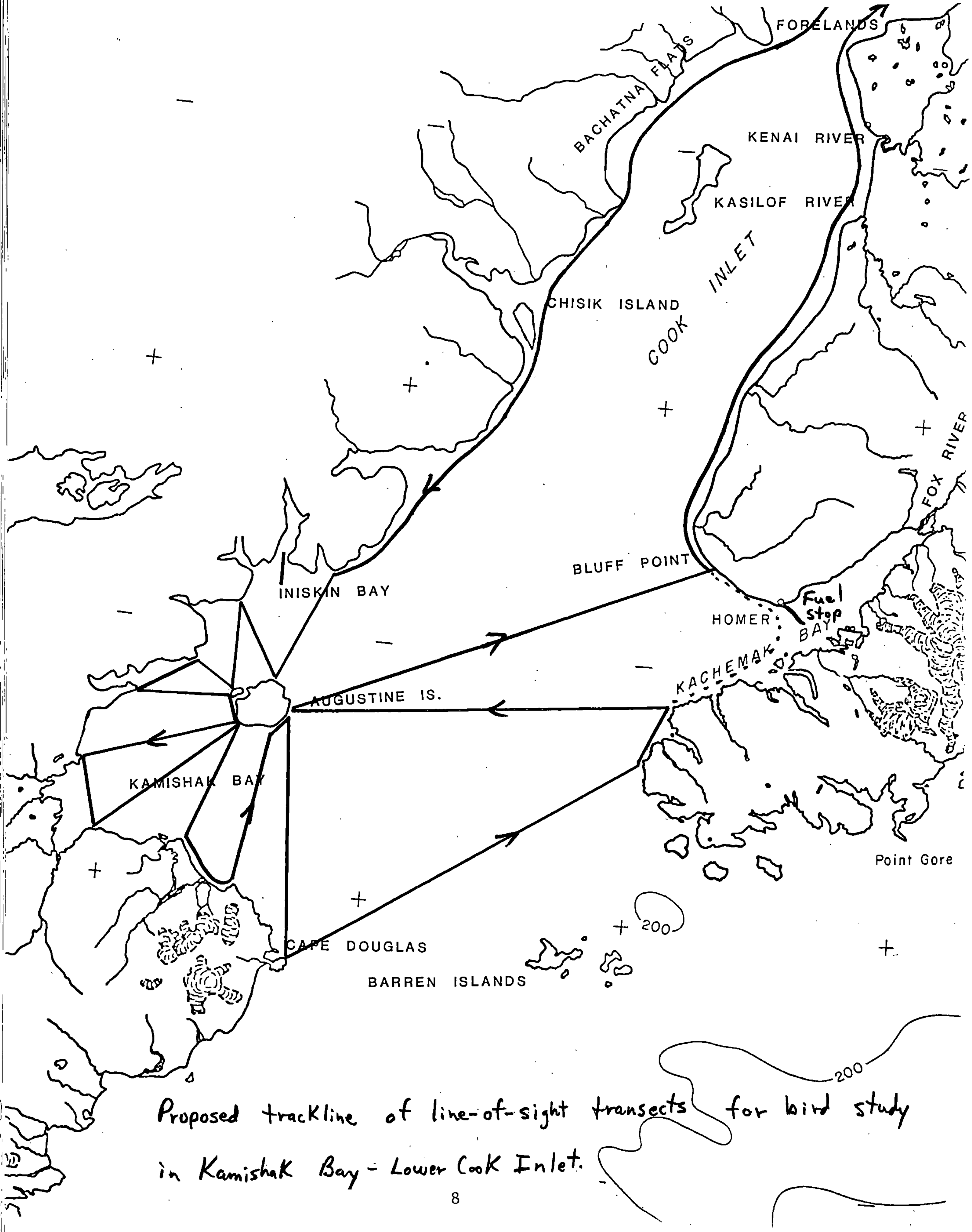
7. Within 10 days of the completion of a cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.

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."



Proposed trackline of line-of-sight transects for bird study in Kamishak Bay - Lower Cook Inlet.

File Type 033 - Marine Birds - Ship/Aircraft Census

Common to all records
- File Type
- File Identifier
- Record Type
- Station Number

Record Type '1' - Location
- Geographic Position (Start and End)
- Date/Time/Elapsed Time /Time Zone
- Speed/Course/Distance Made Good
- Height above Sea Surface
- Platform Type (code)
- Sampling Technique (code)
- Ship Activity (code)
- Photos Taken (code)
- Width of Transect (code)
- Angle of View (code)
- Observation Condition (code)
- Watch Type (code)

Record Type '2' - Environmental Data
- Water Depth
- Surface Temperature/Salinity
- Thermocline/Secchi Depths
- Humidity/Pressure
- Wind/Sea State (codes)
- Weather (codes)
- Water Color (code)
- Sun/Glare/Visibility/Light Level (codes)
- Moon Phase
- Tide Information
- Distance to Shoreline/Shelf
- Debris Present (code)

Record Type '3' - Ice
- Ice Characteristics in Transect (codes)
- " " outside Transect (codes)
- Open Water Information (codes)
- Visible Ice Characteristics/Locations (codes)
- Arctic Cod Observed (code)
- Ice Algae (code)
- Mammal Trace (code)
- Percent Water vs Land Covered
- Size of ponds

Record Type '4' - Text
- Text
- Sequence Number

Record Type '5' - Data
- Time of Observation
- NODC Taxonomic Code/ Subspecies/Species Group (codes)
- Age/Sex (codes)
- Color/Plumage/Molt (codes)
- Number of Individuals
- Counting Method/Reliability (codes)
- Distance/Direction Measurement and other Information (codes)
- Direction of Flight (code)
- Type of Association/ Linkage (codes)
- Number of Species
- Behavior (code)
- Special Marks/Condition (codes)
- Food Source Association (code)
- NODC Taxonomic Code-Food Species
- Debris/Oil Present (codes)
- Distance to Nearest Breeding Colony
- Habitat (code)
- Sequence Number
- Substrate (code)
- Cover (code)

4/77

File Type 035 - Bird Colony Data

Common to all records
- File Type
- File Identifier
- Record Type
- Station Number
- Sequence Number

Record Type 'A' - Header
- Geographic Positon
- Date/Time
- Photos Taken (code)

Record Type 'B' - Environmental Data
- Sample Date/Time
- Wind/Sea State (codes)
- Weather (codes)
- Visibility (code)
- Tide Information (code)
- Snow Depth (code)
- Air Temperature

Record Type 'C' - Text
- Text

Record Type 'D' - Flat Habitat
- NODC Taxonomic Code
- Substrata (code)
- Habitat (codes)
- Nest Measurement and Location Data (codes)
- Distance To Nearest Neighbor
- Soil Sample Taken (codes)
- Percent Nitrogen/Organics
- Number of Plant Species
- Vegetation Sample Taken (code)
- Nest Material Taken (code)
- Predator (code)

Record Type 'E' - Cliff Habitat
- NODC Taxonomic Code
- Substrata (code)
- Habitat (code)
- Ledge Descriptions
- Cliff Exposure (code)
- Nest Measurement and Location Data (codes)
- Distance to Nearest Neighbor
- EDS Taxonomic Code for Neighbor
- Number of Other Species
- Predator (code)

Record Type 'F' - Clutch
- Sample Date/Time
- NODC Taxonomic (code)
- Station Type (code)
- Number of Eggs/Chicks/Adults
- Egg/Chick Mortality Cause (code)
- Number of Incubators
- Number of Nests
- Adult Activity (code)
- Nest Condition (code)
- Number of Adult Pairs
- Number of Non-breeding Birds

Record Type 'G' - Egg and Chick Development
- Sample Date/Time
- NODC Taxonomic Code
- Egg Number/Weight
- Endo - and Ectoparasites (codes)
- Egg/Chick Morality Cause (code)
- Chick Number
- Chick Weight Before/After Food Sample
- Food Sample Number
- Band Number
- Wing Length
- Estimated Date Laid
- Estimated Date Hatched
- Culmen Length
- Tarsus Length

Record Type 'H' - Specimen
- Sample Date/Time
- NODC Taxonomic Code
- Sex/Age Class (code)
- Food Present (codes)
- Food Sample Number
- Endo - and Ectoparasites (codes)
- Gonad Size
- Body Weight
- Fat Classification (code)
- Sternum Length
- Gross Abnormalities (code)
- Lab Sample (code)

Record Type 'J' - Food
- Sample Date/Time
- NODC Taxonomic Code - Species
- Food Sample Number
- NODC Taxonomic Code - Food Sample
- Food Sample Source (code)
- Material (code)
- Food Quantity/Wet and Dry Weight/ Volume
- Representative Length

Format Type 038 - Bird Sea Watch

Common to all records
- File type
- File Identifier
- Record Type
- Station Number (1,2,3,4,C)
- Sequence Number (1,2,3,4)
- Specimen Number (A thru L, except C)

Record Type "1" - Station Header
- Latitude and Longitude
- Distance from Shore
- Platform Type
- Sampling Technique
- Height Above Water
- Scope Bearing

Record Type "2" - Text
- Text-alphanumeric information

Record Type "3" - Detail
- Observation Start
- Elapsed Time
- Taxonomic Code
- Subspecies Code
- Species Group Axle
- Age, Color, Sex
- Color phase, plummage, molt
- Number of individuals
- Counting Method and Reliability
- Directions of flight
- Technique
- Behavior
- Number of species
- Linkage

Record Type "4" - Sea Watch
- Present weather
- Tide trend
- Tide height
- Sea State

Record Type "A" - Location
- Latitude and Longitude
- Date/Time and Zone

Record Type "B" - Environmental Record Type
- Air and Sea Surface Temperature
- Wind direction and speed
- Present weather
- Barometric pressure

Record Type "C" - Ice
- In and outside transect --coverage, type, form, relief, thickness, & melt
- Open water--type, direction and distance
- Lead or polynya width
- Visible Ice--description, direction, and distance
- Arctic Cod observaton
- Excess sediment
- Ice Algae Layer
- Mammal Trace

Record Type "D" - Field Data
- Taxonomic Code
- Collection method
- Disposition
- Sex, Age, Color Phase
- Plumage
- Brood Patch
- Ecto Parisites
- Food sample origin and preservation method
- Behavior
- Collection Site habitat
- Micro-environment
- Distance to tide line
- Prey sampling
- Number of species
- Linkage
- Accession number
- USFWS Catalog Values
- Text type

Record Type "E" - Meristic Data
- Diagonal Tarsus
- Exposed Culmen
- Bill Width
- Right Wing Length
- Bursa Length
- Total Width and Length
- Type
- Dry, Fat Free and Viscera Weights
- Largest Gonad
- Fat

Record Type "F" - Text record
- Text - alphanumeric info

Format Type 038 - Bird Sea Watch

- Common to all records
  - File type
  - File Identifier
  - Record Type
  - Station Number (1,2,3,4,C)
  - Sequence Number (1,2,3,4)
  - Specimen Number (A thru L, except C)

- Record Type "1" - Station Header
  - Latitude and Longitude
  - Distance from Shore
  - Platform Type
  - Sampling Technique
  - Height Above Water
  - Scope Bearing

- Record Type "2" - Text
  - Text-alphanumeric information

- Record Type "3" - Detail
  - Observation Start
  - Elapsed Time
  - Taxonomic Code
  - Subspecies Code
  - Species Group Axle
  - Age, Color, Sex
  - Color phase, plummage, molt
  - Number of individuals
  - Counting Method and Reliability
  - Directions of flight
  - Technique
  - Behavior
  - Number of species
  - Linkage

- Record Type "4" - Sea Watch
  - Present weather
  - Tide trend
  - Tide height
  - Sea State

- Record Type "A" - Location
  - Latitude and Longitude
  - Date/Time and Zone

- Record Type "B" - Environmental Record Type
  - Air and Sea Surface Temperature
  - Wind direction and speed
  - Present weather
  - Barometric pressure

- Record Type "C" - Ice
  - In and outside transect
  - --coverage, type, form, relief, thickness, & melt
  - Open water--type, direction and distance
  - Lead or polynya width
  - Visible Ice--description, direction, and distance
  - Arctic Cod observaton
  - Excess sediment
  - Ice Algae Layer
  - Mammal Trace

- Record Type "D" - Field Data
  - Taxonomic Code
  - Collection method
  - Disposition
  - Sex, Age, Color Phase
  - Plumage
  - Brood Patch
  - Ecto Parisites
  - Food sample origin and preservation method
  - Behavior
  - Collection Site habitat
  - Micro-environment
  - Distance to tide line
  - Prey sampling
  - Number of species
  - Linkage
  - Accession number
  - USFWS Catalog Values
  - Text type

- Record Type "E" - Meristic Data
  - Diagonal Tarsus
  - Exposed Culmen
  - Bill Width
  - Right Wing Length
  - Bursa Length
  - Total Width and Length
  - Type
  - Dry, Fat Free and Viscera Weights
  - Largest Gonad
  - Fat

- Record Type "F" - Text record
  - Text - alphanumeric info

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)

   100-140 feet for all surveying
   See attached Proposed trackline for bird surveys, Lower Cook Inlet

2. Describe types of observations to be made.

   Record bird species and numbers and environmental parameters

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)

   Freeze-up early-late November?, early January, late February, early April
   ± two weeks

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

   Total flight hours? 4 days, 6 hours/day 24 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?

   Preferably principal investigation

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?

   100#, 3'x3'x3'

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

   Twin-engine amphibious

9. Do you recommend a source for the aircraft? Yes
   If "yes" please name the source and the reason for your recommendation.
   Charlie Allen Flying Service; locally based, experienced pilot, no comparable aircraft in Homer.

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

    Presently $185/hour, likely $200 in FY 78.

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

    Two

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

    Anchorage

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)

   It would be convenient to transfer fuel and supplies from Surveyor to Crooked Island base camp via helicopter. Also, using a helicopter with GNS-500 would be desirable for pelagic transects to determine foraging distances.

2. Describe types of observations to be made.

   Bird species and numbers.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

   Mid-April for equipment caching, early to mid-July for transects.

4. How many days of helicopter operations are required and how many flight hours per day? One for transport of equipment, one for pelagic transects.

   Total flight hours? 9 hours (3 for fuel drop, 6 for survey)

5. How many people are required on board for each flight (exclusive of the pilot)?

   Two

6. What are the weights and dimensions of equipment or supplies to be transported?

   50# for survey, 5000# for fuel and equipment drop.

7. What type of helicopter do you recommend for your operations and why?

   Jet Ranger - better visibility for observations.

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?

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

    Bristol Bay

11. Will special navigation and communications be required?

    GNS-500.

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)

Field camp at Walrus Islands (likely Crooked Island)
May to Sept, 1978
2 persons, 125 days 250 man-days

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

Yes, we will furnish our own.

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

$12 per 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?

Estimated food costs plus pro-rated field gear.

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?

Getting necessary barrels of fuel and heavy field gear onto the Walrus Islands likely will pose the biggest problem. It would take 4 trips of 5 hours each at $250 per hour (today's price) in an Otter from King Salmon to complete the task. It would be preferable to have the fuel and lumber offloaded from a NOAA vessel if one was in the vicinity prior to late April or first of May.

MILESTONE CHART

RU #: 3 PI: Paul Arneson

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
Bird Survey - Lower Cook Inlet (250*)			△												
Quarterly Report			△												
Bird Survey - Lower Cook Inlet (250*)				△											
Bird Survey - Lower Cook Inlet (250*)					△										
Final Report for Fiscal Year 76-77 project					△										
Annual Report FY 78 project						△									
Bird Survey - Lower Cook Inlet (250*)						△									
Bird Colony Work - Walrus Islands (10,000*)								—	—	—	△				
Quarterly Report												▲			
Analysis of Summer's Data													—	—	△
Quarterly Report															△
Data submitted 90 days after collection															
* estimated number of records															

△ Planned Completion Date ▲

AMENDMENT 1

September 14, 1977

Dr. Herbert E. Bruce
U.S. Dept. of Commerce, NOAA
OCS Environmental Assessment Program
Bering Sea-Gulf of Alaska Project Office
P.O. Box 1808
Juneau, Alaska 99802

Dear Herb:

Because of the recent changes in direction and emphasis for Research Unit #3, the following revisions to my original work statement (dated June 3, 1977) are in order:

1. Section III. Cost of Proposal

A.	Science	$64,000
B.	P.I. provided logistics	$ 6,000
C.	Total	$70,000
D.	Distribution of Effort	

50% Winter Bird Surveys - Lower Cook Inlet
50% Summer Bird Colony Study - Lower Cook Inlet

2. Section V. Objectives

Winter Bird Surveys - Lower Cook Inlet

1. To determine the winter distribution and abundance of marine birds in relation to ice conditions and other environmental parameters.

2. To attempt to determine the cause of various bird distribution patterns.

Bird Colony Study - Lower Cook Inlet

1. To determine phenology of events from arrival to departure of birds.
2. To determine the distribution and abundance of birds.
3. To obtain baseline information on reproductive biology of birds.
4. To describe habitat utilization during the breeding season.
5. To obtain food habit and foraging distance information.

3. Section VI. Approach:

Winter Bird Surveys - Lower Cook Inlet

Aerial surveys will be utilized to determine winter bird distribution and abundance in Kamishak Bay. Because cost prohibits use of aircraft equipped with global navigation systems, line of sight transects will be conducted. Partial shoreline or ice edge surveys will be conducted between transects and also from the Forelands down to Kamishak-Kachemak Bays.

Ice conditions will be noted and bird numbers by species will be recorded. The birds' distribution in relation to prevailing ice conditions will be assessed. Attempts will be made to determine why birds are distributed as they are--whether is is for physical and/or biological reasons.

Bird Colony Study - Lower Cook Inlet

The summer field season will be initiated in late April to determine arrival dates of seabirds to their colonies. Birds' distribution and habitat utilization will be determined prior to nesting. As nesting commences, dates of nest initiation, clutch size, hatching success and fledging success will be determined.

Concurrently, sea watches and transects by raft will be conducted to determine distribution and foraging areas of birds of the small colonies. If possible, radial transects could be done to determine foraging distances from the colonies. Food habits of seabirds will be determined by collecting selected individuals or by direct observation on the breeding grounds or at the nest site. Various other parameters will be recorded including weather conditions, plant species composition of the colonies, and beached bird information.

4. Section VII. Sampling Methods:

Winter Bird Surveys

Transects conducted in Lower Cook Inlet will be of standard width (100 or 200 meters on each side of the aircraft) and of known length so that area and therefore densities of birds will be determined. Birds' location in relation to ice flows and the possible gyre south of Augustine will be recorded.

The first survey will be conducted at the start of severe weather. Two more sampling periods will be conducted as winter progresses and a final survey will be flown at winter's end. Changes in bird distribution as a result of changes in ice conditions will therefore be determined.

Bird Colony Study - Lower Cook Inlet

Observations will commence at about the time birds first arrive on the study area. Dates will be recorded as each new species arrives. Sea watches will be conducted on a regular basis to determine the magnitude of migration in the area. The specific colonies to be studied in detail will be determined after a preliminary reconnaissance of the area.

At the study colonies, date of nest initiation for each species, clutch size, hatching success, fledging success and departure dates will be determined. Methods used will be the same as those used by other OCSEAP P.I.'s so that data is directly comparable. Colonies not previously identified will be examined to determine species composition and abundance.

5. Section IX. Anticipated Problems:

Not having ready access to colonies best suited for study may pose the biggest problem. Colonies to be studied are uninhabitable and widely scattered. Because phenology of events is an important part of the study and because frequent inclement weather may prevent access to colonies at opportune times, gaps in the data may be unavoidable.

Extreme weather conditions (either very mild or severe) during the winter will affect bird distribution and therefore bias the results of a one-year study.

6. Section X. Delineable Products:

A. Digital Data: See attached table.

B. Narrative Reports:

Most information about the research will be presented in Quarterly and Annual reports. However, it is anticipated that a separate report on general bird distribution of Lower Cook Inlet will be sent to a journal for possible publication.

Contents of narrative reports on the winter surveys will include a description of sampling techniques, results of the surveys by species and numbers and their distribution and discussion and/or conclusions as to reasons for their specific distribution.

For the small colony study, narrative reports will contain techniques utilized, results of the phenology of events, reproductive ecology, life histories, foraging areas and changes in distribtuion and the necessary discussion and/or conclusions about the results.

See Attached milestone chart for data submission dates.

C. Visual Data Products.

A list of approximate titles of figures and tables is as follows:

Winter Bird Surveys

Fig.	Location of pelagic transects within Lower Cook Inlet
Fig.	Relative abundance of birds in offshore waters of Lower Cook Inlet
Table	Species composition and abundance for pelagic birds of Lower Cook Inlet

Bird Colony Study

Fig.	Location of seabird colonies of Lower Cook Inlet
Fig.	Location of seabird colonies of Lower Cook Inlet that were intensively studied during this report period
Table	Breeding chronology of _______ _______ (several species) on _______ (Colony)
Table	Body measurements for _______ _______ (several species)
Table	Food organisms of ______ ______ (several species)

Likely many more tables and figures will be present in the reports, but at this time it is unknown what specific information will be collected.

E. Data Submission Schedule

Data will be submitted to the Project Office within 120 days of completion of a survey.

7. Logistics Requirements for Lower Cook Inlet Bird Colony Study

It will be necessary to have at our disposal at all times either a Boston Whaler or Zodiac with which to be continually visiting widely separated colonies. At times we will have to be airlifted back and forth between Kamishak and Kachemak Bays to monitor colonies in both localities and from northern Kamishak to southern Kamishak Bay. To determine foraging distances from the colonies, pelagic transects on a larger boat could be conducted while "piggybacking" with other P.I.'s.

I assumed a craft of some kind would be available and did not budget for it in the Cost Proposal Form.

There would normally be two persons travelling to each location and we would have approximately 250 lbs of equipment and survival gear. No special handling is involved.

Because the chronology of breeding events is to be studied on a variety of areas, it will be necessary to be flexible as to when and where we go, and therefore a craft at our disposal is necessary.

It will be helpful to have gas and oil cached at various locations in Kamishak Bay to aid us in getting to all parts of the area.

Herb, I believe this covers all points in your guidance letter and thoroughly updates the original proposal. If more is necessary or if there are questions, please call me for clarification.

Sincerely,

Paul D. Arneson

Paul D. Arneson
Game Biologist

Table 1. Limits for data parameters for file types 038, 035 and 033.

Parameter	Limits
Latitude	59° 00' to 60° 30'
Longitude	150° 30' to 154° 30'
Distance from shore	0-60 km
Height above water	15-61 m
Elapsed time	0-45 min
Number of individuals	1-10,000?
Air temperature	-34°C to 27°C
Distance to nearest neighbor	0-160 m
Number of plant species	1-75
Number of eggs	0-25
Number of nests	1-3,000
Number of adult pairs	1-3,000
Number of non-breeding birds	1-5,000
Egg weight	1-100 g
Chick number	1-25
Wing length	20-1000 mm
Culmen length	1-60 mm
Tarsus length	1-75 mm
Body weight	0-5.0 kg
Sternum length	0-350 mm
Food weight	0-100 gm
Food volume	0-250 ml
Water depth	0-200 m

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)
1. Birds - aerial transects	Disks	250 records	033	Yes	Late Nov 77	Jan 78
2. Birds - aerial transects	Disks	250 records	033	Yes	Early Jan 78	Mar 78
3. Birds - aerial transects	Disks	250 records	033	Yes	Late Feb 78	April 78
4. Birds - aerial transects	Disks	250 records	033	Yes	Late March	May 78
5. Bird colony Information	Disks	10,000 records	033 035 038	Yes	April - Sept 78	Dec 78

AMENDMENT 2

February 17, 1978

Dr. Paul Becker
NOAA/OCSEAP
P.O. Box 1808
Juneau, Alaska 99801

Dear Paul:

When research in Bristol Bay was stopped for FY78, it was decided that RU #3 should study bird colonies in Kamishak Bay in addition to the winter bird surveys. After looking more closely at the situation, I decided it would not be feasible to study specific colonies because the colonies are small and widely scattered (usually containing only one or possibly two species that could be studied) and frequent inclement weather would preclude the necessary daily visits to colonies. In most other colony studies, researchers are able to live on the colony itself and not rely on frequent boat operations. The situation is different in Kamishak where no colonies are large enough to live on.

For these reasons I am requesting a change in research objectives for bird studies of Kamishak Bay. Stan Senner studying shorebirds on the Copper River Delta (RU #341/342, Study Task A3) has hypothesized that Western Sandpipers and Dunlin require an intermediate stop during spring migration to get sufficient fat reserves to continue migration. He has determined that Western Sandpipers use Fox River Flats in Kachemak Bay, but since Dunlin are not found there, this species may be using the west side of Lower Cook Inlet for migration staging. Dennis Raveling, University of California (Davis), has also suggested that Cackling Canada Geese need an intermediate stop prior to their arrival on their breeding ground and that western Lower Cook Inlet may be providing the necessary staging area for this species.

If it is true that certain waterfowl and shorebird species require a staging area in western Lower Cook Inlet to prepare them for their migration to breeding areas, the habitat they utilize would be termed "critical". To date I know of only one spring survey that has been conducted along the entire shore of western Cook Inlet, and it was at a time that was too late for observing most of the waterfowl migration and too early for peak shorebird migration. Therefore, I consider it very important to take a closer look at what is happening during spring migration on the west side of Lower Cook Inlet. As we have previously discussed, I suggest a project to determine the magnitude of usage in spring by waterfowl and shorebirds, and the objectives of such a study would be:

1. To determine species distribution and abundance of waterfowl and shorebirds in Lower Cook Inlet (west side).
2. To determine if critical habitats exist for these species groups on western Lower Cook Inlet.
3. To determine periods of peak usage and duration of usage in spring for these species groups in western Lower Cook Inlet.
4. To determine, if possible, food organisms utilized by these species groups during migration staging.

To meet these objectives a minimum of two aerial surveys per species-group-migration-period would be conducted. Waterfowl should move through during the last two weeks of April and shorebirds the first two weeks of May. We will try to get advance notice of the chronology of migration from observers on the Copper River Delta and time our flights when it is expected that the most birds should be in the area. It will therefore be easier to determine which areas are used more than others. It is now anticipated to remain in the field between the two waterfowl and the two shorebird flights to gather more information on habitat usage by those species. There will be four flights and each should last approximately 6 hours or 24 hours total flying time. This flying time has not been budgeted for and therefore it will be necessary for OCSEAP (Juneau Project Office) to furnish the necessary funds for flights. The only other cost would be food and supplies while in the field, but these costs would be minimal and already available.

The enclosed Figure 1 shows the areas where the surveys will be concentrated. The cross-hatched areas contain extensive intertidal habitat and will be the most likely areas for migration staging birds. The most suitable field camp would be in McNeil Cove to observe both shorebirds and waterfowl without using a boat.

After these surveys, when the data is analyzed, a report would be written - possibly as a quarterly report - that would show areas of greatest usage and importance by appropriate figures, maps and tables.

A second project would be initiated during summer months to gather information on colonies in Kamishak Bay. Objectives for this project are as follows:

1. To determine species composition and abundance of marine birds on colonies in Kamishak Bay.
2. To determine as many aspects as possible of the breeding biology of marine birds on the colonies.
3. To determine whenever possible the food habits of nesting marine birds and their young.
4. To determine changes in abundance of breeding populations of marine birds on colonies visited in 1976.
5. To make other incidental observations of habitat use, forage areas, migration areas and abundance of non-colonial marine birds.

To meet these objectives we will boat along the coastline from Rocky Cove to Shaw Island stopping at each colony site to document what is present. Breeding biology information will be collected during the visits to the colony and colonies will be revisited at a later date if possible. These surveys will be conducted during June, July and August or as long as it takes to thoroughly cover the area. If possible, colonies in the Iniskin Bay area that were documented in 1976 will be revisited to determine year to year changes in composition and abundance. Figure 2 depicts the area to be covered.

It may be necessary during weather too inclement for rubber raft operations to be airlifted or transferred in a larger vessel (skiff or the chartered fishing boat) to a different spike camp site to continue the shoreline travel when weather permits. It is not anticipated that additional logistic support will be required other than that which will already be in the area during the summer field season. It will just mean hitching a ride when an aircraft or boat is available.

At the completion of the analysis for the summer's data, a report will be written to show by maps, charts and tables the distribution and abundance of breeding marine birds, various aspects of their breeding biology, information on food habits, and habitat usages of marine birds.

It has been suggested that Kamishak Bay will be the final trap for oil spilled in Lower Cook Inlet. These two projects will gather significant information as to what and where avian species may be affected by the likelyhood of a catastrophe during oil development in the region. They will complete definite gaps in our knowledge about bird use on the western side of Lower Cook Inlet, an area where little research has been conducted in the past.

I look forward to conducting and completing this research since I feel it is important in our understanding of the total picture of what is happening in Lower Cook Inlet. It is significant from the standpoint of the birds themselves - an animal class highly susceptible to oil development - and also to the prey organisms of birds.

If you need any items clarified or have any questions please don't hesitate to ask.

Sincerely,

Paul

Paul Arneson
Game Biologist

Enclosures

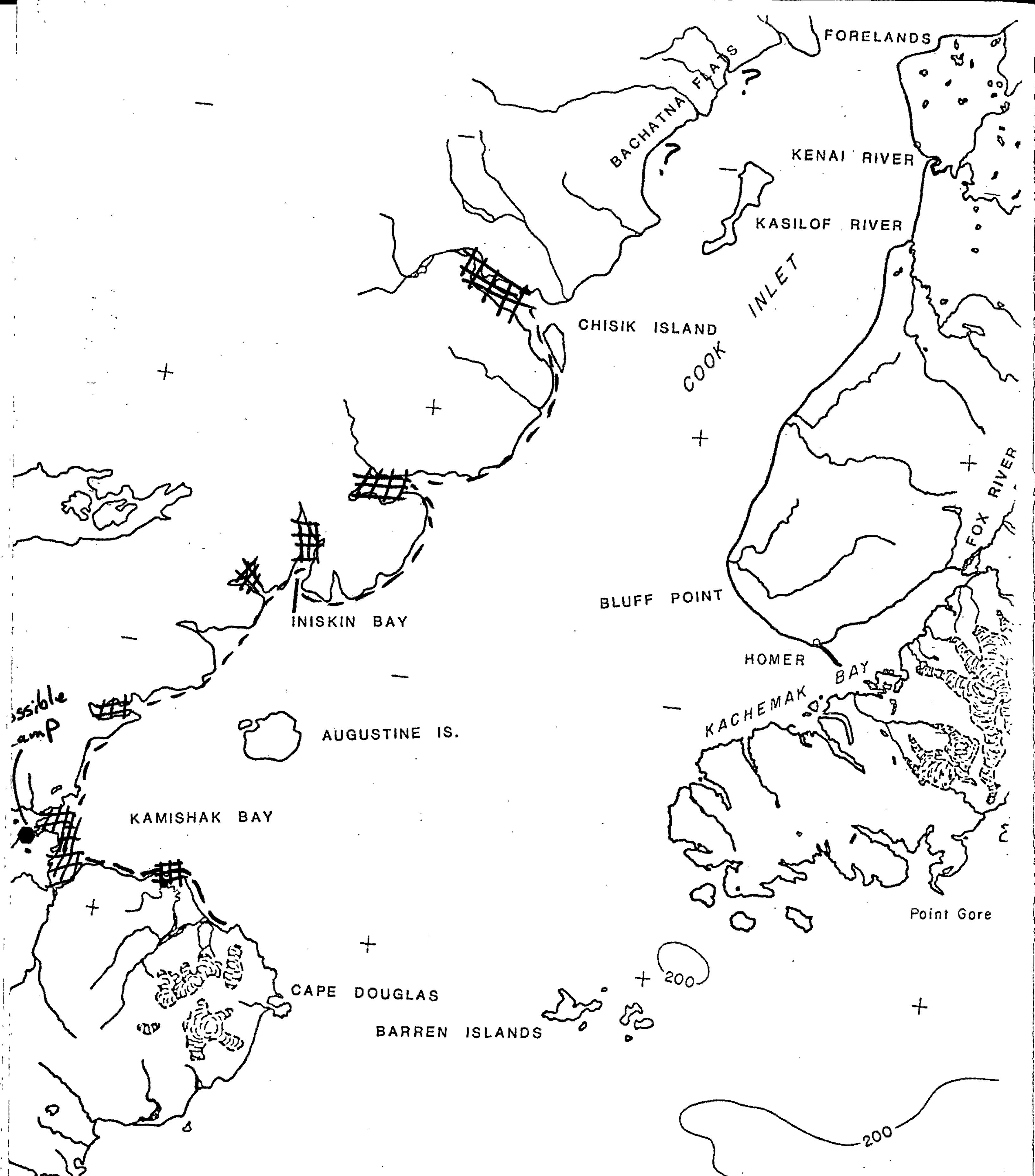


Figure 1. Areas to be surveyed for waterfowl and shorebirds.

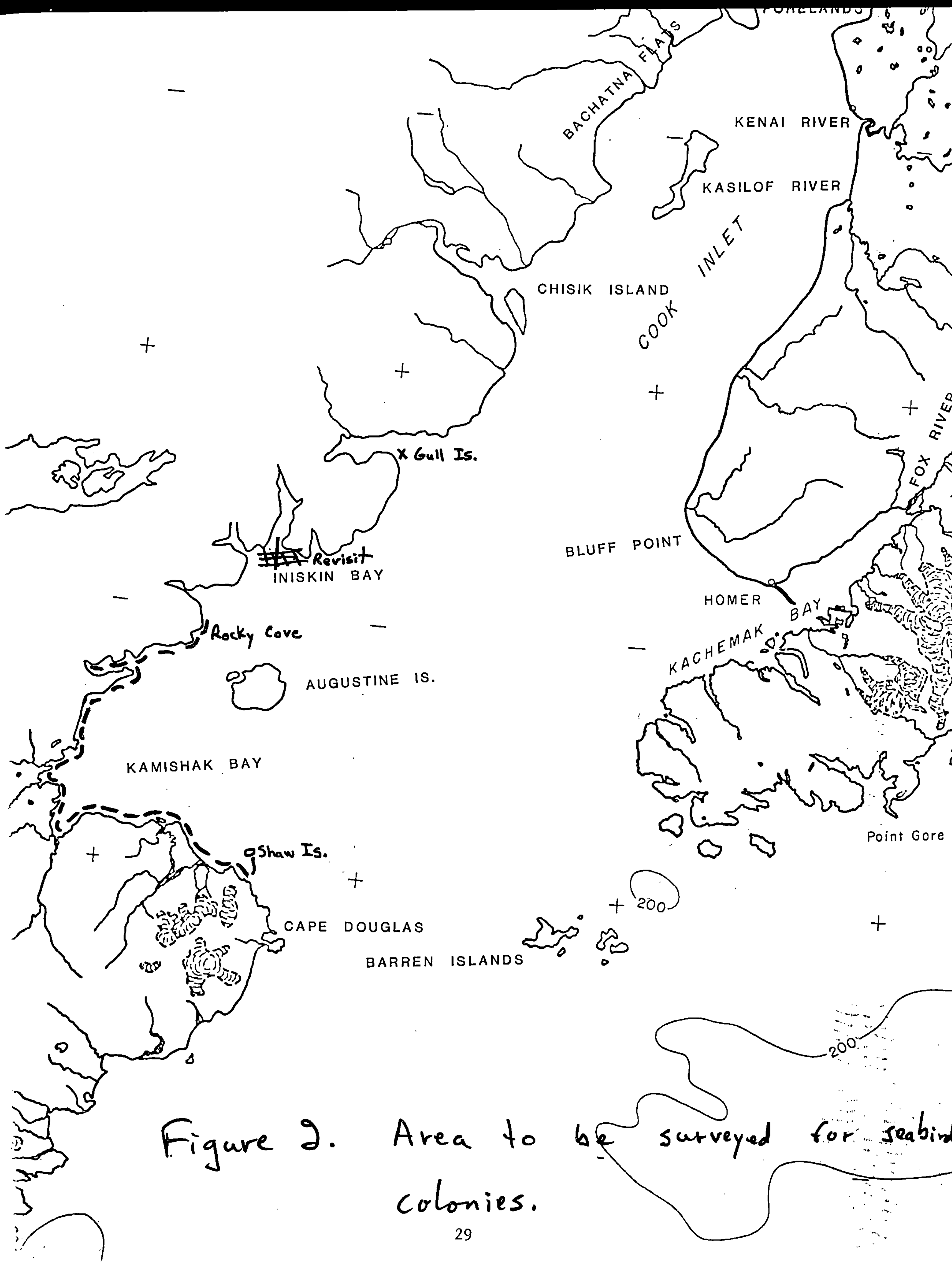


Figure 2. Area to be surveyed for seabird colonies.

OCS 78-2
OCS 78-8

RESEARCH PROPOSAL

to

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

DISTRIBUTION, ABUNDANCE, COMMUNITY STRUCTURE AND TROPHIC RELATIONSHIPS OF THE NEARSHORE BENTHOS OF THE KODIAK SHELF, COOK INLET, AND NORTH EAST GULF OF ALASKA

R.U. #5

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

H. M. Feder, Principal Investigator
Institute of Marine Science
University of Alaska
(907) 479-7841

J. Robert Moore, Director
Institute of Marine Science
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A. B. Frol, Director
Administrative Services
University of Alaska
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K. B. Mather, Vice Chancellor
Research and Advanced Study
University of Alaska
(907) 479-7282

October 7, 1977

C. TECHNICAL PROPOSAL

I. Title

Distribution, Abundance, Community Structure, and Trophic Relationships of the Nearshore Benthos of the Kodiak Shelf, Cook Inlet, and Northeast Gulf of Alaska.

Research Unit No. 5.

II. Principal Investigator

Dr. Howard M. Feder

III. Cost of Proposal (FY 78)

Total	$395,000
Kodiak Shelf	40%
Lower Cook Inlet	40
NEGOA	20

IV. Background

A. Kodiak Shelf. The operations connected with oil exploration, production, and transportation in the vicinity of Kodiak Island present a wide spectrum of potential dangers to the marine environment there. Adverse effects on a marine environment cannot be assessed, or even predicted, unless background data pertaining to the area are recorded prior to industrial development. Insufficient long-term information about an environment, and the basic biology of species in that environment can lead to erroneous interpretations of changes in species composition, abundance and interactions that might occur if the area becomes impacted (see Nelson-Smith, 1973; Pearson, 1971, 1972, 1975; Rosenberg, 1973, for general discussions on benthic biological investigations in industrialized marine areas; see Lewis, 1970 for discussion of population fluctuations of benthic invertebrates in time).

Benthic organisms (primarily the infauna and sessile and slow-moving epifauna) are useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes and by their presence, generally reflect the nature of the substratum. Consequently, the organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Addy, 1976; Feder *et al.*, 1973; Pearson, 1971, 1972, 1975 and Rosenberg, 1973 for discussions on usage of benthic organisms for monitoring pollution). The presence of large numbers of benthic epifaunal species of actual or potential commercial importance (snow crab, king crab, pandalid shrimp, scallops, snails, bottom fishes) on the shelf ecosystem of Kodiak Island further dictates the necessity of understanding benthic communities there since many commercial species feed on infaunal and small, slow-moving epifaunal residents of the benthos (see

Feder *et al.*, 1977a, 1977b; Zenkevitch, 1963 for discussions of the interaction of commercial species and benthic biota in Alaska waters). Thus, drastic changes in density of the food benthos would undoubtedly affect the health and numbers of these fisheries organisms.

Few data on non-commercially important invertebrate components of the shallow, nearshore benthos of the Kodiak shelf were available until recent OCSEAP studies were initiated (Feder *et al.*, 1977b). To date, Russian workers have published most of the data from the western Gulf of Alaska (AEIDC, 1974), but OCSEAP investigations in the northeast Gulf of Alaska provide some comparable data from adjacent areas (Feder *et al.*, 1977a). The benthic invertebrate biomass on the Kodiak Shelf appears to be greater than that of the NEGOA area, and a higher percentage of the Kodiak biomass is believed to be available as food for fish (see summary draft report by MacDonald and Petersen, 1976). Additional summary information for the Gulf of Alaska is also available in the literature review of Rosenberg (1972). The Soviet benthic work was accomplished in the deeper waters of the Kodiak shelf, and was of a semi-quantitative nature with little hard data to permit extrapolations useful for predictive analyses of the effects of oil on the benthos. The exploratory trawl program of the National Marine Fisheries Service is the most extensive investigation of commercially important species of the Kodiak shelf (unpub. data; reports available from the National Marine Fisheries Service Laboratory, Kodiak). However, most of the invertebrate data from the latter investigation are difficult to interpret, but some idea of the dominant organisms likely to be encountered in the offshore waters of the shelf is available from the study.

Additional, but unpublished, information on the epifauna in the vicinity of Kodiak Island is available as a byproduct of the Alaska Department of Fish and Game King Crab Indexing Surveys (inquiries concerning these reports may be directed to Alaska Department of Fish and Game, Box 686, Kodiak). The International Pacific Halibut Commission surveys parts of the Kodiak shelf annually, but only records commercially important species of crab and fishes; non-commercially important invertebrate and fish species are generally lumped together in the survey reports with little specific information available. A compilation of some relevant data on renewable resources of the Kodiak shelf is available (AEIDC, 1974). The only recent inshore survey of the invertebrate benthos of the Kodiak Shelf is that of Feder *et al.* (1977c) accomplished in conjunction with the fish studies of P. Jackson and J. Blackburn of the Alaska Department of Fish and Game (OCSEAP Annual Report, 1977). These studies intensively investigated the benthos of two bays of Kodiak Island, Alitak and Ugak, and described the distribution and abundance of epifaunal invertebrates and demersal fishes there. Sufficient data was available from these studies to develop a preliminary food web for these two bays and inshore waters around Kodiak Island. Feder *et al.* (1977b) discusses the relevance of the inshore benthic study in the two bays, and the Kodiak shelf in general, to petroleum development there.

Although OCSEAP sponsored research has initiated some inshore benthic studies in the Kodiak area, the coverage has been restricted geographically. Furthermore, little offshore benthic data is available to integrate with the inshore benthic work proposed for the coming year. Species found in bays, shallow inshore areas and deeper benthos of the Kodiak shelf are all highly mobile, and some of the more important species (e.g. king crab, snow crab, halibut) migrate between deep and shallow water during the course of a year. Data collected for these species in inshore areas only will not address their biological interactions, presumably also important ones, in deeper shelf waters. Expansion of the data base from inshore to offshore waters is especially suggested in this proposal for one epibenthic, commercially important species, the king crab. The pursuit of the latter species results in the most important invertebrate fishery in Alaska waters, and Kodiak king crab stocks support a substantial portion of the fishery.

Commercial catch statistics of the Kodiak king crab stocks in past years showed classic exploitation patterns with a peak year catch occurring in the 1965-66 season. Since that time, annual harvest levels (quotas) have been imposed. Recent data substantiate that king crab stocks are responding to the reduced fishing pressure resulting from this management decision, and populations are apparently in the rebuilding phase. The two most commercially utilized stocks are southern district stocks II and III which cover Kodiak Island's southern waters to the continental shelf edge (unpub. Alaska Department of Fish and Game Reports). Recent trawl studies conducted in two Kodiak Bays (Alitak and Ugak) show king crab as the dominant species there (Feder *et al.*, 1977c). Alitak Bay is also a major king crab breeding area (Gray and Powell, 1966; Kingsbury and James, 1971). The intensive king crab food study within commercial stocks II and III proposed here (see Objectives and Methods of this proposal) should ultimately help explain distribution and abundance patterns, including high commercial yield areas and molting and/or breeding areas.

Based on OCSEAP feeding studies initiated in the northeast Gulf of Alaska (inclusive of Cook Inlet) and two bays on Kodiak Island (Feder *et al.*, 1977a, 1977b), it is apparent that benthic invertebrates play a major role in the food dynamics of commercial crab and demersal fishes of the Kodiak shelf. Proposed studies of relative abundance, seasonal distribution, life history and inter-species relationships of nearshore fish communities in the Kodiak Island lease area by Blackburn and Jackson (R.U. 486) will examine the trophodynamic relationships within these communities. Investigations of this type are essential to comprehend these nearshore communities. Integration of the invertebrate data derived from work accomplished in the course of R.U. 5 with fish data resulting from R.U. 486 and bird data resulting from R.U. 341 will markedly strengthen our understanding of the nearshore benthic communities in the proposed study area.

B. Lower Cook Inlet. The operations connected with oil exploration, production, and transportation in Cook Inlet present a wide spectrum of potential dangers to the marine environment. Adverse effects on a marine environment cannot be assessed, or even predicted, unless background data pertaining to the area are recorded prior to industrial development. Insufficient long-term information about an environment, and the basic biology of species in that environment can lead to erroneous interpretations of changes in species composition, abundance and interactions that might occur if the area becomes impacted (see Nelson-Smith, 1973; Pearson, 1971, 1972, 1975; Rosenberg, 1973 for general discussions on benthic biological investigations in industrialized marine areas; see Lewis, 1970 for discussion of population fluctuations of benthic invertebrates through time).

Benthic organisms (primarily the infauna and sessile and slow-moving epifauna) are useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes and by their presence, generally reflect the nature of substratum. Consequently, the organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Addy, 1976; Feder *et al.*, 1973; Pearson, 1971, 1972, 1975; Rosenberg, 1973 for discussions on usage of benthic organisms for monitoring pollution). The presence of large numbers of epifaunal species (juveniles and adults) of actual or potential commercial importance (snow crab, king crab, pandalid shrimps, scallops, bottom fishes) in Cook Inlet (Feder *et al.*, 1977a and draft copy of Lower Cook Inlet Synthesis Report, 1977) further dictates the necessity of understanding benthic communities since most of these commercial species feed on infaunal and small, slow-moving epifaunal residents of the benthos (see Feder *et al.*, 1977a,b; Zenkevitch, 1963 for discussions of the interaction of commercial species and benthic biota). Thus, it is apparent that drastic changes in density of the food benthos would affect the health and numbers of these commercially important epifaunal organisms.

Few data on non-commercially important invertebrate components of the benthos of Cook Inlet were available until recent OCSEAP studies were initiated (Feder *et al.*, 1977b and D. Lees, unpub. data and reports; draft copy of Lower Cook Inlet Synthesis Report, 1977). The primary data available were principally catch and assessment records for commercial shellfish species. Based on OCSEAP feeding studies accomplished in lower Cook Inlet, it is apparent that benthic invertebrates play an important role in the food dynamics of commercial crabs and demersal fishes there. Proposed studies for 1977-78 by Feder (R.U. 5) and Blackburn (R.U. 512) on relative abundance, seasonal distribution, life history and inter-species relationships of nearshore invertebrate and fish communities in the inshore waters of Lower Cook Inlet will clarify some of the ecological interactions operating within these benthic assemblages. Further, intertidal and shallow subtidal investigations by Lees (R.U. 417) will examine inshore many of the same species found in deeper waters. His studies will not only expand our understanding of these species over the entire range of their distribution, but will closely integrate the life history of these species with land-derived nutrient materials (river runoff with contained terrestrial detritus) and algal detrital derivatives. Lees (R.U. 417) suggests that the macrophytes of the intertidal and shallow subtidal regions produce materials utilized by detritivores in shallow and deep waters throughout Cook Inlet. Many of the organisms depending on these plant materials are either of commercial importance or are food items important to commercial species. Lees indicates that in the past few years information linking the macrophyte producers to commercially important species has begun to emerge but that the full importance of this linkage has yet to be recognized. He also points out that many marine birds and mammals depend heavily on organisms living in the inshore areas which in turn are dependent on plant material produced by macrophytes. In

Lees studies of the past two years and those proposed in his R.U. 417, great emphasis will be placed on acquiring data on primary production of major seaweeds from the high intertidal zone to a depth of 60 feet. These data and additional information from the proposal by Feder (R.U. 5) should assist in assessing the relative importance of macrophyte and terrestrial detrital materials as food sources to the biological assemblages of the inshore benthos of Lower Cook Inlet. Additional data collected by diving, and collections taken by boat in areas not accessible for divers will be used to examine the trophic dynamic processes operational in these inshore areas. This data will further supplement the initial food studies reported by Lees (OCSEAP and unpub. studies in Cook Inlet) and Feder *et al.* (1977a). These studies suggested very strongly that the very abundant deposit feeders in lower Cook Inlet were concentrated in regions of detrital accumulations (e.g. Kamashak Bay).

Thus detrital materials, as food for deposit feeders in lower Cook Inlet, are important, and much of this detrital input appears to be derived from inshore macrophytes. If the role of detrital material is to be better comprehended in the Cook Inlet area, studies on transfer of energy from detrital food sources to selected deposit feeders need to be initiated here as well as in NEGOA. Detrital sources and the nature of the detritus should be examined to evaluate the quality of the food resources available to deposit-feeding species. The latter problems will be addressed by Larrance (R.U. 425) in a project in Lower Cook Inlet concerned with source identification and variability of detrital materials. Incidental to the latter data, information should be gathered concerning food available to dominant suspension-feeding components of the nearshore areas.

The ultimate goal, therefore, of studies in lower Cook Inlet, as in NEGOA, will be the documentation of energy flow from the sediment-detrital system through deposit-feeding species to epifaunal scavengers and/or carnivores. Disturbance or contamination, by oil-related activities, to sediment and detrital materials will directly affect the quality and quantity of food available to deposit-feeding species. Carbon flow and assimilation studies will establish the basic patterns to be expected in healthy systems. In conjunction with the sediment-infauna energy transfer investigations suggested above, feeding data for such species as the snow crab (a dominant species in Cook Inlet and an important food resource for some bottom-feeding fishes) must be obtained. Intensive studies of the food of this crab are restricted to a single collection from Cook Inlet (Feder *et al.*, 1977a; Paul *et al.*, in press), and were conducted primarily to identify the frequency of occurrence of prey items used. No quantitative information is available. Thus, it is further suggested in this proposal that the feeding biology and other aspects of the biology of major prey items used by the snow crab be examined. In Cook Inlet these food items have been identified as deposit-feeding clams, crangonid shrimps and hermit crabs (Feder *et al.*, 1977a). Further feeding data on the abundant king crab in Cook Inlet is also needed (see preliminary data in Feder *et al.*, 1977a). The relationship of bottom-feeding fishes to benthic food webs has been examined in Cook Inlet and a preliminary food web constructed (see Feder *et al.*, 1977a), but it is suggested in this proposal that further documentation be obtained by additional frequency of occurrence and some quantitative data on selected species in collaboration with Blackburn (R.U. 512).

Examination of relationships of the reproductive biology and the appearance of meroplankton in the overlying waters will be possible in conjunction with the studies of English (R.U. 424). Interactions of bottom-feeding birds with inshore benthic invertebrates will be documented by way of discussions with Lensink (R.U. 341).

C. Northeast Gulf of Alaska. The operations connected with oil exploration, production, and transportation in the Gulf of Alaska present a wide spectrum of potential dangers to the marine environment there. Adverse effects on a marine environment cannot be assessed, or even predicted, unless background data pertaining to the area are recorded prior to industrial development. Insufficient long-term information about an environment and the basic biology of species in that environment can lead to erroneous interpretations of changes in species composition, abundance and interactions that might occur when the area becomes impacted (see Nelson-Smith, 1973; Pearson, 1971, 1972, 1975; Rosenberg, 1973 for general discussions on benthic biological investigations in industrialized marine areas; see Lewis, 1970 for discussion of population fluctuations in time).

Benthic organisms (primarily the infauna and sessile and slow-moving epifauna) are useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes and by their presence, generally reflect the nature of the substratum. Consequently, the organisms of the infaunal benthos have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Addy, 1976; Feder *et al.*, 1973; Pearson, 1971, 1972, 1975; Rosenberg, 1973 for discussions on usage of benthic organisms for monitoring pollution). The presence of large numbers of benthic epifaunal species of actual or potential commercial importance (snow crab, king crab, pandalid shrimps, snails, bottom fishes) in the shelf ecosystem of the northeast Gulf of Alaska further dictates the necessity of understanding benthic communities since many commercial species feed on infaunal and small, slow-moving epifaunal residents of the benthos (see Feder *et al.*, 1977a,b; Zenkevitch, 1963 for discussions of the interaction of commercial species and benthic biota). Thus, drastic changes in density of food benthos would undoubtedly affect the health and numbers of these fisheries organisms.

Little was known about the biology of the invertebrate benthos of the northeast Gulf of Alaska at the time that OCSEAP studies were initiated there, although a compilation of some relevant data on the Gulf of Alaska was available in Rosenberg, 1972 (also see the review in AEIDC, 1974). Some scattered data based on trawl surveys by the Bureau of Commercial Fisheries were also available but much of the information on the invertebrate fauna in these surveys was so general as to have little value. In the summer and fall of 1961 and spring of 1962 otter trawls were used to survey the shellfishes and bottomfishes on the continental shelf and upper continental slope of the Gulf of Alaska (Hitz and Rathjen, 1965). The surveys were part of a long-range program begun in 1950 to determine the size of bottomfish stocks in the northeastern Pacific Ocean between southern Oregon and Northwest Alaska. Invertebrates taken in trawls were only of secondary interest, and only major groups and/or species were recorded. A short survey in the summer of 1975 added some benthic biological data for a specific area south of the Bering Glacier (Bakus and Chamberlain, 1975). Results of the latter study are similar to those reported by Feder and Mueller (1975) in their preliminary NEGOA investigation.

Further knowledge of invertebrate stocks in the north Pacific is scant. The International Pacific Halibut Commission surveys parts of the Gulf of Alaska annually and records selected commercially important invertebrates; however, non-commercial species are typically discarded. Thus, the benthic investigations summarized by Feder *et al.* (1977a) in their study of the past two and one half years represent the first intensive qualitative and quantitative examination of the benthic infauna and epifauna of the northeast Gulf of Alaska. Furthermore, information in a literature survey have uncovered data that will aid in the interpretation of the biology of some of the dominant organisms in the Gulf of Alaksa (Feder and Mueller, 1977). Preliminary analysis of data from Feder *et al.* (1977a) and Jewett and Feder (1976) indicates that crustaceans, molluscs and echinoderms are the leading invertebrate groups on the NEGOA shelf with the commercially important crab, *Chionoecetes bairdi*, clearly dominating all other species. Stomach analysis of the Pacific cod *Gadus macrocephalus* on the Kodiak shelf, lower Cook Inlet, and presumably also the NEGOA region, reveals that *C. bairdi* is a dominant food item of that fish (Feder *et al.*, 1977a,b). Thus, the Pacific cod, a non-commercial species that has commercial potential (Jewett, 1977; unpub. M.S. thesis), is preying intensively on a species of great commercial significance. Furthermore, laboratory experiments with *C. bairdi* have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil (Karinen and Rice, 1974). The result of these experiments on this important crustacean must be seriously considered during development of petroleum resources in the Gulf of Alaska.

The shallow subtidal regions (those accessible by diving techniques) are little known but extremely important components of the shelf system of the northeast Gulf of Alaska. These regions are closely tied to the deeper shelf regions by way of nutrient and biotic interactions. The macrophytes in these shallow regions may produce materials utilized by detritivores in some areas of the shelf. Many of the organisms here that depend on these plant materials are either of commercial importance (e.g. shrimps, clams) or are food items (e.g. polychaete worms, amphipods, small crabs) important to non-commercial species. In the past few years, information linking the macrophyte producers to commercial fisheries has begun to emerge, althouth the full importance of this linkage has yet to be recognized (D. Lees, person. commun. and R.U. 417). Additionally, many important marine bird and mammals depend heavily on organisms living in the inshore areas which in turn are dependent on the detrital materials produced by macrophytes. Furthermore, the shallow inshore areas are important to many commercial species for spawning and rearing activities. It is obvious that increased information on nearshore communities is essential. The data produced from nearshore work will be of particular importance to investigators examining inshore fish and bird populations as well as shallow water and offshore benthic assemblages. An expansion of the data base on the seasonal and long-term variation in species composition and structure of the nearshore (shallow water) zone in NEGOA is recommended in this proposal; regions accessible to SCUBA and to shallow-draft boats need intensive work on species composition and distribution.

Some preliminary information on feeding biology of epifaunal invertebrate species of the Gulf of Alaska is available from literature analysis and very preliminary information collected on NEGOA cruises of the past two years. Feeding habits of infaunal invertebrate species have been tabulated from literature sources and unpublished data (Feder and Mueller, 1975). The fact that (1) most of the food data for infaunal invertebrate species in Appendix Table VI of Feder and Mueller (1975) is based on literature extrapolations from related species or the same species from other areas and (2) that food information for invertebrate epifaunal species in NEGOA is almost nonexistent, emphasizes the paucity of data on the feeding biology of Gulf of Alaska fauna. This lack of basic data dictates the urgency of immediate support of food studies and experimental work on species of the benthic infauna as well as epifauna in the nearshore and offshore waters of the Gulf of Alaska and elsewhere along the Alaska continental shelf.

Results of surveys of the offshore benthic infauna in NEGOA have shown that infauna throughout much of the area is dominated by deposit feeders both in terms of abundance and biomass. In the areas examined, energy transfer from detritus through deposit feeders and eventually to higher trophic levels probably accounts for the major portion of energy flow from infauna to epifaunal organisms and demersal fishes. If an understanding of the trophic dynamics of the benthos in NEGOA is to be achieved, it is important that the transfer of energy from detrital food sources to selected deposit feeders be investigated. The species selected for investigation should be infaunal species that have been quantitatively documented as dominant or which demonstrate potential as a food resource for critical species at higher trophic levels. Furthermore, detrital sources and the nature of the detritus in the study areas should be examined in order to evaluate the quality of the food resources available to deposit-feeding infauna. Incidental to the latter data, information should be gathered concerning the food available to dominant suspension-feeding components of the infauna.

The ultimate goal of feeding studies in NEGOA will be the documentation of energy flow from the sediment-detrital system through deposit-feeding species to the dominant epifaunal carnivores and/or scavengers. Disturbance or contamination, by oil-related activities, to sediment and detrital materials will directly affect the quality and quantity of food available to deposit-feeding species. Carbon flow and assimilation studies will establish the basic patterns to be expected in healthy systems. Furthermore, it is ultimately intended to examine the importance of deposit feeders as nutrient-carbon recycling mechanisms of the benthos. In conjunction with the sediment-infauna energy transfer investigations suggested above, feeding data for such species as the snow crab *C. bairdi*, must be obtained. Intensive studies of the food of this crab are restricted to a single collection from Cook Inlet (Feder *et al.*, 1977a; Paul *et al.*, in press), and were conducted primarily to identify the frequency of occurrence of prey items used. No quantitative information is available, and no detailed studies of the feeding of *C. bairdi* from other areas exists. This crab, like the king crab, moves between shallow inshore and deeper offshore waters, and is an important component of all regions of the NEGOA shelf. Thus, additional quantitative data on the feeding habits of the snow crab from selected important NEGOA sites are necessary to understand a major component of inshore and offshore shelf benthic communities. It is further suggested in this proposal that the feeding and other aspects of the biology of the major prey items used by the snow crab be examined. In Cook Inlet these items have been identified as deposit-feeding benthic bivalves, crangonid shrimps, and hermit crabs (Feder *et al.*, 1977a). The relationship of bottom-feeding fishes to benthic food webs has been examined in preliminary investigations in waters of the Alaska shelf (Feder *et al.*, 1977a,b,c; Smith *et al.*, 1976), but it is suggested in this proposal that further documentation be obtained by additional frequency of occurrence data on selected species.

V. Objectives

A. Kodiak Shelf. It is the intent of this investigation to conduct a qualitative and limited quantitative inshore survey of benthic invertebrates within the Kodiak Island oil lease area in conjunction with the Alaska Department of Fish and Game (Blackburn and Jackson, R.U. 486).

The specific objectives of this survey are:

1. Assess spatial and temporal distribution and relative abundance of epifaunal invertebrates in selected bays and inshore areas.
2. Where possible, assess spatial and temporal distribution of selected, important inshore infaunal invertebrate species.
3. Determine, where possible, the feeding habits of the principal inshore epifaunal invertebrate species exclusive of king crab (see 4 below).
4. Determine the feeding habits of the king crab. The following listed objectives should eventually delineate (1) what the major geographic areas are that support (in terms of food) king crab of various sizes and life stages, and (2) which food item(s) or group(s) are most important to the enhancement of the size of a particular king crab stock.
    a. Examine the percent weight and/or volume composition of prey items of king crab of different sex, length and ecdysis stage by area (depth) and time of the year.
    b. Examine the feeding intensity of king crab following the same parameters as in objective (a) above.
    c. Examine the correlation between catch number of king crab and their feeding intensity as determined by objective (b).
5. If appropriate, determine food habits of selected bottom-feeding fishes (species predominantly or exclusively utilizing invertebrates for food) (see Feder *et al.*, 1977a,b,c for examples of a similar approach).
6. Develop food webs integrating invertebrate, fish and bird feeding data in collaboration with the Alaska Department of Fish and Game R.U. 486 (see references in 5 above for examples of this approach) and U.S. Fish and Wildlife Service (R.U. 341).
7. Compile seasonal reproductive data, and other biological data whenever possible, on dominant benthic epifaunal invertebrates.
8. Initiate recruitment, age and growth, and mortality studies on important clam species (specifically species important as food for dominant epifaunal species such as king crab, snow crab, selected species of bottom-feeding fishes) taken in the course of the proposed study.

9. Utilize data obtained in this proposed work in conjunction with data on inshore fishes (proposed study by A.D.F.&G. for R.U. 486) and bottom-feeding birds (proposed study by U.S. Fish and Wildlife Service for R.U. 341) to suggest the potential sensitivity of the inshore marine communities to oil pollution.

B. Lower Cook Inlet. It is the intent of this investigation to conduct a qualitative and limited quantitative inshore survey of benthic invertebrates within the lower Cook Inlet lease area in conjunction with D. Lees (R.U. 417) and J. Blackburn (R.U. 512). Site specific studies will be initiated within areas to be selected by way of intensive discussions with D. Lees and J. Blackburn, and will be based on data input from past OCSEAP studies in Cook Inlet. Close coordination with the hydrocarbon studies of Shaw (R.U. 275) heavy metal investigations of Burrell (R.U. 162), and detrital studies of Larrance (R.U. 425) is planned. Studies of the energy flow through inshore benthic invertebrates will be in close collaboration with studies planned by Shaw to delineate the movement of hydrocarbons through benthic species.

The specific objectives of this survey are:

1. Assess spatial and temporal distribution and relative abundance of epifaunal invertebrates in selected inshore areas and juvenile snow crab in the deeper areas adjacent to Cape Douglas (see Feder *et al.*, 1977a for comments on this nursery area).
2. Where possible, assess spatial and temporal distribution of selected, inshore infaunal invertebrate species.
3. Initiate a research and development effort, in conjunction with the NEGOA invertebrate project, that will address energy transfer from a sediment-detrital system to infaunal deposit feeders (see NEGOA Technical Proposal for detailed objectives. Species from either Cook Inlet or the NEGOA area, or both areas, will be used initially to establish the detrital system-organism interactions).
4. Initiate, as time and logistics permit, studies of the feeding habits of the principal inshore epifaunal invertebrates, exclusive of the snow crab, by diving and trawling techniques.
5. Conduct an intensive study of the feeding habits of the snow crab at specific sites to be chosen (see NEGOA Technical Proposal for detailed objectives. Crab from either or both areas will be used; ultimately it is intended to comprehend the feeding biology of snow crab of both areas).
6. Initiate an investigation of the basic biology of the major prey species of snow crab: species to be examined will be chosen from selected bivalve, hermit crab, and crangonid shrimp species. Whenever possible, the following data are to be collected: food habits, abundance, recruitment, and productivity.
7. If appropriate, in conjunction with Blackburn (R.U. 512), determine the food habits of selected inshore, bottom-feeding fishes (species predominantly or exclusively utilizing invertebrates for food) (see Feder *et al.*, 1977a,b,c for examples of similar approach using frequency of occurrence data).

8. Develop food webs integrating invertebrate, fish, bird and marine mammal feeding data in collaboration with Lees (R.U. 417), Blackburn (R.U. 512) and Lensink (R.U. 341). See Feder *et al.*, (1977a,b,c) and Lees (OCSEAP Reports) for examples of this approach.
9. Compile seasonal reproductive data, and other biological data whenever possible, on dominant benthic epifaunal invertebrates.
10. Continue age and growth, and initiate mortality studies on important clam species (especially those important as food for dominant epifaunal invertebrate species, such as snow crab) and demersal fishes.
11. Utilize data obtained in this study to suggest potential sensitivity of the inshore benthic communities to oil pollution.

C. Northeast Gulf of Alaska. It is the intent of this investigation to initiate a qualitative and limited quantitative inshore survey of benthic invertebrates within the northeast Gulf of Alaska (NEGOA) lease area in conjunction with D. Lees (R.U. 417) and Dr. Lensink (R.U. 341). Site specific studies will be initiated either near Hinchinbrook Entrance or Kayak Island, or both. Other sites to be examined in the future, in conjunction with the long-term SCUBA studies of D. Lees, are in the vicinity of Danger Island (near Latouche Point) and the mouth of Port Etches off Constantine Harbour (R.U. 417).

The specific objectives of this survey are:

1. Assess spatial and temporal distribution and relative abundance of epifaunal invertebrates in selected inshore areas as time and logistics permit, specifically Hinchinbrook Entrance and vicinity, and/or Kayak Island sites; Danger Island and off Constantine Harbour.
2. Where possible, assess spatial and temporal distribution of selected, inshore infaunal invertebrate species.
3. Initiate a very limited research and development effort that will address the energy transfer from a sediment-detrital system to infaunal deposit feeders. The preliminary study will include, as logistics and time permit (also see Lower Cook Inlet objectives):
   a. An estimation of the rate of deposition of sediment and detrital material (in close association with Larrance, R.U. 425), and an evaluation of the quality of the organic components of the settling material as a food resource for the benthic infauna.
   b. Determination, as time and logistics permit, of the concentrations of non-living organic carbon and nitrogen, and the bacterial biomass of the substrate.
   c. Examination, as time and logistics permit, of the stomach contents of selected biologically important infaunal species as a basis for development of infaunal food webs.
   d. In conjunction with similar studies in Lower Cook Inlet, a limited endeavor in NEGOA will include the following activities. Measurement of ingestion and assimilation rates of selected infaunal species of major importance to higher trophic levels. The benthic infauna represents an important food source for epifaunal invertebrates and demersal fishes, but little is known

about the nature of the food supply available to the infauna or the efficiency of the infauna in utilizing available food in the sediments. However, the importance of microorganisms in sediments is well established (Christian and Hall, 1977), and the association of large numbers of bacteria with the detrital components of sediments is also documented (Tenore, 1977). The bacteria in sediments of inshore waters, especially in areas with considerable macrophyte detrital accumulation, probably represent a major source of food for infaunal species there. Since the food of deposit-feeding infauna is intimately connected with the substrate, contamination of bottom sediments by oil could have an effect on these organisms (as well as suspension feeders) by way of the adsorption of oil onto active suspended sediments (see Cline and Feely, OCSEAP Annual Reports), plankton and suspended detrital materials which are deposited on the substrate. The latter effect may be especially serious on the NEGOA shelf where high sedimentation rates occur (Carlson and Molnia, R.U. 216).

4. Initiate studies, whenever possible, on the feeding habits of the principal inshore epifaunal invertebrates, exclusive of the snow crab, by diving and trawling techniques.
5. Initiate a study of the feeding habits of the snow crab at specific sites (in conjunction with similar studies in Lower Cook Inlet),
   a. Examine the percent weight and/or volume composition of prey items of snow crab (1) of different sex and length, (2) at varying times of day and (3) at different seasons of the year.
   b. Examine, when possible, the feeding intensity of snow crab following the same diurnal, seasonal parameters as in objective (a) above.
   c. Experimentally examine the food preference and feeding rates of snow crab of different sex and size, and at varying times of the day and year (diurnality and seasonality).
   d. Determine dry weight and carbon values of (1) prey species, and (2) various sizes of snow crab.
6. Initiate (in conjunction with similar studies in Lower Cook Inlet) an investigation of the basic biology of the major prey species of snow crab: initially with selected bivalves, selected hermit crab species, and crangonid shrimps. Additional species are to be examined as the inshore NEGOA area is assessed in the program. Whenever possible, the following data are to be collected: (a) food habits, (b) abundance, (c) recruitment, and (d) productivity.
7. If appropriate, determine food habits of selected inshore, bottom-feeding fishes (species predominantly or exclusively utilizing invertebrates for food (see Feder *et al.*, 1977a,b,c for examples of a similar approach).
8. Develop food webs integrating invertebrate, fish and bird feeding data in collaboration with Lees, R.U. 417 (see Feder *et al.*, 1977a,b,c for examples of this approach), and U.S. Fish and Wildlife Service (R.U. 341).
9. Compile reproductive data, and other biological data, whenever possible, on dominant benthic epifaunal invertebrates.

10. Initiate age and growth, and mortality studies on important clam species (especially species important as food for dominant epifaunal species such as snow crab and demersal fishes).
11. Utilize data obtained in this proposed study on inshore invertebrates, fishes and bottom-feeding birds (U.S. Fish and Wildlife Service, R.U. 341) to suggest the potential sensitivity of the inshore benthic communities to oil pollution.

VI. General Strategy and Approach

A. Kodiak Shelf. The general approach in the field to accomplish the objectives is similar to that proposed by Blackburn and Jackson for R.U. 486 in the Kodiak area. Most of the data will be obtained in conjunction with the seasonal trawling activities of Alaska Department of Fish and Game in the Marmot Bay-Chiniak Bay area, selected bays in the Sitkalidak Strait area, and the Horse's Head area. Intensive sampling will be accomplished in these areas from April-August with additional cruises in November and February if possible. The study areas will be sampled intensively with approximately 12 cruises planned in this proposal. Sampling will encompass stations systematically established at the selected study sites. A variety of sampling gear will be employed to ensure success of the inshore sampling program. Most of the gear will be the same as that used by the ADF&G project, but, in addition a pipe dredge (or other dredging gear if necessary) will be used whenever possible to qualitatively sample infauna at selected stations. Station selection for the latter sampling will be primarily related to the needs dictated by the feeding studies on crab and selected bottom fishes and clam growth studies. If need, time and logistics (i.e. appropriate vessel) so dictate, a limited number of quantitative stations (using a van Veen grab) may be established. The intensity at which sites are sampled will be dependent on weather and available survey time. Care will be taken to maintain the same sampling locations and intensity of sampling at each collection period. Epifaunal material and some fish stomachs will be examined on shipboard according to the methodology described in Feder *et al.* (1977a). All other material will be examined in the laboratory. The king crab feeding study will be coordinated with Guy C. Powell, king crab biologist, ADF&G, Kodiak. A reconnaissance survey, if time, funds and logistics permit, of one selected site will be initiated using diver techniques; a similar approach to that used by Dennis Lees in Lower Cook Inlet in 1976 and described by Lees in R.U. 417 for the upcoming year will be followed.

Studies will be conducted in conjunction and close coordination with R.U. 486 (Nearshore Fish Communities). The close coordination between projects, besides promoting efficiency and economy, should enhance assimilation and interchange of data on inter-species relationships and seasonal succession of marine organisms.

B. Lower Cook Inlet. The general approach in the field to accomplish the objectives in waters below diving depth is similar to that proposed for the other lease areas. Data will be obtained by trawling, grab-sampling and dredging activities in selected inshore study areas to be selected, in part, by discussions with Lees, Blackburn, Shaw and Burrell. Sampling will be accomplished in the intensive study sites from April through August with an additional cruise in November if possible. Five to six cruises are planned, although several more may be included, as the study progresses, if need indicates further collections will enhance the quality of the final report. Sampling will encompass stations to be systematically established at selected sites. A variety of gear will be employed. Dredging and grab-sampling will primarily be related to the needs dictated by feeding studies and clam growth studies. The intensity at which sites are to be sampled will be dependent on weather and available survey time. Epifaunal material and some fish stomachs will be examined on shipboard according to the methodology described in Feder *et al.* (1977a). All other material will be examined in the laboratory.

Experimental studies on snow crab food preferences and feeding rates will be performed in the field and adjacent to the Seward Marine Station. A cruise designed to develop procedures for this study will take place in Resurrection Bay. Experiments proposed for Cook Inlet are applicable to benthic areas in NEGOA. Thus, specimens from either area or both, Cook Inlet and NEGOA, will be chosen for the experiments. Funds from the NEGOA and lower Cook Inlet benthic invertebrate projects will be used to jointly support this experimental study.

The approach used to accomplish the objectives in waters of diving depth will be to coordinate our program with that of Lees (R.U. 417) at some of his intensive study sites (see Lees OCSEAP reports), e.g. Seldovia Point, Bluff Point, Iniskin Bay, Kamashak Bay, or other sites chosen at a conference before the start of the new project period. Funding from the proposed project (R.U. 5) will be used to enhance Lees investigation by extending his work into additional feeding and growth studies (e.g. as need dictates, initiate studies on selected species of crabs, and/or *Modiolus*, and/or *Saxidomus*, and/or *Mya* spp.), and should complement his R.U. 417 sponsored work. Dennis Lees and Rick Rosenthal as well as one of the assistants on R.U. 5, if he is needed, will be directly involved in the diving program; R.U. 417 will furnish material (e.g. crabs, bivalve molluscs) to R.U. 5 for food and growth analyses to be done in Fairbanks and Seward. Analysis of all diving activities and data will be a joint endeavour between Feder, Lees and Rosenthal. Techniques to be used in the surveys are described in R.U. 417.

Measurements of rate of deposition of sediment and its quality as a food source will be obtained from Larrance (R.U. 425). All other aspects of the study on energy flow from sediment-detrital systems to infaunal deposit feeders are the same as that described for the NEGOA study. Funds from NEGOA and Cook Inlet invertebrate studies will jointly serve to support this experimental investigation. Species from either area, or both, will be used in the experiments, as determined by ongoing research activities; results from both areas will be pooled to assess the import of the results.

Close coordination with R.U. 417, R.U. 341, R.U. 424, R.U. 275 and R.U. 5, besides promoting efficiency, should enhance assimilation and interchange of data.

C. Northeast Gulf of Alaska. The general approach in the field to accomplish the objectives in waters below diving depth is similar to that proposed for the other lease areas. Data will be obtained by trawling, grabbing and dredging activities primarily (1) at selected stations near Hinchinbrook Entrance including Port Etches where prior feeding and quantitative bottom data is available (Feder and Paul, unpub. Sea Grant data; Paul and Feder, 1975), (2) at selected stations near Kayak Island, and (3) other inshore NEGOA stations identified as important in the course of the investigation. Intensive sampling will be accomplished in these specific areas from July - August if possible. At least two cruises are planned. Sampling will encompass stations to be systematically established at the selected study sites. A variety of gear will be employed to ensure success of the sampling program. Dredging and grab sampling will be primarily related to the needs dictated by the feeding studies on crab and selected bottom fishes, and clam growth studies. If need, time and logistics (i.e. appropriate vessel) so permit, a limited number of quantitative stations (using the van Veen grab) may be established. The intensity at which sites are sampled will be dependent on weather and available survey time. Care will be taken to maintain the same sampling locations and intensity of sampling at each collection period. Epifaunal material and some fish stomachs will be examined on shipboard according to the methodology described in Feder *et al.* (1977a). All other material will be examined in the laboratory and at the Marine Sorting Center, University of Alaska.

Experimental studies on snow crab food preferences and feeding rates will be performed in the field and the laboratory. The experiments proposed and the results deriving from them are applicable to benthic areas in lower Cook Inlet. Thus, specimens from the latter area may be chosen for the experiments, and the field work might be accomplished here as well as in NEGOA. Funds from the NEGOA and lower Cook Inlet benthic invertebrate projects will jointly serve to support this experimental study.

The approach used to accomplish the objectives in waters of diving depth will be to coordinate our program with that of Lees (R.U. 417) in one of the two intensive study sites that have been examined by him over the past years, Danger Island (Latouche Point) and off Port Etches (Constantine Harbour). Additional sites may be chosen for reconnaissance studies in the future, if necessary, by coordination with Lees. Limited funding from the proposed project will be used to enhance Lees study by extending his work into additional feeding and growth studies, and should complement his R.U. 417 sponsored work. Dennis Lees as well as one of the assistants in our project, if he is needed, will be directly involved in the diving program; R.U. 417 will furnish material to R.U. 5 for food and growth analyses in the laboratories at Fairbanks and Seward. Analysis of all diving activities will be a joint endeavour between Lees and Feder - an effort to continually integrate the diving and offshore studies. Techniques to be used in the surveys are described in R.U. 417.

Measurements of the rate of deposition of sediment and its quality as a food source (organic Carbon, organic Nitrogen, bacterial biomass) will be carried out (depending on ship logistics and weather). Data for this aspect of the project will be obtained from Larrance (R.U. 425). Organic Carbon and Nitrogen concentrations and bacterial biomass of the substrate will also be measured when possible to determine any seasonal changes in the available food supply. Grabs, trawls, dredges, and a Haps corer will be used to collect infaunal organisms for examination of stomach contents (seasonally if possible) and for specimens for feeding experiments. The following organisms will be assessed for their utility in the feeding experiments proposed in the objectives section: *Macoma* spp. (a deposit feeder), *Psephidia lordi* (very abundant), *Nuculana* sp. (deposi feeder; important food item); crangonid shrimps (important food items), hermit crabs (snow crab food), *Sternaspis* (a very abundant deposit feeding worm). The experiments proposed here and the results deriving from them are applicable to benthic areas in lower Cook Inlet. Thus, species from the latter area may also be chosen (e.g. *Tellina nuculoides* - an abundant deposit feeder, *Modiolus* - an abundant, shallow water suspension feeding mussel, *Clinocardium* - abundant, suspension feeder, food item of crab). Funds from NEGOA and lower Cook Inlet will jointly serve to support this experimental study.

NEGOA studies will be conducted in conjunction and close coordination with Lees (R.U. 417) and Lensink (R.U. 341). The close coordination between projects, besides promoting efficiency, should enhance assimilation and interchange of data.

VII. Sampling Methods

A. Kodiak Shelf. Sampling will generally coincide with that of ADF&G; presumably up to two cruises will be conducted per month, April through August, with a continuing rotation between sampling sites. If weather permits, one cruise will be made in November and February. One cruise will be selected in mid-summer for the reconnaissance dive surveys in selected areas. Epifaunal material will be taken with gear fished by ADF&G personnel on each cruise. Invertebrates will be separated, enumerated and weighed according to the methodology described in Feder *et al.* (1977a,b). All invertebrates will be given tentative identifications, and representative samples of individual species preserved and labeled for final identification at the Institute of Marine Science and the Marine Sorting Center, University of Alaska, Fairbanks. Infaunal material will be obtained qualitatively with a pipe dredge or quantitatively with a van Veen grab. Samples will be washed on a 1.0 mm mesh screen, fixed in 10% buffered formalin, and examined in Fairbanks. Stomachs of selected species (e.g. clams, pandalid shrimps, crangonid shrimps, king crab, crab, selected species of bottom fishes) will either be examined on shipboard or in the laboratory in Fairbanks. All species used in feeding studies will be measured. King crab examined in feeding studies will be separated into as many ecdysis stages[1] as possible (up to 8 stages). Whenever possible, the entire gut (stomach and intestine) will be removed. This material will be fixed in 10% formalin. Clams to be used will be separated on shipboard when possible, and growth studies accomplished in the laboratory.

1. Eight classes of king crab (classification adapted after Powell *et al.*, 1974)
   a. Juvenile females: non-ovigerous females <120 mm (length).

b. Adult females: ovigerous females >95 mm.
c. Newshell males <100 mm: individuals that molted during the last molting period.
d. Oldshell males <100 mm: individuals that failed to molt during the last molting period; often referred to as skipmolts.
e. Very oldshell males <100 mm: individuals that failed to molt during the last two or more molting periods; often referred to as double skipmolts.
f. Newshell males >100 mm.
g. Oldshell males >100 mm.
h. Very oldshell males >100 mm.

B. Lower Cook Inlet. One two-week cruise per month will be taken on the remote-sampling (i.e. waters below diving depth) portion of the project from April through August with an additional cruise in November. Sampling will be accomplished on a substantial vessel that will have the capability of trawling with commercial gear, dredging (pipe or other dredge) and grab sampling (van Veen grab). In addition, this vessel should have sufficient space to permit preliminary workup of trawl material (see Feder *et al.*, 1977a for methodology), should have running sea water at an appropriate pressure to permit washing of grab and pipe dredge samples on board ship. At least a few of the cruises should have sufficient laboratory space to work up, in detail, some of the commercially trawled material (this primarily refers to detailed examination of large numbers of snow crab stomachs *in situ* to enable decisions to be made concerning locations of dredging and grab stations to obtain immediate data on location and abundance of food organisms). In addition, cruises of opportunity (for example on the R/V *Acona* when it is working in the study area) will be used whenever possible, to obtain supplemental data. A one-week cruise in Resurrection Bay on a small boat, with trawling and pot capabilities, will be taken to initiate the snow crab feeding study. All dredge and grab material will be washed on 1.0 mm screens. All trawled and dredged invertebrates will be given tentative identifications, and representative samples of individual species preserved in 10% buffered formalin, and labeled for final identification at the Institute of Marine Science and the Marine Sorting Center, University of Alaska, Fairbanks. Stomachs of selected species (e.g. shrimps, king crab, snow crab, hermit crab) will either be examined on shipboard (see special shipboard examination need referred to above) or in the laboratories in Fairbanks. All species used in feeding studies will be measured, separated by sex where readily possible (e.g. in crabs but not necessarily in shrimps), and separated into as many size groups as possible. Clams to be used in growth studies will be separated from sediments on shipboard, and measurements made on them in the laboratory.

In coordination with Lees (R.U. 417), the site specific diving sites selected at the beginning of the project year will be occupied four to five times in the spring, summer and fall. Weather and boat logistics will determine the exact number of cruises occupied by diving techniques. The diving survey on this (R.U. 5) project will extend and complement that of Lees (R.U. 417). The data collected will be primarily from rocky habitats. Densities and size structures of organisms in the field will be determined according to techniques employed by Lees in Cook Inlet (see proposal for R.U. 417). Coverage will be determined by visual estimation within quadrats.

Where possible, soft sediments will be sampled. Techniques used will be those described by Lees in his proposal for R.U. 417. Trophic dynamics of the study sites will be evaluated from *in situ* observations of feeding activities, and the examination of stomach contents of selected species. Bivalve molluscs to be utilized in growth studies will be collected. These bivalves and species to be examined in detail for food contents of stomachs will be taken to Fairbanks and the Seward Marine Station for further study.

Sedimentation rates will be estimated by coordination with Larrance (R.U. 425). Organic nitrogen, organic carbon and bacterial biomass of suspended sediment load will be determined from replicate 30 ℓ water samples taken three to five meters above the substrate in order to collect sufficient material. Sediments from the bottom will be collected using a Haps Corer. Animals for examination of stomach contents and for feeding experiments will be taken by van Veen grab, Haps corer, dredge or otter trawl. Animals will be carefully removed from sediments so as to preserve their stomach contents intact and to avoid damage to the organisms. All of the studies described for the energy flow/sediment-detrital system/infaunal deposit feeder investigations will be integrated with similar studies in the NEGOA area (see NEGOA technical proposal for details), studies of this nature will take place primarily in the Cook Inlet lease area. Success with the latter type of study in Cook Inlet sites will determine the magnitude of involvement in NEGOA.

C. Northeast Gulf of Alaska. One two-week cruise per month will be taken on the remote-sampling portion (i.e. regions below diving depth) of the project in July - August; all work is to be accomplished on a substantial vessel capable of working outside Prince William Sound. The vessel used must have the capability of trawling with commercial trawl gear, dredging and grab sampling. All sampling sites are to be occupied at each cruise if the developing program dictates the necessity; however, the intensive sampling sites off Hinchinbrook Entrance and near Kayak Island will always be sampled at each cruise. Invertebrates taken by trawl and dredge will be separated, enumerated and weighed according to the methodology described in Feder *et al.* (1977a,b). All invertebrates will be given tentative identifications, and representative samples of individual species preserved and labeled for final identification at the Institute of Marine Science and the Marine Sorting Center, University of Alaska, Fairbanks. Infaunal invertebrates will be obtained with a pipe dredge or van Veen grab. Samples will be washed on board ship on a 1.0 mm mesh screen, fixed in 10% buffered formalin, and examined in Fairbanks. Stomachs of selected species (e.g. shrimps, king crab, snow crab, hermit crab) will either be examined on shipboard or in the laboratory in Fairbanks. All species used in feeding studies will be measured, separated by sex where readily possible, and separated into as many size groups as possible. Clams to be used in growth studies will be separated from sediments on shipboard, and measurements made on them in the laboratory.

If coordination with Lees (R.U. 417) is successful, the diving sites in the Danger Island or Constantine Harbour will be occupied in the summer. Weather and boat logistics will determine the number of cruises occupied by diving techniques. The survey on this project will extend and complement that of Lees (R.U. 417). Information from the rocky habitat will be collected. Densities and size structures of organisms will be determined according to techniques employed by Lees (R.U. 417). Coverage will be determined by visual estimation within quadrats. Where possible, soft sediments will be sampled. The density and size structure of the animals in the soft substrates will be sampled with core tubes (small, abundant species) and 0.25 m^2 quadrats (large, relatively less common species). Samples will be screened through 1.0 mm sieves. Trophic dynamics will be examined from *in situ* observations of feeding activities and the examination of stomach contents of selected collected species. Bivalve molluscs to be utilized in growth studies will be collected. The bivalves and species to be examined for food contents of stomachs will be taken to Fairbanks and the Seward Marine Station for further study.

Sedimentation rates will be estimated in conjunction with studies of Larrance (R.U. 425). Organic nitrogen, organic carbon and bacterial biomass of suspended sediment load will be determined from replicate 30 ℓ water samples taken three to five meters above the substrate in order to collect sufficient material. Sediments from the bottom in the intensive study sites will be collected using a Haps Corer. Animals for examination of stomach contents and for feeding experiments will be taken by van Veen grab, Haps corer, dredge and/or otter trawl. These animals will be carefully removed from the sediments so as to preserve their stomach contents intact and to avoid damage to the organisms.

VIII. Analytical Methods

A. <u>Kodiak Shelf</u>. Final analysis of inshore epifaunal and infaunal material will be accomplished in the laboratory in Fairbanks by methods developed in past offshore OCSEAP studies by Feder (Feder *et al.*, 1977a,b,c). All species will be assigned Taxon Code numbers, and will be summarized according to computer programs developed previously (for example, see Feder *et al.*, 1977a). Community composition and structure will be described. Stomach analyses will be accomplished in the laboratory with quantitative data obtained for some species; weight or volume composition of prey items will be specifically taken for king crab material. Feeding intensity of king crab will be calculated using the following Food Index (see Takeuchi, 1959):

$$\text{F.I.} = \frac{\text{FW}}{\text{BW}} \times 10^4$$

where FW = weight of food contents
BW = body weight

All data will be summarized and analyzed with available or specially written computer programs. Growth history analyses of clam species will be applied according to techniques described in Feder and Paul (1974) and Paul *et al.* (1976). Food webs will be constructed from accumulated and integrated (fish, bird, marine mammal) data (see Feder *et al.*, 1977a,b,c for examples); semi-quantitative flow lines indicating the importance of a particular food item will be used in this project whenever possible.

B. Lower Cook Inlet. Final analysis of inshore epifaunal and infaunal material will be accomplished in the laboratory and the Marine Sorting Center, University of Alaska, by methods developed in past offshore OCSEAP studies by Feder (Feder *et al.*, 1977a,b,c). Analysis of some materials in collaboration with Lees (R.U. 417) is planned. All species will be assigned Taxon Code numbers, and will be summarized according to computer programs developed previously for other benthic studies by Feder (for example, see Feder *et al.*, 1977a). Community composition and structure will be described using data available from collections made on the proposed project cruises, past Cook Inlet studies by Feder and the data in the literature compiled by Feder and Muller (1977). (Although the investigations of Feder *et al.*, 1977a in Cook Inlet were well offshore, a great many of the species examined in that study will also occur in the inshore waters to be examined in the current project. Thus, much of the community information derived previously on sediment bottoms will be applicable.) Stomach analyses will be accomplished according to methods listed in the NEGOA proposal. Stomach data will be quantitative for some species, primarily the snow crab, but other species may be so examined as field surveys indicate their importance. In the quantitative analysis of stomach contents, either total weight or volume of the contents will be measured relative to the size (weight) of the whole animal. Feeding intensity of the snow crab (and other species, if need and time permit) will be obtained by using the Food Index of Takeuchi (1959). See details of method in NEGOA section of this proposal. All data will be summarized and analyzed with available or specially written computer programs at the University of Alaska. Clam species will be analyzed according to Feder and Paul (1974) and Paul *et al.* (1976).

Food webs will be constructed in collaboration with Lees (R.U. 417, English (R.U. 424), Blackburn (R.U. 512), and Lensing (R.U. 314), from accumulated and integrated (invertebrate, fish, bird, marine mammal) data (see Feder *et al.*, 1977a,b,c and Lees OCSEAP Annual Reports for example); semiquantitative flow lines indicating the importance of food items will be used in the new project whenever possible.

In the shallow-water sites examined in direct collaboration with Lees (R.U. 417), all techniques described in his R.U. 417 proposal will be used. The details of the analytical procedures to be used are described in some detail in the invertebrate NEGOA section of this proposal (see next page).

The analytical methods planned for the experiments designed to measure energy transfer from sediment to infaunal deposit feeders are the same as those described for the NEGOA area (see NEGOA technical proposal on next page). Cook Inlet sites and species will be used in conjunction with sites and species from NEGOA studies; if Cook Inlet studies are totally successful, most of the work will be accomplished in that area.

The analytical methods planned for the experiments designed to examine snow crab food preferences and feeding rates are the same as those described in the NEGOA technical proposal. As indicated in that proposal, experiments in Cook Inlet and NEGOA are complementary. Thus, sites and snow crab from Cook Inlet will probably be used in the earlier experiments because of the better experimental conditions expected there as compared to the NEGOA study sites. A pilot experiment will be accomplished in Resurrection Bay to develop procedures.

C. Northeast Gulf of Alaska. Final analysis of inshore epifaunal and infaunal material will be accomplished in the laboratory and the Marine Sorting Center, University of Alaska in Fairbanks by methods developed in past offshore OCSEAP studies by Feder (Feder *et al.*, 1977a,b,c). Analysis of some materials in collaboration with Lees (R.U. 417) is anticipated. All species will be assigned Taxon Code numbers, and will be summarized according to computer programs developed previously for other benthic studies by Feder (for example, see Feder *et al.*, 1977a). Community composition and structure will be described using data available from the proposed project, past NEGOA studies by Feder and the data in the literature compiled by Feder and Mueller (1977) (although the investigations of Feder *et al.*, 1977a was offshore, a great many of the species collected in that study will also occur in the inshore waters to be examined in the current project. Thus, much of the community information derived previously on sediment bottoms will be appreciable.)

Stomach analyses will be accomplished in the laboratory and the Sorting Center, University of Alaska. Some of the analyses will be accomplished at the Seward Marine Laboratory, University of Alaska, when necessary. Stomach data will be quantitative for some species, primarily the snow crab, but other species may be so examined as field surveys indicate their importance. In the quantitative analysis of stomach contents, either total weight or volume of the contents will be measured relative to the size (weight) of the whole animal. Feeding intensity of the snow crab (and other species if need and time permit) will be obtained by using the following Food Index (See Takeuchi, 1959 for similar method used for king crab; this method will also be used in the king crab study to be accomplished in the proposed Kodiak lease study. See appropriate section of this proposal):

$$F.I. = \frac{FW}{BW} \times 10^4$$

where FW = weight of food contents
BW = body weight

This index will be modified in the course of the project if results indicate this to be necessary.

All data will be summarized and analyzed with the aid of available or specially written computer programs at the University of Alaska. Growth-history analyses of clam species will be applied according to techniques described in Feder and Paul (1974) and Paul *et al.* (1976).

Food webs will be constructed in collaboration with Lees (R.U. 417) from accumulated and integrated (invertebrate, fish, bird, marine mammal) data (see Feder *et al.*, 1977a,b,c and Lees OCSEAP Annual Reports for examples); semiquantitative flow lines indicating the importance of a particular food item will be used in the new project whenever possible.

In the shallow water sites examined in direct collaboration with Lees (R.U. 417), all techniques described in his R.U. 417 proposal will be taken, inclusive of linear, wet and dry weight measurements wherever possible. Preliminary analysis of gut contents will be accomplished by Lees (R.U. 417) and Feder (R.U. 5) in the laboratory with results to be directly integrated with stomach analysis of the same species taken by boat from somewhat deeper (i.e. inshore but deeper than diving depth) waters. Each research group will be responsible for particular species, and data derived from all stomach analyses will be pooled for final synthesis. Populations will be described where applicable by techniques developed by Lees (R.U. 417); these methods will generate estimates for growth and mortality rates, age-specific size, and longevity. This approach will also be used, if applicable, to deeper-living species taken in the boat surveys. Standard descriptive ecological statistic (diversity indices, classification techniques) will be used to assist in describing the assemblages examined, particularly in soft substrates. Methods developed by Feder (Feder *et al.*, 1977a) for NEGOA may be applicable here, and will be applied in collaboration with R.U. 417 at the appropriate time.

In research and development efforts designed to measure energy transfer from sediment to infaunal deposit feeders, organic carbon and organic nitrogen will be determined using a CHN analyzer. Bacterial biomass will be determined using the muramic acid (Moriarty, 1975, 1976) or other appropriate method. If time and funding permit, both the suspended sediments and those collected from the bottom will be dyed with periodic acid-Schiff reagent (PAS) and examined microscopically to determine the relative abundance of potential food particles (Johnson, 1977). The development of liquid scintillation counters and improved methods of tissue digestion have made it possible to use radiotracer experiments to examine ingestion and assimilation of labeled bacteria, benthic diatoms and detritus by benthic deposit and suspension feeders (Hargrave, 1970; Kofoed, 1975a,b; Moriarty, 1976; Tenore *et al.*, 1968, 1977; Wetsel, 1976; Yingst, 1976). We plan to measure ingestion and assimilation of labeled bacteria and detritus in selected organisms using adaptations of the methods of Tenore (1975) and Yingst (1976). If time permits in this proposal period, these techniques will also be adapted to measure rates of assimilation and ingestion of several food items by important infaunal and epifaunal predators. The food items to be used in these experiments will be determined from the examination of stomach contents in the feeding studies referred to above.

In the experiments designed to examine snow crab food preferences and feeding rates the following approach will be used in conjunction with similar studies on Cook Inlet:

1. Seasonally (if possible) snow crab will be obtained by trawl or diving: either (a) 100 each, mature males, mature females (if available) and 100 juveniles, or alternately (b) 150 large and 150 small crab.
2. 10 males, 10 females and 10 juveniles (minimum sample size of 9) will be sacrificed immediately after their collection for examination of stomach contents. Species content and the volume or weight of each stomach will be determined.
3. The remaining crab will be held in pots (in the field) or in tanks (on shipboard) without access to food. Some of these crabs will be sacrificed every 4-6 hours (interval to be determined) as in step (2) above.
4. The initial collection by trawling or diving will be made three or four times per twenty-four hour period (e.g. 0100, 0800, 1600 hours), and the experiment outlined in (2) and (3) above will be repeated. It is estimated that about one week will be needed for each of the experiments.

5. The above experiments will be carreid out seasonally if possible.
6. A pilot experiment will be accomplished in Resurrection Bay adjacent to the Seward Marine Laboratory. Additional suggested experimental areas are Port Etches (near the diving site area), near Kayak Island, or Cook Inlet (Iniskin Bay).
7. The experiments proposed here and the results deriving from them are applicable to benthic areas in lower Cook Inlet. Thus, snow crab and sites from the latter area will probably be used in some of the earlier experiments because of the better experimental conditions to be expected there. Funds from NEGOA and lower Cook Inlet will jointly serve to support this experimental study.

IX. Anticipated Problems

A. Kodiak Shelf.

1. Weather precluding completion of monthly surveys as planned.
2. Logistic problems precluding completion of diving survey. Specifically, unavailability of proper boat for diving logistics.
3. Timely submission of the reports due July and October 1 due to intensive summer field activities. The major field sampling will occur April through August, and most of the investigators will be in the field during this period. Insufficient time will be available to process most of the field data and prepare it in time for the October Report.
4. Securing use of appropriate seiner type fishing vessel to use in conducting a continuing series of charters.
5. Securing use of appropriate type of vessel to permit grab sampling and pursuit of a limited diving survey.
6. Resolution of the problem concerning workup of food data from the fish species chosen by this project to be directly related to benthic invertebrates of importance. It is essential that our group be permitted to workup some fish stomach data (either frequency of occurrence or limited quantitative data); this approach is essential to the continuing and ever-developing clarification of benthic food webs during the project period. In addition, a close integration of our project with the one concerned with the quantitative workup of fish stomachs must be achieved; the data flow should be as prompt as possible on the species of direct interest to R.U. 5.
7. Acquisition of some crab (king and snow) material from water deeper than 40 m so that a more complete picture of crab feeding habits can be obtained.

B. Lower Cook Inlet.

1. Weather and logistics problems precluding completion of diving and other surveys planned.
2. Timely submission of Quarterly Report due October 1 due to intensive field activities of the preceding summer.
3. Securing use of appropriate vessel with commercial trawling capability and running seawater of the appropriate pressure to wash grab and dredge samples.
4. Securing use of appropriate vessel with commercial trawling capability and laboratory space for shipboard analysis at least twice during the project period.
5. Acquisition of sufficient snow crab to do the feeding rate experiments could be a problem. This might be especially true if an appropriate trawling vessel, capable of dragging up the large numbers of crab needed, cannot be obtained. Weather could also be a continuing problem on all periods chosen to do the snow crab feeding experiments.
6. The need for assurance that R.U. 5 will have access to all material obtained by dragging activities associated with OCSEAP programs in the inshore areas of Cook Inlet. It is especially important that R.U. 5 have access to appropriate samples of snow crab, shrimp, molluscs and bottomfishes on any OCSEAP cruises to Cook Inlet.

7. Acquisition of some juvenile and adult snow crab from deeper waters than 40 m so that a more complete picture of crab feeding and growth activities can be obtained. Sampling in the area off Cape Douglas (see Feder *et al.*, 1977a for comments on this apparent nursery area for snow crab) is especially important.
8. Initial problems with the experiments concerned with energy transfer from sediment to infaunal deposit feeders. See NEGOA technical proposal for details of problems.

C. Northeast Gulf of Alaska.

1. Weather precluding completion of surveys as planned.
2. Logistics problems precluding completion of diving surveys. Specifically, unavailability of proper boat for diving logistics and weather.
3. Timely submission of the Quarterly Report of October 1 due to the intensive field activities of the preceding summer. The major field sampling will occur July through August and most of the investigators will be in the field during this period. Insufficient time will be available to process most of the field data and prepare it in time for the Annual Report.
4. Securing use of appropriate vessel with commercial trawling capability to use in conducting a continuing series of charters off Hinchinbrook and Kayak Islands.
5. Acquisition of sufficient snow crab to do the feeding rate experiments could be a problem. This might be especially true if an appropriate trawling vessel, capable of dragging up the large numbers of crab needed, cannot be obtained. Weather could also be a continuing problem on all weeks chosen to do the snow crab feeding experiments.
6. The need for assurance that R.U. 5 will have access to all material obtained by dragging activities associated with OCSEAP programs in the inshore areas of NEGOA. It is especially important that R.U. 5 have access to appropriate samples of snow crab, shrimp, molluscs and bottomfishes on any cruises to the NEGOA area with this type of gear.
7. Acquisition of some snow crab from water deeper than 40 m so that a more complete picture of crab feeding habits in the NEGOA area can be obtained. It is necessary to recall that acquisition of snow crab feeding data was not directly funded in the past OCSEAP project in NEGOA.
8. In the research and development efforts concerned with energy transfer from sediment to infaunal deposit feeders, initial difficulties will be experienced in collecting, transporting and ultimately maintaining in the laboratory, healthy specimens of desirable test organisms. The organisms eventually selected for the experiments will be ones that meet the above tests, and can be maintained for long periods of time in the sea water system of the Seward Marine Laboratory. Some additional delays in completing the experiments may also be anticipated when the organism(s) is chosen; experiments will have to be adapted to suit the feeding behavior of the organisms of interest. We have not used the muramic acid method as yet, and some initial delay may be expected until all procedures are worked out. It is probable that the complexity of this particular segment of the proposal will result in preliminary data only during this proposal period. However, it is anticipated that the preliminary data will be useful to make some initial suggestions concerning carbon flow to infaunal feeding invertebrates.

X. Deliverable Products

This project will submit quarterly narrative reports which will include a discussion of current objectives, methods and techniques used in sampling, analysis and calibration. Discussion of data and significance of results will utilize graphical and tabular presentations where appropriate. Any digital data requirements will be handled by the University of Alaska OCS Coordination Office. In all lease areas, the specific objectives proposed in this proposal will be addressed in both narrative and data reports, including discussion of results and conclusions where possible.

XI. Information Required from Other Investigators

Input from other investigators is essential to the scientific meaningfulness of this project. Specifically there should be close cooperation with Barton (R.U. 19), Blackburn (R.U. 486), Lensink (R.U. 341), Blackburn (R.U. 512), Lees (R.U. 417), English (R.U. 424), and Larrance (R.U. 425). Direct contact has been made with Lees (Cook Inlet, NEGOA) and Blackburn (Cook Inlet, Kodiak). Contact with all other P.I.'s will be made as soon as the proposed program is initiated in October, or sooner, if the summer activities of all of the above investigators make this possible. We have reasonably close working or scientific relationships with all of the above named investigators.

XII. Quality Assurance Plans

Voucher specimens will be archived for the purpose of providing intercomparisons of taxonomic identifications in future studies.

XIII. Special Sample and Voucher Specimen Archival Plans

Voucher specimens will be archived for the purpose of providing intercomparisons of taxonomic identifications. This archive will be maintained for the duration of this contract period; at which time the specimens will be handled in accordance with a plan presently being formulated by and negotiated with OCSEAP Juneau.

XIV. Logistics Requirements

See attached forms.

Kodiak Lease Area

For OCSEAP use only.
R.U #______
Disc..pline______
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 Univ. of Alaska PRINCIPAL INVESTIGATOR H. M. Feder

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.
   Cannot be described until station locations are determined.

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. Primarily otter trawl. Some dredge and grab samples. Will need washing water for mud and 1.0 mm screen on some cruises. For single dive survey in several bays, ship use will be limited to transportation and lodging.

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.) For trawl and dredge surveys April-August, November. Two cruises per month at 7-10 days. Trip arranged with ADF&G. Dive survey in summer.

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.)
   Arranged with ADF&G - approx. 7-10 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? Cooperative effort (trawl survey); equal time requested. Dive survey - principal one.
   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. Maximum of 10 hrs/day for trawl survey. Maximum of 8 hrs/day for dive survey.

6. What equipment and personnel would you expect the ship to provide?
   Trawl. Trawl survey - assistance with trawling gear, dredge and grab sampling.

7. What is the approximate weight and volume of equipment you will bring?
   Grab = 80#; pipe dredge = 125#; wash stand = 200#; diving gear = 1500#, 75 cu. ft.

8. Will your data or equipment require special handling? Not for trawl gear If yes, please describe:
   Dive Gear: Compressor and Bottles will need great care.

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.
    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. Trawl charter to be arranged with ADF&G. Dive vessel must be rigged for diving but can negotiate for vessel.

12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals.
    Trawl survey: 2 for first leg - Steve Jewett or Max Hoberg and John Rose
    Dive survey: Dennis Lees and Rick Rosenthal.

Cook Inlet

For OCSEAP use only.
R.U.# ____________
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 Univ. of Alaska PRINCIPAL INVESTIGATOR H. M. Feder

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.
   Cannot be described until stations located.

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

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.)

   See attached

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.)
   See attached

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you 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.

   See attached

6. What equipment and personnel would you expect the ship to provide?
   Trawl survey: assistance with trawl
   Snow crab study: assistance with pot retrieval

7. What is the approximate weight and volume of equipment you will bring?

   Grab = 80#; dredge = 120#; wash box = 200#; diving gear = 1500#

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.
    See attached

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. See attached

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

2. Trawl/Dredge/Grab/Core Sampling Survey: commercial otter trawl; pipe dredge; grab; Haps core; running seawater to wash grab and pipe-dredge material. Need stable vessel that will have sufficient space to permit preliminary workup of trawl material; must have sufficient space and appropriate pressure with wash water for washing mud. At least two of the cruises should have sufficient laboratory space to workup, in detail, some of the commercially trawled material (this primarily refers to detailed examination of large number of snow crab stomach *in situ*) to enable decisions to be made concerning locations of stations for (a) grab and (b) dredge material -- this will permit direct interaction with trawl feeding data and precise location of feeding grounds. Cruises of opportunity on, for example the R/V *Acona*, will permit supplemental grab and dredge as well as some light trawling operations well inshore.

   Snow Crab Feeding Experiments: approximately 9-12 pots will be set, each containing snow crab that had originally been collected by commercial trawl. Every 6-8 hours for 24 hours some of the traps will be retrieved and crab removed for examination. Proper space, preferably some lab. space will be needed to remove crab stomachs when traps pulled up.

   Dive Surveys: ship use limited to transportation and lodging.

3. Trawl/Dredge/Grab Survey: April-August, November[1]. One to two week cruises per month to be arranged with ADF&G on trawl charter.

   Snow Crab Feeding Experiments: two times in spring, one to two times in summer or fall; one pilot experiment trawl cruise Resurrection Bay, November or December.

   Dive Surveys: four or five times in spring, summer and fall.

4. Trawl/Dredge/Grab/Core: two weeks per cruise for Cook Inlet

   Snow Crab Experiment: 5 to 7 days per cruise in Cook Inlet; 5-7 days for pilot experiment in Resurrection Bay.

   Dive Surveys: 7 days per cruise with 9 days in spring.

   Ships of opportunity: as per available time.

5. Trawl Survey: could be shared equally with other group (ADF&G)

   Snow Crab Survey: could be shared as long as 2-3 24-hour periods are available for pot retrieval and removal of crab stomachs.

   Dive Survey: principal operation; full use of boat needed.

   Cruise of Opportunity: as many days as available on shared cruise.

---

[1] We plan to take part in a November cruise organized by OCSEAP for Lower Cook Inlet as discussed in a planning discussion at the University of Alaska campus, 30 September 1977.

10. Trawl/Dredge/Grab/Core Survey: non NOAA vessel allright for most of the cruises, but it must be a substantial (e.g. similar to the M/V *North Pacific*) vessel with commercial trawling capability; also must be able to dredge and grab sample. Needs washing capability for mud samples. Need the NOAA vessel *Miller Freeman* on two of the cruises to be certain to obtain trawled, dredged, grabbed material rapidly and efficiently. Also, to be able to have the extensive laboratory space and ship stability to do microscope work onboard. The latter work will be necessary when doing stomach analysis in conjunction with dredged samples to be used for food-source studies.

    Snow Crab Feeding Experiments: NOAA Vessel *Miller Freeman* would be the best vessel for this study. Commercial trawling capability is needed to obtain large numbers of crab, a stable platform and suitable laboratory space to look at stomachs as experiment proceeds is essential, capability of readily handling the retrieval of snow pots is essential. This experiment would probably be done once or twice in Cook Inlet with this vessel. For the pilot experiment in Resurrection Bay, a small trawling vessel with pot retrieval capability would be satisfactory.

    Dive Survey: M/V *Humdinger*. 36 ft. commercial fishing boat with full electronics, rigged for diving; flexibility of schedule, ease of coordination, lower daily costs, local knowledge of crew.

    Cruise of Opportunity: R/V *Acona*, when available, is excellent for supplemental grab and pipe dredge work; also can obtain small amounts of material with light otter trawl gear; has laboratory space that is useful if ship can be used in protected waters. Can only be used this way - it cannot substitute for a vessel with commercial trawling gear. Good for dive survey in early spring and fall in remote areas of Cook Inlet because of sea worthiness.

11. Trawl Charter: to be arranged with ADF&G

    Trawl Charter for Resurrection Bay: to be arranged

    M/V *Humdinger*: $500 per day

    R/V *Acona*: approx. $3,200 per day

12. Trawl/Dredge/Grab Survey: 1-2 people (A. J. Paul and H. M. Feder)

    Snow Crab Survey: A. J. Paul and H. M Feder or TBN Technician

    Dive Survey: 2-3 per cruise.

NEGOA

For OCSEAP use only.
R.U ______
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 Univ. of Alaska PRINCIPAL INVESTIGATOR H. M. Feder

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.
   Cannot be described until precise station locations determined.

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

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.)
   See attached

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.)
   See attached

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback?
   See attached
   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.
   See attached

6. What equipment and personnel would you expect the ship to provide?
   Trawl survey: trawl/grab/dredge assistance
   Dive survey: boat operator

7. What is the approximate weight and volume of equipment you will bring?
   crab pots: weight
   Dredge = 125#; grab = 60#; wash bot = 200#; dive gear = 1500#, 75 cu.ft.; not known

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.
    See attached

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. See attached

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

2. Trawl/Dredge/Grab Survey: commercial otter trawl, pipe dredge, grab; need wash water to wash grab and pipe dredge samples.

   Snow Crab Feeding Experiments: approximately 9-12 pots will be set each containing snow crab that had originally been collected by commercial trawl. Every 6-8 hours for 24 hours some of the traps will be retrieved and crab removed for examination.

   Dive Surveys: ship use limited to transportation and lodging.

3. Trawl/Dredge/Grab Survey: July-August
   One-two week cruise per month

   Snow Crab Feeding Experiment: one or two times in spring and summer

   Dive Surveys: one or two surveys summer

4. Trawl/Dredge/Grab: two weeks/cruise

   Snow Crab Experiment: 2-4 days/cruise

   Dive Surveys: summer 6-7 days/cruise

5. Trawl Survey: could be shared equally with other group

   Snow Crab Survey: could be shared as long as 2-3 full 24 hr periods are available for the retrieval of pots; this could be in conjunction with another project.

   Dive Survey: principal one/full use of boat usually needed.

10. Trawl/Dredge/Grab Survey/Core: non NOAA vessel o.k.; should be substantial (e.g. similar to M/V *North Pacific*) with commercial trawling capability and ability to dredge and if necessary grap sample. Needs washing capability for washing mud through 1.0 mm screen. Few days NOAA ship *Miller Freeman*, on several occasions, to do Haps core sampling to obtain intact animals for isotope experiments; need lab space available.

    Snow Crab Feeding Experiments: probably above vessel o.k. but NOAA vessel *Miller Freeman* would be best for a 4-day period to do experiment. This vessel superior for this because of laboratory space needed for removal and weighing of crab stomachs during the experiment.

    Dive Survey: M/V *Humdinger* - 36 ft. commercial fishing boat with full electronics, rigged for diving; flexibility of schedule, ease of coordination, lower daily costs, local knowledge of crew.
    R/V *Acona*, if available. Safe and stable platform for stormy times of the year, excellent for diving base.

11. Trawl Charter: proper vessel must be located as yet

    M/V *Humdinger*: $500/day

    R/V *Acona*: approx. $3,200/day
    3-5 days in July or August

12. Trawl/Dredge/Grab/Core: aprox. 2/cruise

    Dive Survey: 2/cruise

XV. Management Plan

Technical management will be provided by the principal investigator. Fiscal and data management will be provided by the University of Alaska OCS Coordination Office. Milestone charts are provided.

XVI. Outlook

The direction of the research effort for FY 78 has shifted from the extensive, broad offshore shelf activities of the past three years to one that primarily examines site-specific areas. Furthermore, direct research activity for FY 78 has been directed away from a primary goal of species assessment to one that addresses biological processes in the site specific areas. Although many of the approaches suggested in the research proposal for FY 78 were either begun or, at least anticipated in 1976-77, no major effort had been funded during this period for process-oriented studies of the benthos. Thus, much of the work of FY 78 will represent the initiation of new directions in research, and all of the experimental work suggested in the FY 78 proposal will be unique to the OCSEAP program in Alaskan waters. It is to be expected that much of the work suggested for the second year of research will be designed to further strengthen the data base originally developed in FY 78. The understanding of processes operating in the benthic areas to be investigated will, by necessity, develop slowly, but the broadly based and interconnecting studies for FY 78 suggest that major progress should be made in our understanding of inshore benthic communities.

The outlook for the three study areas for the FY 79 and 80 are treated below:

A. Kodiak Shelf

1. Nature of final results
   a. Expand knowledge of spatial and temporal distribution and relative abundance of inshore epifaunal and infaunal organisms.
   b. Expand knowledge of trophic interrelationships of dominant inshore infaunal and epifaunal invertebrates and demersal fishes (emphasis on king and snow crab and other commercially important bottom-feeding species.
   c. Continue recruitment, age and growth and mortality studies on important inshore clam species (specifically species important as food for dominant epifaunal species such as king crab, snow crab, selected species of bottom feeding fishes) taken in the course of the proposed study.
   d. Data on the above from other bays in the lease area as an expansion of the overall data base for the Kodiak shelf.
2. Milestones
   a. Cruises: expanded seasonal coverage with cruises in July, September, November, January, March, May.
   b. Report submission: quarterly reports and annual reports; selected papers and Technical Reports on Food and Feeding Habits.
3. Cost
   $150,000

4. Addition of major equipment
   Centrifuge (for feeding studies)
5. Location
   Same plus additional bays.
6. Logistics
   Roughly the same plus additional cruises during the year.

B. Lower Cook Inlet

1. Nature of final results
   a. Expand knowledge of spatial and temporal distribution and relative abundance of epifaunal invertebrates.
   b. Expand assessment of distribution of selected, inshore infaunal invertebrate species (specifically important food items of commercially important species).
   c. Intensively pursue experiments on energy transfer from a sediment-detrital system to infaunal deposit feeders.
   d. Expand studies of feeding habits of principal inshore epifaunal invertebrates, exclusive of snow crab.
   e. Expand the study of the feeding habits of the snow crab. Interrelate the interaction of sediment-deposit feeder-snow crab as a logical extension of (c) above.
   f. Intensively pursue investigations of the major prey species of snow crab.
   g. Develop food webs interrelating all species from the benthos and pelagic regions, birds, and marine mammals.
   h. Develop and pursue studies on reproductive biology of key species.
   i. Expand age and growth and mortality studies on important clam species.
   j. Consider development of models of the Cook Inlet biotic systems.
2. Milestones
   a. Cruises: continue cruises as dictated by the developing programs.
   b. Report submission: quarterly and annual reports; publication of variety of papers and technical reports on results of biological studies.
3. Cost
   Approximately $150,000 - 200,000.
4. Addition of major equipment
   Some analytical units for the chemical analyses needed in energy flow experiments.
   Compound microscope and lamp.
5. Location
   Same plus additional sites as needed.
6. Logistics
   Roughly the same as FY 78.

C. Northeast Gulf of Alaska

1. Nature of final results
   a. Expand knowledge of spatial and temporal distribution and relative abundance of epifaunal and selected infaunal invertebrates.
   b. Intensively pursue experiments on energy transfer from a sediment-detrital system to infaunal deposit feeders.

c. Expand studies of feeding habits of principal inshore epifaunal invertebrates.
d. Expand the studies on the feeding habits of the snow crab. Interrelate the interaction of sediment-deposit feeder-snow crab as a logical extension of (c) above.
e. Intensively pursue investigations of the major prey species of snow crab.
f. Develop food webs interrelating all marine species in the study areas.
g. Develop and pursue studies on reproductive biology of key species.
h. Expand age and growth and mortality studies on important clam species.
i. Consider development of models of the Northeast Gulf biotic systems.

2. Milestones
   As per Cook Inlet comments.
3. Approximately $200,000.
4. Additional major equipment
   Equipment listed under Cook Inlet will be shared here.
5. Location
   Same plus additional sites as needed.
6. Logistics
   Roughly the same as 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 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 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."

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MILESTONE CHART

R.U. # 5

P.I. H. M. Feder

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
Kodiak cruises					X		X	X	X	X	X	X	X		
Cook Inlet		X			X	X	X	X	X	X	X	X		X	
NEGOA										X	X				
Report submission									X			X			
Carbon flow experiment startup						X									
Snow crab feeding rate experiment startup						X									

APPENDIX A

Inventory of Samples from Past Cruises[1]

1. NEGOA

R/V *Silas Bent* - Cruise 811

Station No.	No. Crabs
25	5
39	3
44	3
48	5
54	2
55	5

R/V *Discoverer* - 23 November-8 December

7	5
60	5
61	5
62	5
63	5

Samples now held from NEGOA represent either duplicate stations or stations not in the regular sampling grid (stations, 60-63). The pattern of distribution of infauna has been well documented by way of all samples processed in the past two years.

Two years of grab samples, including the entire grid, have been processed, and are being used for report preparation. The remaining samples represent duplicate samples or stations not on the sampling grid.

[1]Only grab samples remain unprocessed.

A Research Proposal Submitted to:

The National Oceanic and Atmospheric Administration

Outer Continental Shelf Environmental Assessment Program

TITLE: The distribution, abundance, composition, and variability of the Southwestern Beaufort Sea benthos with special emphasis on the benthic food web. RU #6.

PRINCIPAL INVESTIGATOR: Andrew G. Carey

PERIOD: 1 October 1977 - 30 September 1978

INSTITUTION: School of Oceanography
Oregon State University
Corvallis, Oregon 97331

DATE OF PROPOSAL: 24 June 1977

REQUIRED SIGNATURES:

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TECHNICAL PROPOSAL

I. Title

The distribution, abundance composition, and variability of the southwestern Beaufort Sea benthos with special emphasis on the benthic food web.

Research Unit #6
Contract No. 03-5-022-68
Proposed Dates of Contract: 1 October 1977 - 30 September 1978

II. Principal Investigator: Andrew G. Carey, Jr.
School of Oceanography
Oregon State University

III. Cost of Proposal (FY-78):

Total: $96,315
Distribution of effort by lease area:
Beaufort Sea 100%

IV. BACKGROUND

The past and proposed OCS research on benthic ecology is directed toward defining the distribution and abundance of the sea floor organisms, estimating the spatial and temporal natural variability, and delimiting the food web interactions of the benthic invertebrates.

As a basal portion of the oceanic ecosystem, the sea floor invertebrates utilize the food energy that reaches them, degrading it into simpler chemical compounds and metabolizing it into maintenance and growth products. In turn, these animals must provide a major energy source for higher level carnivores, including the seals, walrus, marine birds, and numerous fish species. As a logical extension of past benthic work, the research to be undertaken in FY-78 will explore the significance of the benthic populations relative to the larger predator species. This proposed research program has been designed to complement the food web studies being undertaken for the marine mammals, birds, and arctic fishes. This study integrates well with coastal benthic research accomplished in the southwestern Beaufort Sea, and with the Canadian work being conducted near the mouth of the Mackenzie River.

V. OBJECTIVES

The specific objectives of the 1977/78 proposed research are listed in order of priority. The major emphasis will be on the delineation of the benthic foodweb and description of the coastal benthos. Efforts to characterize the composition of the Beaufort Sea fauna to the species level will continue since this is a critical step toward understanding the dynamics of the benthic ecosystem.

A. Objective 1 - Beaufort Sea benthic foodweb analysis

1. The numerical density, biomass, and gross taxonomic composition of the benthic macro-infauna at selected water column foodweb stations will be obtained.
2. The identification of prey species important in the benthic foodweb will be undertaken.
3. The gut contents of selected species of benthic invertebrates will be analyzed as far as possible to determine the foodweb links within the benthic communities..

Justification

Foodweb studies are important because these feeding links are the routes by which energy, elements and pollutants are transferred from one trophic level to another. Such studies are necessary to identify the keystone species and important feeding areas on the Beaufort Sea continental shelf.

B. Objective 2 - Beaufort Sea coastal benthos

The numerical density, biomass, and gross taxonomic composition of the coastal benthic macro-infauna will be obtained from grab samples taken at stations on the inner continental shelf and coastal zone. These samples were collected during the summer of 1976 on the R/V ALUMIAK. This research is in large part supported by supplemental funds from NOAA/BLM in response to a letter proposal of April 5, 1977. This research will continue throughout the FY-78 contract year. The station locations and sample numbers are listed and charted in Table 1 and Figure 1.

Justification

The coastal region has been designated by the Beaufort Sea synthesis meeting as a critical zone of foodweb interactions that could be impaired by oil pollution from planned petroleum exploration and production. At the present time little is known of the species composition, distribution, abundance and environmental interactions of the benthic fauna.

Research on coastal benthic invertebrates is proposed to fill the designated data gap that now exists in the southwestern Beaufort Sea within the depth zone of 5 to 25 meters. Because of the large standing stocks of benthic fauna in this shallow continental shelf environment, it is an important feeding ground for the shallow-water fish, diving birds, and marine mammals. The taxonomic composition and abundance of the benthos are strongly correlated with depth and distance from shore. The environmental effects of bottom water and sedimentary characteristics on the benthic communities in this transitional zone are not known at the present time.

Table 1. OCS-5 Smith-McIntyre Grab Samples Taken on the 1976 R/V ALUMIAK Cruise.

Transect	Date (1976)	Station	Position	Depth (m)	Cond.	Salinity (‰)	Temperature (°C)	No. Biol. Samples	No. Sed. Samples
Point Barrow	19 Aug.	BRB-25	71°27.3'N 156°22.3'W	25.9				5	1
		BRB-20	71°28.0'N 156°18.6'W	19.5				5	1
		BRB-15	71°28.2'N 156°13.1'W	15.5				5	1
		BRB-10	71°24.9'N 156°23.8'W	9.8				5	1
		BRB-5	71°23.4'N 156°27.1'W	5.2	25.00	27.00	3.50	5	1
								25	5
Pingok Island	22 Aug.	PIB-15	70°33.2'N 149°34.6'W	14.9	24.87	31.45	1.88	5	1
		PIB-10	70°34.8'N 149°32.3'W	10.2	23.00	22.32	2.15	5	1
		PIB-5	70°34.9'N 149°32.0'W	4.5	20.65	22.08	2.08	5	1
								15	3
Barter Island	31 Aug.	BAB-25	70°11.3'N 143°31.5'W	24.6	24.82	31.88	-2.00	5	1
		BAB-20	70°10.8'N 143°33.7'W	20.3	24.46	31.33	-2.00	5	1
	3 Sept.	BAB-15	70°09.5'N 143°36.2'W	15.1	24.24	30.78	-1.98	5	1
		BAB-10	70°09.0'N 143°32.2'W	10.1	24.28	30.75	-1.86	5	1
		BAB-5	70°08.4'N 143°37.7'W	5.0	23.47	28.40	-0.98	5	1
								25	5
TOTALS:	3 Transects		13 Stations					65 biological samples	13 sediment samples

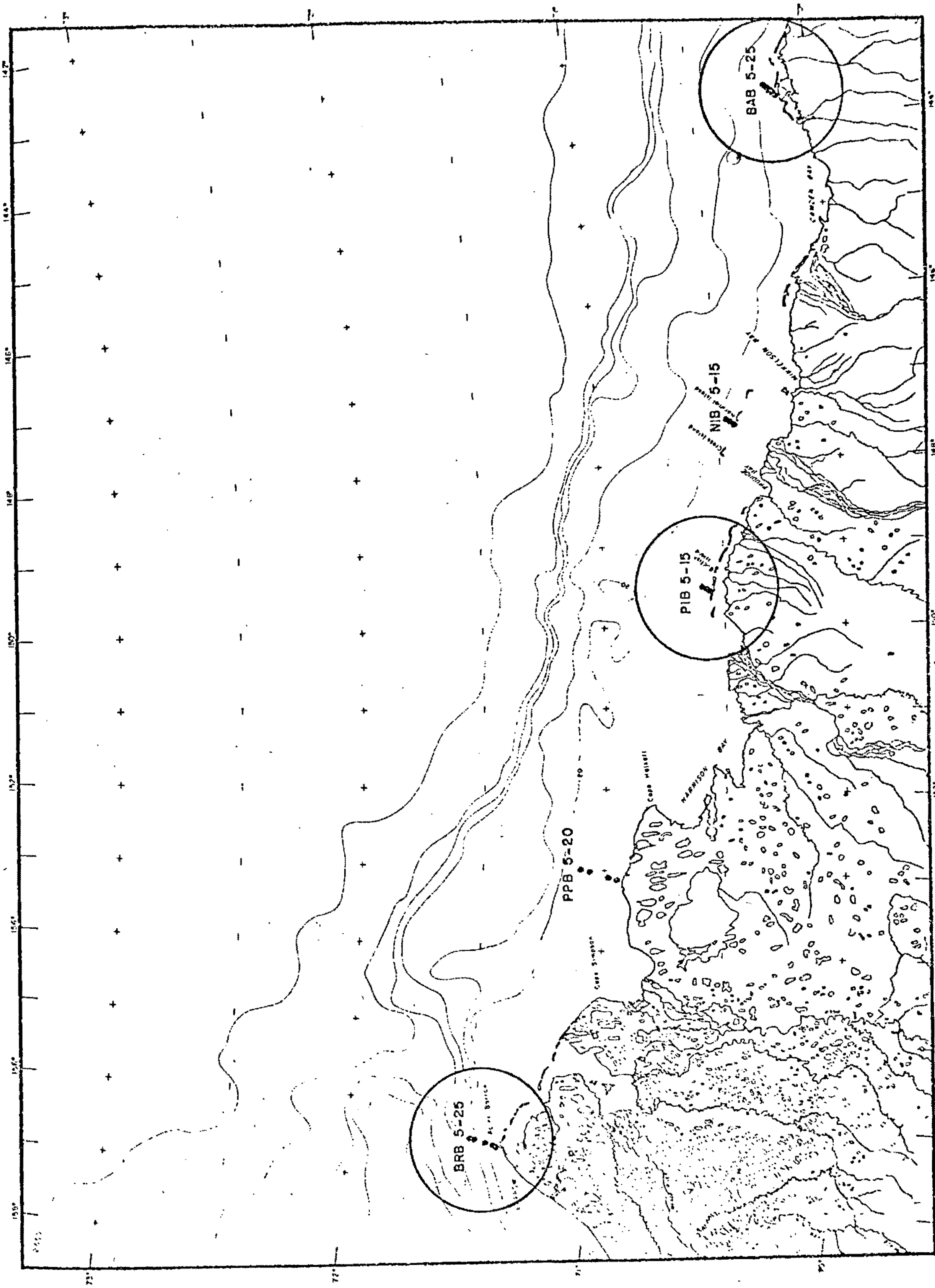

Figure 1. Locations of stations sampled for coastal infauna during the 1976 R/V ALUMIAK cruise. Circles indicate stations to be included in the proposed analyses.

C. Objective 3 - Benthic macro-infaunal ecology

1. Further identifications of abundant species will be undertaken from samples collected in the southwestern Beaufort Sea during the WEBSEC and OCS field trips and cruises.

2. Statistical analyses of species and station groups will be run, and correlations between these and various characteristics of the benthic environment will be made.

Justification

A complete description of the benthic fauna of the Beaufort Sea at the species level is needed to establish a baseline from which future faunal changes can be evaluated. Multivariate analysis of the spatial patterns of the benthic fauna will be useful in gaining insight into which environmental factors are important in controlling animal distributions in this area. This type of knowledge is critical to predicting the impact of environmental perturbations.

D. Objective 4 - Summary and synthesis of benthic environment characteristics.

1. Sediment samples from OCS benthos stations will be analyzed for particle size, organic carbon, and Kjeldahl nitrogen by Oregon State University or a subcontractor.

2. The bottom water characteristics of the southwestern Beaufort Sea continental shelf will be summarized as far as possible with the available information.

Justification

It has been demonstrated that sediment type is one of the key factors in controlling the distribution of benthic infaunal organisms. Therefore, it is useful to map the distribution of sediment characteristics in conjunction with the patterns of faunal distribution. The Beaufort Sea continental shelf is characterized by sediments which are patchy in distribution and of a broad range of types, and it is, therefore, essential that the sediments be defined as completely as possible at each sampling location.

E. Alternate Objectives - This research will be implemented as time allows depending on the sampling success of the foodweb work on the USCGC GLACIER this summer.

Alternate Objective 1 - The numerical density, biomass, and gross taxonomic composition of the large meiofauna will be obtained from selected stations on the southwestern Beaufort Sea continental shelf.

Justification

Only a few data are available from the southwestern Beaufort Sea for the meiofaunal size fraction of the benthos. The larger meiofauna (those organisms which pass through the 1.00 mm sieve but which are retained on a 0.42 mm sieve) may triple the numerical density of animals found in a given sample. This size fraction makes a small contribution to the biomass, but they may make an important contribution to the energy flow through the benthic ecosystem. It is, therefore, important to gain a better understanding of their distribution and abundance in the arctic environment.

Alternative Objective 2 - a) The analysis of seasonal reproductive activity of abundant infaunal species at the benthic stations on the OCS seasonal Pitt Point Station Transect will be undertaken. b) The additional collections made along the Pitt Point Transect during the 1977 GLACIER cruise will be worked up.

Justification

Knowledge of the seasonality of reproductive activity in the Beaufort Sea is important in predicting the impact of any environmental perturbation. Continued monitoring of the Pitt Point Transect will be invaluable in establishing the long term natural variability in benthic populations in the arctic.

VI. GENERAL STRATEGY AND APPROACH

In general, two areas of continuing benthic ecological research are proposed: (1) the extension of research into a food web project which is designed to elucidate the biological interactions within the benthos and between the benthic organisms and other portions of the ecosystem; and (2) the further accumulation of data from existing samples to provide a more complete understanding of the patterns of distribution and abundance of benthic invertebrates across the continental shelf. This descriptive detailing will provide baseline data with more accurate estimates of natural spatial and temporal variability.

To date, the experimental design has included a description of the benthic macro-infaunal and mega-epifaunal communities based on the WEBSEC and OCS samples. Numerical densities, total biomass, and major taxonomic composition have all been examined. As the species within the taxonomic groups have been identified, statistical analyses have delimited species and station groupings, and these groups have been correlated with the environmental characteristics of the benthic boundary. Estimates of natural spatial variability have been of major concern, and the descriptive phases of the research have been extended through a twelve month period to provide estimates of temporal variability and to provide initial information of the life histories of the arctic invertebrates. The studies of interactive pathways with other portions of the ecosystem through the food web is a logical extension of the current benthic research.

VII. SAMPLING METHODS

No additional sample collecting is anticipated for FY-78. All proposed research is to be conducted on the samples to be obtained from the 1977 summer GLACIER cruise, or on samples that are already on hand at Oregon State University.

VIII. ANALYTICAL METHODS

The analytical methods to be used will be the same as those employed by the OSU benthic group for all previous arctic research. Briefly, they are outlined as follows:

A. Infauna

1. The quantitative grab samples are sieved into two fractions, the macro-infauna (≥1.00 mm) and the larger meiofauna (0.42-1.00 mm).

2. The macro-infaunal organisms are picked from the rocks and organic debris under a dissecting microscope, and sorted to major taxonomic category.

3. The organisms are enumerated.

4. The organisms in each gross taxonomic category are wet weighed.

5. The dominant invertebrate species are identified as far as possible, and the identifications are verified by taxonomic specialists where necessary.

B. Epifauna

1. The large epifaunal organisms are sorted from the trawl samples, and are counted and identified as far as possible.

2. Analyses are made of the stomach contents of the larger, more abundant forms.

C. Data Acquisition

1. The data from the quantitative grab samples and the trawl hauls, and the station information and environmental parameters are all coded for inclusion into a computer data base.

2. All data are keypunched onto computer cards.

3. All keypunching is verified before transfer to magnetic tape.

D. Statistical Analyses

The statistical analysis of the data is contingent upon the evenness and richness of the benthic communities. The types of analyses that will be reviewed include multiple correlation analysis, species diversity indices, and similarity indices used in ordination techniques. Classification techniques such as multivariate factor analysis or canonical correlation analysis will also be evaluated (Cooley and Lohnes, 1971; Sneath and Sokal, 1963; Clifford and Stephenson, 1975).

IX. ANTICIPATED PROBLEMS

A. The necessary laboratory research is labor-intensive, and as a result, proceeds along slowly. Samples must be sieved and maintained in proper storage until the organisms can be picked out of the sediment and organic debris. The fauna must then be sorted to major taxonomic category, enumerated, wet weighed, and finally identified to the species level where possible. These tasks require skilled technicians and experts trained in benthic taxonomy. As the data becomes available, it still must be coded, keypunched and verified before any statistical analyses can be originated. In all, benthic research on the Beaufort Sea continental shelf does not lend itself to the required rapid data transmission.

B. A detailed research schedule cannot be finalized until the sampling success of the 1977 USCGC GLACIER OCS food web cruise is known. If samples are not collected during this summer effort, alternative objectives utilizing samples obtained from previous OCS field efforts are proposed.

X. DELIVERABLE PRODUCTS

A. Digital Data

1. Parameters to be recorded:

Sample parameters recorded:

a) Time
b) Position
c) Depth
d) Cruise Number
e) Vessel Name
f) Station Number
g) Surface Area Sampled
h) Bottom Salinity*
i) Bottom Temperature*
j) Sediment Organic Carbon*
k) Sediment Total Carbon*
l) Percent Sand*
m) Percent Silt*
n) Percent Clay*
o) Minimum Sieve Size
p) Average Phi Size*
q) Equipment Code
r) Sample Number
s) NODC Taxonomic Code (New).
t) Number of Individuals
u) Total Wet Weight of Individuals
v) Qualitative Code
w) Descriptive Text*

*Data product is not consistently available.

2. 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. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Benthic Organisms	Magnetic Tape	Maximum of 150 records per sample	032	Yes	8/76 - 9/76	10/78
Benthic Organisms	Magnetic Tape	Maximum of 150 records per sample	032	Yes	8/77 - 9/77	10/78

B. Narrative Reports

Several manuscripts to be submitted for publication are planned. Initial results from the Pitt Point seasonal sampling will be described by Dickinson and Ruff at the Pacific Section, ASLO Meeting in San Francisco in June, 1977. Two papers on the time series study at five stations across the continental shelf will be prepared on the general community structure and on the gammarid amphipod fauna during the fall, and submittal to appropriate journals is planned. Additional manuscripts on the new benthic sample siever and on the distribution of species groups and communities are also scheduled for 1977-78.

C. Visual Data

All visual data presenting Beaufort Sea benthic ecological data will be presented in quarterly and annual reports.

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS.

In most cases contacts have been made to obtain these data:

A. Hydrography: Bottom water salinity, temperature, O_2 concentration, position and depth. The OCS transect line off Pitt Point is of particular interest.

B. Ice dynamic: Extent of active ice gouging on the bottom sediments in terms of depth, location, and frequency.

C. Primary production: Location and timing of standing stock and production of phytoplankton and attached under ice diatoms.

D. Sediment: Particle size distributions on the southwestern Beaufort Sea continental shelf and the processes and sources of sedimentation.

E. Circulation: Predominent seasonal currents on the Beaufort Sea continental shelf and slope.

XII. QUALITY ASSURANCE PLANS

Whenever possible internal and external checks on accuracy and methodology will be maintained to ensure accurate data.

A. Sampling processing: The accuracy of picking-sorting-counting will be evaluated and maintained by an experienced technician who will spot-check samples previously processed.

B. Faunal identifications: Systematics of the OSU research will be verified by competent specialists whenever possible.

C. Data Transfer: All data which is coded and keypunched for statistical analysis is routinely subjected to verification before it is transferred to magnetic tape.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLANS

All infaunal organisms taken from the Beaufort Sea continental shelf and slopé since 1971 have been maintained in 70% ethanol in fairly temperature-stable biological storage areas on the Oregon State University campus pending further taxonomic research. Unpicked and unsorted grab samples have been transferred as rapidly as possible from neutralized 10% formalin to 70% isopropanol. Invertebrates from trawl samples have been stored in five gallon sealed plastic buckets under similar conditions. All these samples are available as comparative material for a portion of the proposed foodweb research.

Voucher specimens, identified or verified by qualified taxonomic specialists, have been accessioned into the Oregon State University Benthic Invertebrate Reference Museum. Each species has been given an OSU species code number which is entered into a computer file for future reference. A range of sizes and developmental stages have been placed on taxonomically organized shelves in an air-conditioned room adjacent to a benthic laboratory. Approximately 250 arctic species now reside in the collection, and a comparable number remain to be entered. The available keys, reprints, and monographs pertinent to the arctic fauna are also being accumulated. The collection has been organized with the aim of forming a scientifically useful reference museum and taxonomic literature library.

XIV. LOGISTICS REQUIREMENTS

INSTITUTION Oregon State University PRINCIPAL INVESTIGATOR A.G. Carey, Jr.

The logistics requirement forms have been deleted since no field work is proposed for FY-78. There are no research vessel or aircraft requirements, nor are quarters or field support necessary. All proposed research will be conducted upon samples which will already be on hand at Oregon State University when the contract period begins.

XV. MANAGEMENT PLAN

The management of all phases of the Beaufort Sea benthic ecological research during FY-78 will be organized so that as principal investigator, I will be responsible for the overall progress and results of the research program. A laboratory manager, R. Eugene Ruff, will work with me to ensure the proper quality and quantity of pertinent data and the timely reporting of results.

During the 1977/78 contract year, weekly briefings and progress report meetings with research personnel will be held for exchange and discussion of information. Updated schedules of field trips (FY77 GLACIER CRUISE), scientific meetings, internal subproject deadlines, quarterly and yearly reports, scientific publications, and any special tasks will be maintained and used as guidelines for research progress evaluation. The lab manager and I will work with the Benthos research group to maintain schedules and to meet the necessary deadlines.

Research objectives, schedules, and priorities will be organized for the year at the beginning of the contract. As principal investigator, I will be involved in the writing of final and yearly reports, in the analysis and synthesis of data, in the reporting of results in scientific publications, and in the overall direction of the research program.

The Activity/Milestone chart outlines the major projects and deadlines proposed for FY-78.

XVI. OUTLOOK

A forecast of additional research pertinent to a useful description of the benthic community in the southwestern Beaufort Sea should include an accurate assessment of the temporal variability, a synthesis of the dynamics of the community components, and a description of the smaller-sized organisms. Data obtained from stations taken in 1975-76 from the continental shelf off Pitt Point have indicated that both numerical density and total biomass tend to fluctuate with the sampling season. This temporal variability within the benthic community should be measured through several successive years to verify the trends and establish the magnitude of the fluctuations. Knowledge of the repopulation and growth potential of the dominant invertebrate organisms would provide estimates of the maximum recovery rates which could be expected after a major oil spill or other large-scale catastrophic event. A study of reproductive adaptations of the abundant and critical foodweb species would provide information on the sequence of recolonization as well as the mechanisms of repopulation. Data on the distribution, abundance and taxonomic composition of the larger meiofauna would provide an evaluation of the importance of this portion of the total benthic community. The addition of these data would allow a direct comparison and synthesis with the benthic data obtained in the Canadian sector of the Beaufort Sea.

An evaluation of the dynamics of the total benthic community is the next logical step in the arctic research program. The natural temporal variability must be verified, the smaller members of the community must be determined, the growth rates of the dominant organisms must be measured, and the modes and rates of repopulation must be ascertained before meaningful predictions can be made on the potential consequences of a major extinction event occurring on the Beaufort Sea continental shelf.

A. Seasonal Sampling

1. Nature of the Final Results and Data Products:

The results of three years of quantitative sampling from transects across the Beaufort Sea continental shelf would establish the magnitude of the changes in the numerical density and total biomass of the benthic invertebrates with season. This knowledge of natural temporal variability would form a basis for evaluating perturbations in the benthic community initiated by industry-related oil pollution or other catastrophic extinction events.

2. Significant Milestones:

a. The changes in numerical density would be elucidated for the total benthic community across the continental shelf with season.

b. The changes in biomass (grams wet weight) would be elucidated for the total benthic community across the continental shelf with season.

c. The changes in numerical density and biomass would be examined at specific depths with changing season.

d. The changes in numerical density and biomass would be examined at specific times with changing depths.

e. The seasonal changes in abundance would be determined at the species level for the dominant invertebrate groups.

3. Cost by Fiscal Year:

FY-79	$ 90,000
FY-80	100,000
FY-81	110,000
Total	$300,000

4. Additional Major Equipment Required:

None

5. Location of Future Field Efforts:

a. OCS Pitt Point Transect, Beaufort Sea.

b. OCS Prudhoe Bay Transect, Beaufort Sea.

6. Logistic Requirements

a. Yearly summer cruise aboard the R/V ALUMIAK.

b. Three yearly research efforts via helicopter.

B. Benthic Community Dynamics

1. Nature of the Final Results and Data Products:

The final results would include estimates of the rates of repopulation by dominant components of the benthic community. The sequence of recolonization after an extinction event would be established in selected areas across the Beaufort Sea continental shelf. The modes and adaptations of reproductive activity would be described for the major elements of the benthic foodweb, and the time needed for the reconstitution of these species in specified areas would be derived.

2. Significant Milestones:

a. Growth rates would be determined for selected invertebrate species.

b. The rate and sequence of species recolonization would be elucidated.

c. The reproductive rates and the special adaptations exhibited by various species would be described.

d. An estimate of the length of time required for a disrupted benthic community to return to an equilibrium state would be derived.

C. Benthic Meiofauna

The meiofaunal organisms (0.10-1.00 mm in size) are numerically prominent in the marine benthic community. They have been demonstrated to play a major role in the energetics of the bottom community, and they undoubtedly are important links within the arctic foodweb. They have been cited as an integral part of a salmonid fish foodweb in more temperate waters (Sibert et al., 1977).

Because of their numerical and energetic importance, the larger meiofaunal organisms (0.42-1.00 mm) should be quantified and identified as far as possible. With the addition of these data we can compare the benthic community of the Alaskan northern coastal waters with that reported from the southeastern Beaufort Sea off Canada. Such a comparison would allow the direct contrast and synthesis of the taxonomic composition and numerical abundance across the whole of the Beaufort Sea continental shelf from Point Barrow to the Mackenzie River.

1. The Nature of the Final Results and Data Products:

The total numerical abundance and the major taxonomic composition of the larger meiofaunal organisms (0.42-1.00 mm) would be determined. The animals would be identified to the species level where possible. The acquisition of these data would permit direct comparison with the benthic community data reported from the Canadian sector of the Beaufort Sea.

2. Significant Milestones:

a. The larger meiofaunal organisms would be sorted from existing quantitative grab samples taken at selected sites across the Beaufort Sea continental shelf.

b. The organisms would be partitioned into major taxonomic category, and the total numerical abundance would be determined.

c. The animals would be identified to the species level where possible.

d. The trends in the total benthic community structure would be elucidated.

e. The total community structure would be compared and contrasted with the ecological patterns reported from the Canadian sector of the Beaufort Sea.

XVII. PROCEDURES

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."

MILESTONE CHART

RU #: 6 PI: Andrew G. Carey, Jr.

Major Milestones: Reporting, data management and other signigicant 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
Foodweb research - infaunal community analysis							△								
Foodweb research - gut content analysis							△								
Coastal benthos community analysis				△											
Benthic macro-infaunal ecology											△				
Benthic environmental characteristics										△					
Meiofaunal analysis (Alternative Objective 1)											△				
Benthic seasonal studies (Alternative objective 2)											△				
Quarterly Reports			△			△			△			△			
Yearly Report						△									
Data Analysis					△			△			△				
Data Transmission						△			△				△		

△ = Planned Completion Date ▲ = Actual Completion Date

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A Renewal Proposal to the

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

for

A SEISMOTECTONIC ANALYSIS OF THE SEISMIC AND VOLCANIC HAZARDS IN THE PRIBILOF ISLANDS-EASTERN ALEUTIAN ISLANDS REGION OF THE BERING SEA

R.U. #16 Contract No. NOAA 03-5-022-70

Co-Principal Investigators: John N. Davies, Klaus H. Jacob

Institution: Seismology Department, Lamont-Doherty Geological Observatory of Columbia University in the City of New York

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TECHNICAL PROPOSAL

I. Title: A Seismotectonic Analysis of the Seismic and Volcanic Hazards in the Pribilof Islands-Eastern Aleutian Islands Region of the Bering Sea

R.U.#: 16

Contract #: NOAA 03-5-022-70

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

II. Principal Investigators: Drs. John N. Davies and Klaus H. Jacob

III. Cost of Proposal:

A. Science: $80,730

B. P.I. Provided Logistics: None

C. Total: $80,730

D. Distribution of Effort by Lease Area:

1. Aleutians 75%

2. St. George Basin 25%

IV. Background:

We propose to continue to monitor seismic and volcanic activity on the Pribilof Islands, Eastern Aleutian Islands, and Western Alaska Peninsula. Since seismic and volcanic activity has periods on the order of decades and centuries, this project is conceived as a long-term effort to obtain the best record possible of the seismicity of the study area. This project is complementary to similar projects being carried out by the University of Alaska in the Kodiak and Lower Cook Inlet areas and the USGS in Lower Cook Inlet and the Gulf of Alaska. In addition it is viewed as a subset of a larger seismotectonic study of the Aleutian arc funded by ERDA. Relevant seismic and geodetic results from this ERDA study are reported to NOAA through the present contract.

We propose to expand the scope of this work with the part-time addition of a structural geologist who will spend one month in the field evaluating the major faults exposed on the Shumagin Islands and the adjacent Alaska Peninsula. This work is expected to complement that of the USGS marine geophysical studies by examining any on-shore extensions of faults which may be discovered by their seismic profiling. If significant lineaments or faults are discovered, seismic activity in the vicinity will be reevaluated and effort may be concentrated there to determine the level of seismic activity associated with such a fault.

V. Objectives:

A. Monitor seismic activity level on Saint Paul Island.

B. Monitor and locate earthquakes in the Eastern Aleutians.

1. Evaluate changes in seismicity patterns.
2. Compute b-values on a regular basis.
3. Compute V_p/V_s ratios on a regular basis.

C. Examine major faults exposed on the Shumagin Islands and adjacent Alaska Peninsula.

1. Correlate with off-shore work.
2. Evaluate nearby seismicity.

D. Monitor seismic acitvity of Pavlof, Akutan, and Makushin volcanoes.

E. Evaluate relevant seismotectonic results from ERDA study in terms of seismic and volcanic hazards.

The overall objective of this work is to evaluate the earthquake and volcanic hazard to petroleum exploration and development in the St. George Basin and eastern Aleutian areas. We have examined the historical record to provide a statistical evaluation of the risk in general areas. We have summarized other seismotectonic work that relates to the special risk posed by the Shumagin seismic gap. We have and propose to continue to monitor the current activity to evaluate any changes that might signify an immenent major event. We propose to evaluate specific faults that might require special consideration in the location and construction of major structures and pipelines.

VI. General Strategy and Approach:

Monitoring Seismic and Volcanic Activity. A regional seismic network consisting of about 20 stations has been established and is maintained annually with NOAA logistic support. These stations are continuously recorded and the data is mailed to L-DGO where it is reduced and analyzed. This network provides the basic data required for the seismic studies proposed. Several of the stations are located on or near active volcanoes and thus perform double duty, recording both tectonic and volcanic events.

Evaluation of Faults. We propose to have a structural geologist spend one month evaluating the faults exposed on the Shumagin Islands and the adjacent Alaska Peninsula. This study will be correlated with off-shore work and will provide the basis for more concentrated seismic studies than are now made with the regional network. Another anticipated product of this evaluation is a delineation of the block-structure of the region which will be invaluable in an interpretation of the geodetic data being collected under the ERDA sponsored seismotectonic study.

VII. SAMPLING METHODS

N/A

VIII. ANALYTICAL METHODS

A. Seismicity: The primary output of this study is the location, origin time and magnitude for earthquakes larger than about body-wave magnitude one. This data set is sent quarterly to NGSTDC. It is also presented as quarterly, yearly and years-to-date epicenter maps and hypocenter cross sections. These maps and cross sections are used to monitor the seismicity pattern. Any radical change could be cause to suspect an imminent earthquake.

B. b-values. Upon the completion of a magnitude scale for Shumagin Island earthquakes, we intend to regularly compute the "b-value" or slope of the cumulative frequency versus magnitude relation:

$$\log N_{m \geq m_i} = a + bm_i.$$

This is a standard measure of the relative frequency of occurrence of small events compared to large ones. If there are changes in the bulk properties of the rock in the source area for the earthquakes being monitored (due, for example, to dilatency hardening), these changes may be reflected in the b-values.

C. V_p/V_s ratios. The V_p/V_s ratio is the quotient of the velocity of the P-wave divided by that of the S-wave. It can be determined directly from the slope of a Wadati diagram (S-P time plotted against P arrival time for the body phases of an earthquake at a series of seismic stations). This ratio can often be determined better than the individual velocities, since their determination depends upon knowledge of the location and origin time of the event which is itself dependent upon the velocity model assumed in the location program. The V_p/V_s ratio has been shown to decrease by a few to ten percent prior to shallow thrust earthquakes (Nursesov, ____; Aggarwal et al., ____; Whitcomb et al., ____). This decrease is also thought to result from a change in the material properties of the source region prior to an earthquake. It will be necessary to refine our velocity model and to develop source-region-dependent station corrections to be able to measure the arrival times accurately enough to determine V_p/V_s ratios whose scatter is low enough to observe less than ten percent changes. It is hoped that a great earthquake will be preceded by observable changes in V_p/V_s.

D. Relevant ERDA-supported work. With previous ERDA support, a set of broad-band seismograms were collected. Currently ERDA is supporting the operation of four Kinemetrics strong-motion accelerographs. Data from these sources will be analyzed to develop acceleration and velocity spectra and acceleration versus distance relations which should be considered in the design of earthquake resistant structures.

IX. ANTICIPATED PROBLEMS

The major difficulty expected with the proposed work is the collection of a uniform data sample. Because of weather and wildlife hazards and equipment malfunctions, it has been difficult to maintain an adequate network of operational stations throughout the year. We have made an attempt during the current field season to upgrade the quality of the physical installations of a number of stations, especially those which repeat other signals. It is hoped that the improvements made will significantly increase the number of stations which remain operational. However, it is probably unrealistic to expect a system of this complexity and which is subject to severe Aleutian winters to survive largely intact for a year without maintenance.

It is important that as many stations as possible do remain operational so that comparison of the seismicity patterns from one quarter to the next are valid. If too many stations fail, it will become impossible to locate earthquakes in part or all of the study area, and the resulting seismicity patterns will be skewed or non-existent. Therefore, we propose to explore with the logistics officer of the Juneau Project Office ways in which we might provide for one or two unscheduled repair trips to critical malfunctioning stations.

X. DELIVERABLE PRODUCTS

A. Digital Data: The hypocenter coordinates, origin time, magnitude and quality information for each earthquake are punched onto an IBM card. The format is that of the USGS, Menlo Park, as standardized between the University of Alaska, L-DGO and Menlo Park (see letter to Data Manager, Juneau Project Office, for details). The hypocenter cards are forwarded to NGSTDC quarterly. The cost of providing data in this format is negligible.

B. Narrative Reports. We plan to produce a catalog of the earthquakes which have been located by the Shumagin Islands network. This catalog will include a listing of the data on the hypocenter cards; quarterly and annual epicenter maps and hypocenter cross-sections; maps of the station locations; and a discussion of the magnitude scale used.

C. Visual Data. We will produce quarterly epicenter maps and hypocenter cross sections. These will be plotted on 8-1/2 x 11 sheets. There will be a total of 3 to 12 such maps and sections each quarter.

D. Other Non-Digital Data. None.

E. Data Submission Schedule. The first data for this contract period will be collected in October, 1977. The data collection effort will be finished in September, 1978. Data will be submitted on the following schedule:

Collection Period	Data Submission
Oct-Dec 1977	Apr 1978
Jan-Mar 1978	July 1978
Apr-June 1978	Oct 1978
July-Sep 1978	Jan 1979

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

We will require information from marine geophysical investigations bearing on the structure of the E. Aleutians and the St. George Basin. We are in contact with the principal investigators and will obtain information from them as needed.

XII. QUALITY ASSURANCE PLANS

The most critical variable in seismographic work is time. It is necessary to read the arrival times of body waves at the various stations with a relative precision of better than one-tenth of a second. This precision is assured by telemetering regionally grouped stations to a common recording center so that all use the same time standard. At each of the recording centers a Sprengnether crystal-controlled clock is used as a local time standard. This clock is compared daily to WWV or WWVH. A strip chart record of this comparison is kept so that an accurate and verifiable plot can be made of the drift of the local time standard with respect to Coordinated Universal Time (CUT). Since most seismic records are referred to CUT, our records can be used in conjunction with them to an accuracy of one-tenth of a second. This level of timing accuracy imposes a limit to the accuracy of location of hypocenters which is of the order of one kilometer.

Computation of the magnitude of an earthquake is problematic at best and is further complicated when the recording system includes radiotelemetry links. A telemetry system imposes more elements needing calibration and a limit to the dynamic range of the overall seismographic system so that coda-length measures of magnitude become necessary. Because of incomplete knowledge of the site geology, it is difficult to assess the coupling of the seismometers to the ground and the transfer function of the local soils and crustal rocks. Therefore, there is no good way to directly calibrate the magnification of a seismic network. As a first approximation, we assume that the seismometer responds according to the manufacturer's specifications, electronically calibrate the rest of the system as installed and compute a theoretical magnification for each seismograph. Richter-type magnitudes are then computed for the set of earthquakes where arrivals are not clipped at most of the stations. The coda-lengths for these arrivals are plotted against the Richter-type manitudes to obtain a coda-length magnitude scale. The standard deviation of magnitudes computed in this way is approximately one-half of a magnitude unit, which is about what is usually observed. We have examined the individual station deviations for bias and found none; therefore, there are no systematic errors in calibration for any given station.

Hypocenter locations are found using a version of Lee and Lahr's computer program, HYPO-71. This program computes estimates of the error in the arrival times and the vertical and horizontal coordinates. We use only those events for which these estimates are less than 0.25 seconds and 15 and 10 kilometers, respectively. Hypocenter cross sections show a Benioff zone which appears to be 20 kilometers thick. Assuming that all of these events occurred on a plane, this would imply a standard deviation in the locations of about seven kilometers. Note that this is only an estimate of the level of precision in the locations. We do not have a good estimate of the accuracy. An evaluation of the accuracy of our hypocenter locations awaits refinements in the velocity model and relocation using ray-tracing to determine the effect of the dipping slab of oceanic plate.

XIII. ARCHIVAL PLANS

All of the original records (tape, film, paper) are archived at L-DGO in the Seismology Department's seismogram archive. The only exception to this is a set of Helicorder records of the Pavlof Volcano station, PVV, which are made by the University of Alaska in parallel to the L-DGO develocorder film record of this station. These Helicorder records are archived by the University of Alaska (contact Dr. Juergen Kienle).

XIV. LOGISTIC REQUIREMENTS

Institution: Lamont-Doherty Principal Investigator: Davies

A. Ship Support: None requested.

B. Aircraft Support (fixed wing): None requested.

C. Aircraft Support (helicopter):

1. Flights are requested to transport equipment and personnel from the following base locations to the listed seismic stations (seq = sequence, see E, below):

Base Locations	Seq.	Seismic Stations	Code
Cold Bay	1a	Akutan Is.	AKN
	1b	Black Hills	BLH
	1b	False Pass	FPS
	1 or 2b	Sanak Is.	SNK
	2a	Makushin Valley	MKV
	2b	(Baldy Mtn.)*	(BAL)
	3b	Deer Is.	DRR
	4b	Dolgoi Is.	DLG

* Service by truck

Sand Point	1*	Coal Harbor	CHR
	1a	Big Koniuji Is.	BKJ
	1a	Ivanof Bay	IVF
	1b	Chernabura Is.	CNB
	1c	Pavlof Volcano	PVV
	2a	San Diego Bay	SGB
	2b	Nagai Is.	NGI
	2c	Zachary Bay	ZKB
	3b	Squaw Harbor	SQH

* Must follow Cold Bay "b" stations.

Port Moller	1a	Pavlof North-1	PN1
	1a	Pavlof North-2	PN2
	1a	Pavlof North-3	PN3
	1a	Pavlof North-4	PN4
	1b	Pavlof North-5	PN5
	1b	Pavlof North-6	PN6
	1b	Pavlof North-7	PN7
	1b	Pavlof North-8	PN8
	1c	Pavlof South-1	PS1
	1c	Pavlof South-2	PS2
	1c	Pavlof South-3	PS3
	1c	Pavlof South-4	PS4
	2a	Pavlof Repeater-1	PR1
	2b	Pavlof Repeater-2	PR2
	2c	Pavlof Repeater-3	PR3

* Five days of flight-time are requested for general repairs at least two weeks following the last service trip to make any adjustments that become necessary during this time.

2. The purpose of these flights is to change batteries and service remote seismic stations.

3. Optimum time is July-August plus or minus one month. June is okay for stations to be serviced out of Cold Bay and Sand Point. Those out of Port Moller are above the snow line in June. Dividing the work into two time frames allows a break for personnel which is almost necessary. The optimum interval between these time frames would be two-three (plus or minus one) weeks.

* At this time NOAA is unable to provide for unscheduled helicopter support for repair trips. This emergency service can be handled only on a case-by-case basis and is subject to approval by the COTR.

The optimum interval between the last servicing and the general repairs is two weeks (plus one or two).

4. Assuming an average of two stations per day, an average round trip of one hour, two trips per station and one day travel to each base (plus one day for travel for general service time), we require:

   19 days of helicopter operations at
   4 hours per day which equals
   76 hours total.

5. Usually there will be two people, minimum aboard each flight. With the UHIH, the number of people varies according to the logic of the particular situation, four people working in various combinations seems to be close to optimum.

6. Weight and dimension of equipment (per station):

5 air cells (dry)	22 lbs. ea.	9x10x12 inches
6 gallons water	50 lbs. total	14x14x14 inches
2 back packs	50 lbs. ea.	14x18x32 inches
1 spare antenna	20 lbs. ea.	36x36x6 inches
1 spare mast	20 lbs. ea.	96x2 (diam.) inches
4 spare guy-bars	10 lbs. total	96x1x1 inches
Misc. supplies	30 lbs. total	12x12x24 inches

7. We have used both the 206 and the 205. The 205 is preferable, but we can use either.

8. NOAA, if possible; Kenai Air, if not.

9. Per hour costs for Kenai Air are:

206B	$295	(4 hour min. per day)
205	$750	(1 hour min. per day)

10. Recommended staging areas are the base locations given in (1) above: Cold Bay, Sand Point and Port Moller. Note that commercial fuel is available only in Port Heiden, Cold Bay and Dutch Harbor.

11. Require: Radio for base location and for two field parties. Base and field parties should be able to communicate with each other and with the helicopter.

D. Quarters and Subsistence Support:

1. Scientific personnel will make their own arrangements for quarters and subsistence. Cost will be covered by per diem requested under this and the ERDA proposal.

2. Scientific personnel plan to lodge as follows:

   Cold Bay - U. S. Air Force

   Sand Point - Rent apt. from Shumagin Homes, Inc.

   Port Moller - Room and board with RCA personnel

E. Special Logistics Problems:

The chief logistic problem is fuel. It is available at Cold Bay. It must be cached at Sand Point and Port Moller. If plans are made far enough in advance, it can be transported by sea to those places, saving a great deal over air freight from Anchorage. Because the fuel source determines the day-to-day logistics, it would be useful for the P.I. and the pilot to agree several months in advance on the sources so that batteries and equipment could be shipped directly to the base from which they will be used. Note that since some stations serve as repeaters for others, there is an optimum sequence for servicing the stations. In Section C, above, the base locations have been given in optimum order; as have the stations associated with each base. The number and letter under "Seq." indicate the telemetry sequence and grouping, respectively; so for example, 1a's must precede 2a's, but a's can be serviced independent of b's.

XV. MANAGEMENT PLAN

The data collection proposed is the continuation of an ongoing project. The seismic data are sent weekly from the recording sites to Lamont. A full-time record reader is responsible for reading the records, making preliminary locations of hypocenters, producing maps and cross sections of these hypocenters, and reporting quarterly these data to NOAA. Two graduate students and the principal investigators will evaluate these maps and cross sections, produce quarterly plots of b-values and V_p/V_s ratios, produce velocity and acceleration spectra from strong-motion data as it becomes available and undertake special analysis of larger events (such as focal mechanism studies) to understand their tectonic significance. The results of these studies and those relevant studies undertaken for ERDA (e.g., geodetic measurements of tilt rates) will be reported as they are completed in quarterly and annual reports.

XVI. OUTLOOK

As was indicated in the background section, seismic activity is quasi-periodic with characteristic periods on the order of decades and centuries. The historic data for the Shumagin gap indicates return periods for $M_b \geq 7$ and $M_b \geq 8$ earthquakes of approximately 15 and 80 years, respectively (Davies et al., 1976). Apart from other arguments based on the existence of a seismic gap, of time-space progressions, this fact alone is sufficient to require careful seismic monitoring of this region should major petroleum development take place in the eastern Aleutian or St. George Basin lease areas. The long-term purpose of this monitoring is to establish a basic data set upon which an earthquake prediction program would, in part, be based.

Therefore, we propose that essentially the present level of seismic monitoring be maintained until any major development work takes place. At that point, a real-time earthquake prediction program should be established. The long-term component of this program would consist of three parts: seismic, volcanic and geodetic monitoring. If particular risk areas are identified, then the intermediate term component would be activated within those areas. This component would consist of: increased seismic monitoring, perhaps requiring OBS deployments or regular detonation of explosives; addition of tilt meters and/or geodetic surveys on or around active volcanoes, if any, within the area; increased frequency of resurveying geodetic lines and figures; the possible initiation of other geophysical measurements such as resistivity, radon contents of well or spring water, temperature of hot springs, tilt, and strain. If any of these measurements produce positive results then a short-term component of the program would be initiated, if possible. This component would be highly dependent upon the area to be monitored. It might include measurements of microseismicity, static electricity, and anomalous animal behavior.

When it becomes apparent that a major development will take place in a given lease area, an earthquake prediction program for that area should be planned in detail along the lines indicated above. The planning of such a program would take about a year. Necessary aspects of this program would be the continuous and reliable collection of data, and the need for rapid reduction of this data. These aspects would probably require the establishment of a full-time staffed recording center to which all of the data would be telemetered.

In addition to the continuation and modest upgrading of the current seismic monitoring, several other programs should be initiated:

A. Volcanic Monitoring. Volcanic activity has been shown to respond to the regional stress (Nakamura, Yoshii, Mauk, McCann, Berg, Stoiber and Carr). Careful monitoring of regional volcanic activity may help recognize changing stress conditions heralding the onset of a great earthquake. Therefore, some effort should be made to continuously monitor at least all of the active volcanoes in a given lease area. The technique employed could range between local event recording (counting seismic disturbances above a given threshold) to continuous telemetry of seismic, tilt, and other data via satellites. The level of funding would determine which technique could be employed. Because the present record of regional volcanic activity is so incomplete, some systematic attempt to monitor this activity should be begun as soon as possible, no matter at what funding level.

B. Geodetic Monitoring. Geodetic measurements may be the single most important, long-term data set for the evaluation of the state of stress of a given region. Repeated trilateration triangulation and leveling surveys in Japan have provided there an invaluable record of the preseismic, co-seismic and postseismic deformations associated with great earthquakes. For this reason, we suggest that the OCSEAP urge that NOS undertake a program of regular geodetic measurements in the Aleutian and Gulf of Alaska regions.

C. Development of a Portable, Microearthquake Array. For monitoring both possible active faults and areas in which an earthquake is expected, the availability of a portable, telemetered microearthquake array is essential. The development of this array should be begun soon so that it will be available when needed. Valuable information could also be gained by recording aftershocks of large earthquakes. A portable array, dedicated to short-term projects would be ideally suited for this purpose.

D. Development of an Offshore Monitoring Capability. It is obvious, since all of the lease areas are offshore and much of the seismic activity near those areas is too, that some means of offshore seismic monitoring is required. There are several options available at this time, including tethered buoy and ocean-bottom systems. We propose that an engineering feasibility study be undertaken to evaluate various kinds of systems in the context of monitoring seismic activity on the outer continental shelves of Alaska. This problem presents several difficulties which are unique and have not been addressed by builders of ocean-bottom seismograph systems. Among the difficulties are severe storms for much of the year, strong currents, intensive fishing by domestic and foreign fleets, and the need for long-term recording under conditions where access may be limited to the summer months for recovery and/or repair. Following this feasibility study prototypes should be deployed and tested. This system might be incorporated into the portable microearthquake array.

1. Nature of Final Results and Data Products

   A. Seismic Monitoring: Quarterly seismicity map, hypocenter cross sections, and b-value and V_p/V_s ratio plots.

   B. Volcanic Monitoring: Quarterly counts of volcanic events.

   C. Geodetic Monitoring: Annual resurveys of level lines and braced trilateration/triangulation figures.

   D. MEQ Portable Array: Seismicity maps from possible active faults, unusually active regions, aftershock zones, erupting volcanoes, etc. To be dedicated to short-term projects (one year or less).

E. OBS Seismic Detection: Development of an offshore MEQ capability. Results same as D, above.

F. Earthquake Prediction:

Long Term - Weekly reduction of seismic and volcanic data; monthly seismicity maps, hypocenter cross sections, b-value and V_p/V_s ratio plots and counts of volcanic events. Quarterly resurveys of selected geodetic figures.

Intermediate Term - Daily reduction of seismic, volcanic and other geophysical data. Weekly seismicity maps, counts of volcanic events, plots of V_p/V_s ratios and other geophysical data. Monthly plots of b-values and resurveys of selected geodetic figures.

Short Term - Daily reduction and plotting of all geophysical data. Weekly resurveys of selected geodetic figures.

2. Significant Milestones

FY 79 Moderate upgrading of seismic monitoring.

Significant upgrading of volcanic monitoring.

Establishment of leveling lines and braced figures on Kodiak Island, Shumagin Islands and Dutch Harbor.

(Tie to ERDA-supported, L-DGO-installed tide gauges and to NOS tide gauges.)

Design and build portable, arctic MEQ array.

Design OBS seismic detection system.

Plan long-term earthquake prediction program (present contract).

FY 80 Continuation of seismic, volcanic and geodetic monitoring.

Deployment of MEQ array on possible fault.

Construction of prototype OBS seismic detection unit.

Implementation of long-term earthquake prediction program in Shumagin gap.

Plan intermediate-term earthquake prediction program.

FY 81 Continuation of seismic, volcanic and geodetic monitoring (incorporated into earthquake prediction program, if implemented.

Redeployment of MEQ array to new area.

Construction of 10 OBS seismic detection units.

Plan short-term earthquake prediction program.

Implement intermediate-term earthquake prediction program, if necessary.

FY 82 Continuation of seismic, volcanic and geodetic monitoring.

Redeployment of array on new fault, or other area of interest.

Deployment of OBS seismic detection array, perhaps in conjunction with MEQ array.

Implement short-term earthquake prediction program, if necessary. Maintain long-term prediction effort in Shumagin gap.

3. Additional Major Equipment Required

   A. Seismic monitoring - none.

   B. Volcanic monitoring - four telemetered seismic stations and recorders.

   C. Geodetic monitoring - depends upon NOS, if they do not provide equipment, then a geodimeter and accessories would be required. L-DGO could provide a small, short-range (< 6 km) geodimeter and Zeiss NiII level.

   D. MEQ array - six, telemetered seismic stations and portable field recording gear.

   E. OBS seismic detection array - ten instruments to be designed, prototyped and fabricated.

   F. Earthquake prediction - staffed recording center, space to be rented, some new telemetry and recording gear, playback equipment for tapes.

4. Location of Future Field Efforts

   A. Shumagin gap - If major exploration/development takes place here, then a long-term prediction program should be instituted. Geodetic and volcanic monitoring should be begun as soon as possible.

   B. Other major plate boundary areas (Kodiak, Cook Inlet, Gulf of Alaska) - Same as A, above, except slightly lower priority for earthquake prediction program.

C. Saint George Basin - This basin appears to be fault controlled. There is some minor evidence that these faults may be active. This is an example of a place where the OBS seismic detection array would be invaluable. The nearest land-based seismometers are about 200 km away from the center of the basin and must be run at low gain due to the surf noise. Therefore, it is impossible to locate small ($M_b \leq 2$) earthquakes in this area.

5. <u>Logistic Requirements</u>

A. Seismic and volcanic monitoring - Same as for existing efforts, annual helicopter servicing of remote stations.

B. Geodetic monitoring - A substantial geodetic program would require that a party of at least four be in the field for three months each summer. This would require continuous support, either from a ship, or better, a helicopter.

C. MEQ array - Depending upon the particular research target, the array may be installed for a year at a time and relocated each summer or more often. If recording is at a remote site, supplies may have to be flown into an operator.

D. OBS seismic array - Depending upon final design--if telemetered or designed for long-term submersion--may have to be serviced once a year by ship; land-based telemetry would be similar to existing seismic network telemetry.

E. Earthquake prediction program - A staffed recording center may be achieved either by renting space in a village close to data collection area, or by telemetering all of the data, via satellite, to an existing facility such as the Tsunami Warning Center in Palmer or the Geophysical Institute of Fairbanks, or to L-DGO in New York.

E. Other Information

1. ERDA Contract: The major operational support for the seismic network is under contract number ERDA (11-1) 3134 with the Energy Research and Development Administration. The NOAA support has been designed to be complementary to this contract. It provides for logistic and personnel support that otherwise would not be available, with the effect of providing hazards analysis on a timely basis for the purposes of the OSCEAP program. The logistic support provided by NOAA has allowed the installation of additional strong motion instruments under the ERDA contract which otherwise would not have been possible due to budgetary constraints. These strong motion instruments will provide invaluable data for the design of earthquake resistant structures.

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

RU #: 16 PI: Davies

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

MAJOR MILESTONES	1977 O	1977 N	1977 D	1978 J	1978 F	1978 M	1978 A	1978 M	1978 J	1978 J	1978 A	1978 S	1978 O	1978 N	1978 D
Data Submission Schedule (hypocenter cards, epicenter maps, hypocenter cross sections, b-value and V_p/V_s ratio plots)						△			△			△			△
Quarterly Reports			△						△			△			
Annual Report						△									
Field Work (service stations)									△	△	△				

A Supplemental Proposal to the

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

for

A SEISMOTECTONIC ANALYSIS OF THE SEISMIC AND VOLCANIC HAZARDS IN THE PRIBILOF ISLANDS-EASTERN ALEUTIAN ISLANDS REGION OF THE BERING SEA

R.U. #16	Contract No. NOAA 03-5-022-70
Co-Principal Investigators:	John N. Davies, Klaus H. Jacob
Total Cost of Proposal:	Version A: $12,575 Version B: $9,375
Institution:	Seismology Department, Lamont-Doherty Geological Observatory of Columbia University in the City of New York
Period Requested:	1 March - 30 September 1978
IRS Number:	13-5598093
Congressional District No:	20
Make Grant to:	The Trustees of Columbia University in the City of New York, Box 20 Low Library, New York, NY 10027

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L-DGO Proposal No. 1700

BACKGROUND

Over the past two years it has become increasingly difficult to maintain reliable recording at the Dutch Harbor seismic station. Several persons have agreed to operate the station only to give up after a few weeks or months of trying to keep four different recorders and an exacting time correction system operational. Because of the life style and telephone system in Dutch Harbor and the distance to New York it has often been months between failure of the seismic system and the possibility for remedial action.

We have considered several possible solutions to this problem. The solutions fall into three catagories: (a) cease operations temporarily or permanently; (b) telemeter all of the data for recording elsewhere, e.g., Sand Point; and (c) simplify the recording at Dutch Harbor such that a local person could be expected to operate the station. Cessation of operations has been rejected on the grounds that possible strong-motion data and the requisite associated short-period data are valuable enough to spend the funds and staff time necessary to obtain them. Telemetry of the data to Sand Point could be accomplished either by utilizing the commercial phone system or installing a 5-station VHF repeater link. The former would cost about $10,000 per year for rental of a phone channel and about $5,000 in set-up equipment. The latter would cost $13,000 for set-up equipment and $1,000 a year for batteries plus servicing costs; with a high probability for failure since the failure of a single station would cause the loss of all the data. Simplifying the recording system would cost about $10,000 with minimal requirements in additional logistic support. We have chosen this option in the following proposal.

PROPOSAL

We propose to replace the operator-intensive recording and timing system at Dutch Harbor with a tape-recording system that places minimum requirements upon the operator. The principal rationale for this proposal is that with such a system in place we should be able to find in Dutch Harbor a person capable and willing to operate the system far more reliably than is now possible.

The existing recording system in Dutch Harbor consists of 3 Helicorders, a two-channel Autocorder, a TS100 clock and a WWV time receiver. The Helicorders require paper changing once a day and gain changes by the operator to avoid pen damage. The Autocorder requires an exacting change of paper rolls once every eight days and gain changes to avoid pen damage. The TS100 clock must be calibrated against WWV daily.

The proposed system is a modification of a L-DGO system now in operation in Nurek, USSR (Figure 1). The Dutch Harbor system (Figure 2) is designed around 2 four-channel TEAC tape recorders. The amplitude-modulated signals from the discriminators (for remote stations) and amplifiers (for local instruments) are monitored by event detectors (E.D., Figure 2). The event detection is based on comparison of a short-term average (STA) to a long-term average (LTA) of the signal. When the STA/LTA ratio exceeds a selectable value a pulse is sent to the control unit. The frequency modulated signals are mixed and recorded on a delay loop on the first tape recorder. Also recorded are an IRIG B BCD time code and a one kilohertz reference tone. Whenever a pulse is received by the control unit the contents of the tape loop are recorded on the second tape recorder. The clock is automatically synchronized to WWV via a satellite relay of the standard time broadcast. The loops and the reels of tape will be changed approximately once per week. The single long-period helicorder will remain to provide the operator feedback on the condition of the long-period seismometer. If the daily paper change on this component becomes too onerous it can be omitted without affecting the operation of the tape system. The event tapes will be played back on existing facilities at L-DGO.

The advantages of this proposed system are:

(1) Minimum time and skill are required of the operator;

(2) No operator is required to achieve time corrections;

(3) Time corrections will be made via UHF satellite signal rather than HF ground station broadcast. This should increase the frequency of good time corrections because the magnetic substorm activity in the auroral regions will not affect the UHF signals nearly as much as the HF ones;

(4) The system can record up to 16-24 stations;

(5) Only events are recorded on the data tapes, eliminating time-consuming scanning of records;

(6) Tape recorded data can be automatically filtered and/or digitized depending upon the use to which it will be put.

This proposal is made in two versions. Version one includes $3,200 for test equipment for which we have no back-up and which if lost or damaged would seriously jeopardize the servicing of the remote stations. Version two includes only the items required to install and operate the proposed analog event recording system.

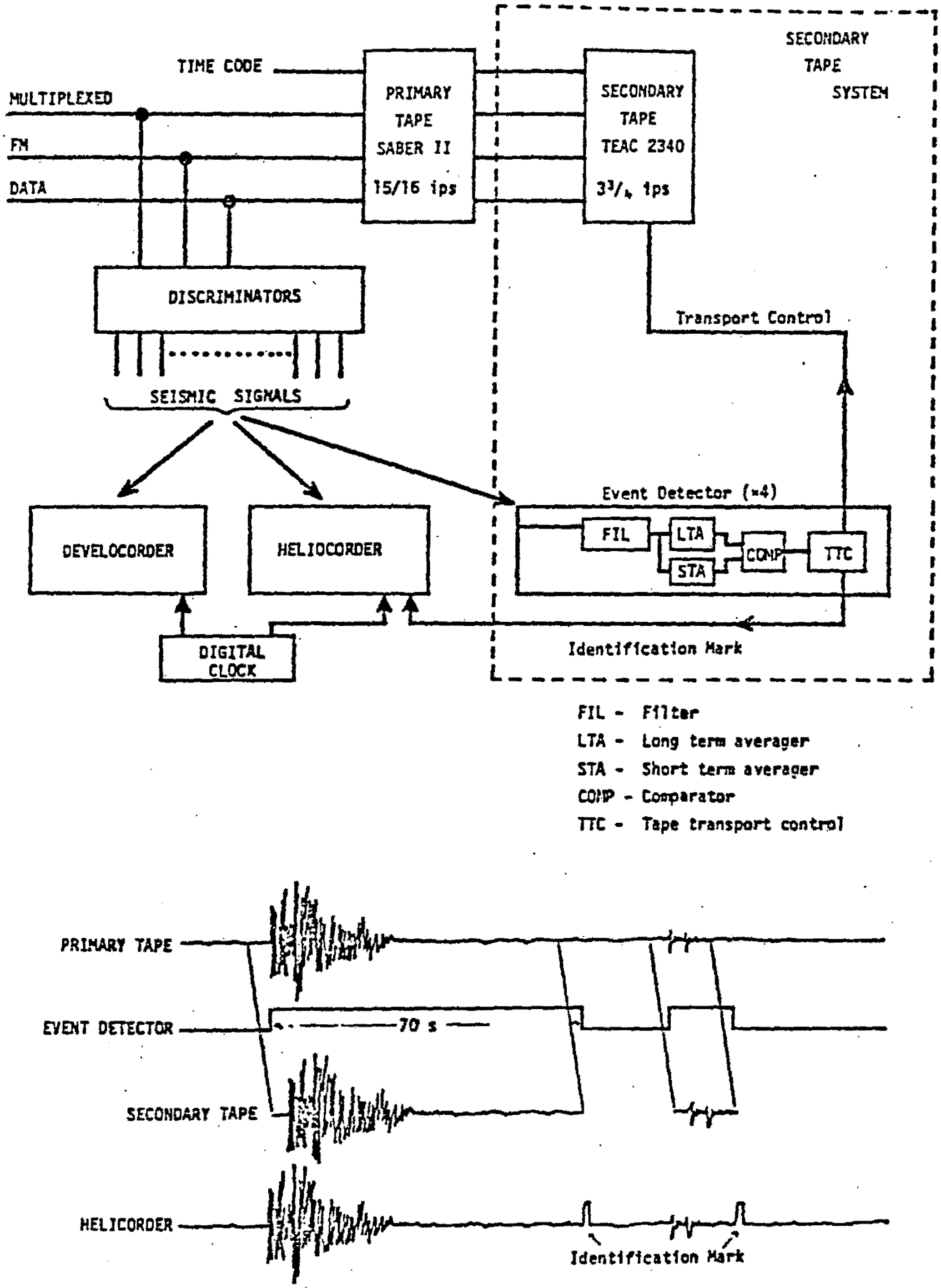

Figure 1: Block diagram of Nurek recording system. Three channels of multiplexed FM data (6 seismic components each) are recorded continuously on the primary tape deck. When an earthquake occurs, the event detector switches on the secondary tape deck, which records the data, delayed by 5 seconds in the primary tape deck. When the secondary deck turns off, an identification mark is written on the heliocorder to show which events have been transferred to the secondary deck. If an event remains above the detector threshold for less than 10 seconds, only a short record is made.

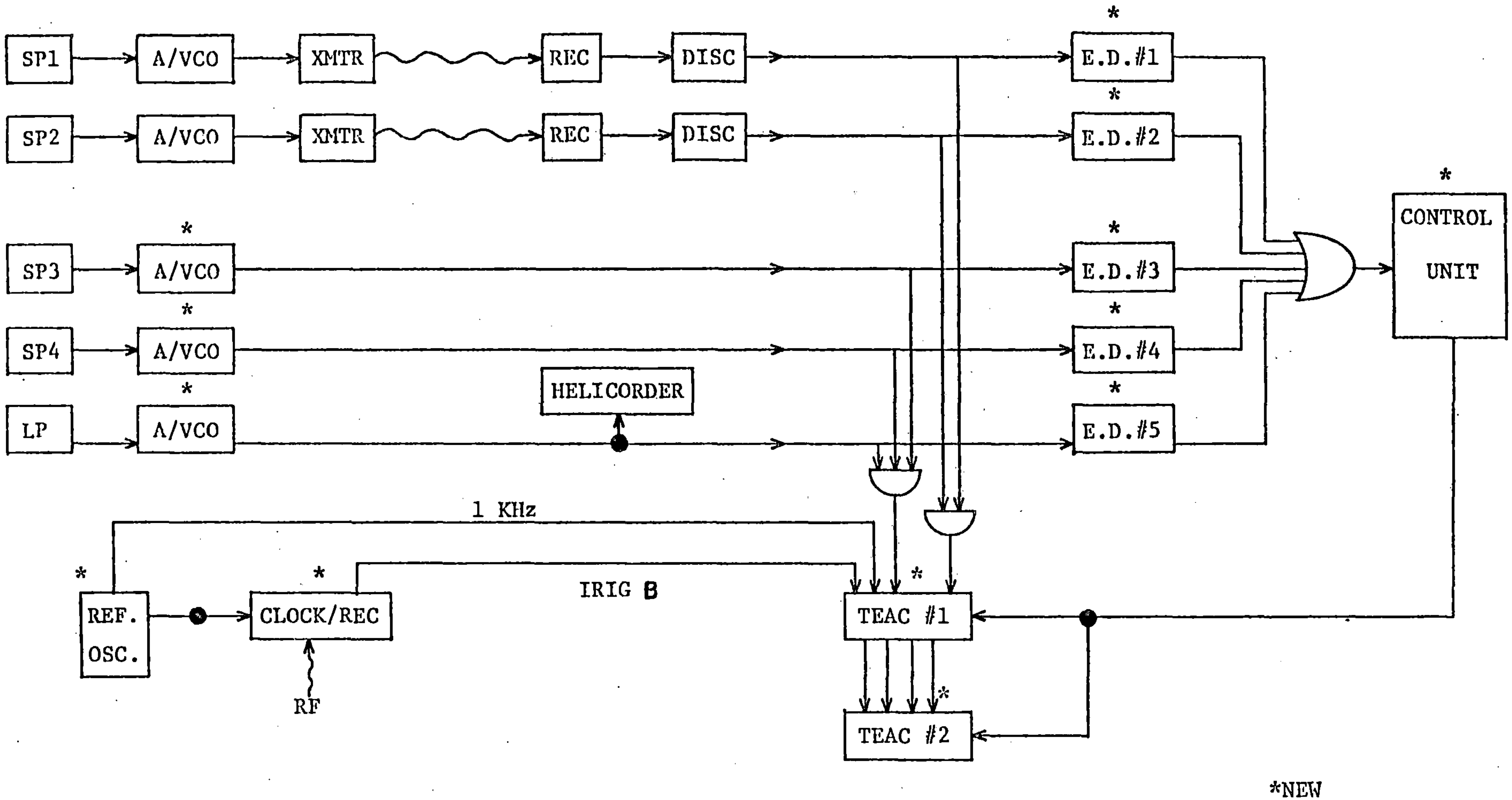

Figure 2. DUTCH HARBOR - PROPOSED ANALOG EVENT RECORDING SYSTEM 3/6/78

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Finfish Resource Surveys in Norton Sound
Research Unit No. 19
(Formerly R.U.19E)

Principal Investigator

Louis H. Barton
Alaska Department of Fish and Game
Commercial Fisheries Division
333 Raspberry Road
Anchorage

October 1, 1977 through September 30, 1978

TECHNICAL PROPOSAL

I. Title: Finfish Resource Surveys in Norton Sound

Research Unit: R.U.19

Contract Number:

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

II. Principal Investigator: Louis H. Barton

III. Cost of Proposal

C. Total: $59,000

D. Distribution of Effort: 100% Norton Sound lease area.

IV. Background

Work proposed in this paper represents a continuation of data collection on the pelagic finfish resources in the nearshore waters of Norton Sound. Initial funds were made available in Fiscal Year (FY) 1976. In that year reconnaissance-type surveys of the nearshore and offshore waters in the study area were conducted to determine the spatial and temporal distribution of pelagic finfish. Spawning populations of herring and other foraging finfish were examined as well as a subsistence utilization survey of fishery resources by local residents. In FY77, collection of data continued at the "nominal" level in selected nearshore waters from the Yukon River Delta to Port Clarence and in offshore waters in Norton Sound and Kotzebue Sound. Proposed work in FY78 is designed for more detailed studies in selected areas which exist as potential high impact areas from petroleum related activities; areas which may or may not typify other coastal estuaries throughout the study area. Specific objectives can be found in section V. In addition to nearshore sampling in selected areas, aerial surveillance for spawning herring stocks will be phased down to minimal coverage to complement FY76 and FY77 studies and fill in any data gaps which may still exist.

V. Objectives

1. Describe species composition by season and area for onshore fish populations in selected areas using a varity of sampling gear designed to sample juvenile and adult forms.

2. Determine trophic relationships for major fish species by examination of gut contents.

3. Describe spawning areas and seasons for major species.

4. Determine age dependent movement of populations and seasonal growth characteristics.

The relevance of these studies to an environmental assessment of the Alaska Continental Shelf will be to provide information on fishery resources potentially subject to impact from petroleum related activities; seasonal periods when a particular fishery resource would be most vulnerable to impact in terms of its life stage (i.e., juvenile vs. adult); areas and their usage during various life stages of development of major fish species (e.g., spawning, migration, feeding, etc.); and existing trophic relationships which would be potentially subject to impact. Such knowledge would enhance proper planning, exploration and development of petroleum activities in the study area to insure necessary protection to fishery resources.

VI General Strategy and Approach

Aerial Surveillance

A. Aerial surveillance, to compl~~i~~ement FY76 and FY77 studies, will be conducted during estimated spawning dates in major herring spawning areas. This limited coverage in FY78 will constitute the phasing-out of OCS herring spawning surveys. It is felt limited coverage will be necessary to complete data gaps identified from 1976 and 1977 studies.

B. The number of schools observed, estimated surface area and location of each will be documented.

C. Study Area: Major spawning areas from lower Norton Sound to/and including the Seward Peninsula. Such areas will include St. Mike, Cape Denbigh, Golovin Bay, Port Clarence, Shishmaref and Eschscholtz Bay.

Nearshore Finfish Sampling

A. In estuarine and nearshore areas within one mile of the coastline, a variety of sampling gear (seines, gillnets, small trawls and townets) will be fished. A continual evaluation of gear types will be made to sample a larger spectrum of fishes at various life stages. Selected study areas include the Port Clarence Complex, Golovin Bay and the Moses Point/Elim area.

B. Major emphasis will be placed in Port Clarence as it exists as a major potential impact area from petroleum related activities. Port Clarence is the only large vessel deep water harbor north of Dutch Harbor on the west coast of Alaska and consequently, is a potential major staging or refueling area for large vessels associated with oil exploration and/or development. The first phase of sampling, limited reconaissance surveys of this area with seines and gillnets, was initiated in FY77. FY78 studies will be intensified to a major plateau level to meet the objectives cited in Section V.

C. Based upon analysis of FY77 results, permanent sample stations will be selected and repetatively fished in Port Clarence with various gear types. Data obtained for catches will be standardized and reported by gear type, date and hour, location, distance from shore and water depth. Weather and ice conditions will be monitored and water temperature and salinity measurements taken. All catches will be recorded (by species), measured and major species preserved for subsequent food habits studies. In addition, age and relative maturity examinations will be made.

D. SCUBA diving will be employed to measure and map marine vegetative types, spawning areas, spawn density and egg deposition, substrate type and collect samples as needed.

E. Two spring-summer sampling seasons of gathering data on fishery resources at the "nominal" level in Golovin Bay will have been completed by October 1, 1977. These studies will be phased out in FY78, while at the same time, assessment of the feasibility of future trophic relationship studies in Golovin Bay and the Moses Point/Elim area will be made.

VII. Sampling Methods

Sampling in the Port Clarence complex will be conducted from 22 foot open skiffs by two 2-man mobile crews. If funding is made available in a timely manner, intensive sampling will be initiated in the fall of 1977 (October 1 until freeze-up) and then from breakup (late June - early July) until September 1978. Limited winter sampling (test fishing) may be attempted or else winter subsistence catches of major species sampled for length, age and stomach analysis as funding level permits. Spring, summer and fall sampling will consist of fishing various types of gear (to include variable mesh gillnets, seines, small trawls and townets). Sampling stations will be selected and repetatively fished with consistent gear types to determine spatial and temporal distribution characteristics of fish species.

Not more than 120 fish per species will be measured per set. Subsampling of major species per set for age, stomach and relative maturity analysis will be conducted. Subsampling effort will be adjusted in accordance with size of catches and necessary time and cost involved for subsequent analysis.

SCUBA diving will be employed as qualified personnel are available to determine and map vegetative types in selected areas. Any spawning areas will be defined and extent and density of spawn documented. Underwater photographs will be taken of various spawning areas and habitat types and presented in quarterly and annual reports.

Sampling in Golovin Bay will commence October 1, 1977 and continue through freeze up. Sampling will resume following ice breakup in late May-early June and continue on a limited basis throughout FY 78. Sampling stations selected in 1976 and 1977 studies will be repetitively fished to bridge any data gaps which may still exist. Sampling will be conducted by a two-man crew from a 16 foot open skiff and will consist of variable mesh gillnets and beach seines. This crew would be deployed, as possible, to the Moses Point/Elim area to assess the feasibility of future trophic relationship studies. Biological sampling will include length, age, stomach and relative maturity analysis. The number of samples from these areas will be much reduced from studies being conducted in Port Clarence area.

With the exception of detailed studies in Port Clarence in FY 78 distribution of sampling effort in other sections of the Norton Sound study area may be somewhat altered pending analysis of FY77 results.

VIII. Analytical Methods

Spatial and temporal distribution of various species will be examined by comparisons of catch per unit effort by gear types throughout the study period. Other data analysis will include age-length correlations with time for examing age structures and growth characteristics, and qualitative and quantitative analysis of stomach contents for major fish species to assess trophic relationships.

IX. Anticipated Problems

The OSCEAP Juneau project office has stressed in their guidance letter for preparing the FY78 project proposal that "seasonal" relationships be examined. Because of initial late funding of the first OCS Norton Sound program in FY76, sampling began in the near shore waters near the end of June. Sampling terminated in mid September due to a delay in funding (December 1977) of the FY77 project. Consequently, only three months have been sampled since inception of Norton Sound OCS work. Therefore it is stressed here that any delay in funding of the FY78 proposal will negate fall sampling (October and November). This is imperative if seasonal comparisons are to be made. A commitment on funds must be made to the Sate of Alaska, Department of Fish and Game not later than September 1, 1977 to insure 1977 fall sampling (October 1, 1977 through freezeup) can be conducted. This is in view of the fact that the State of Alaska SOP in reference to receiving and spending federal funds, equipment purchase calender dates and contract award vendors must be adhered to.

The largest single problem which will affect the entire program will be inclement weather and size of the study area. The North Bering Sea and Chukchi Sea are subject to frequent high winds and storms especially in the fall months. In order to cope with this problem, crews will be equipped and located in sample areas from breakup to freezeup to take advantage of sampling conditions whenever possible. Hypothermia is a constant threat and therefore all field crews will be equipped with floatation jackets. All crew members sampling the inshore coastal waters from open skiffs will be equipped with the survival suits. It is hoped that inclement weather will not create the problems experienced in 1976 and 1977 since most effort will be confined to bays or inlets which offer more protection.

A problem encountered in FY77 studies was experienced by having to absorb part of the state OCS coördinators (Pete Jackson - Kodiak) salary. The FY77 proposal was not inflated by OCSEAP, as initially we were informed, by an amount sufficient to cover part of these expenses. Consequently the FY78 proposal has been inflated by funds sufficient to cover 2 man months of salary for this position over and above actual R.U. 19 operational costs. If these additional monies are rejected the entire proposal is subject to change due to the high cost of salaries.

X. Expected Products

A. Digital Data - Attached

B. Narrative Reports: It is not known at this time whether or not any special reports apart from the required quarterly and annual reports will be prepared from results of these investigations.

C. Visual Data

a. Maps identifying sampling sites.

b. Charts illustrating:

(1) Seasonal distribution of principal life stages for each major species or species group.

(2) The primary use made of area, i.e., migration, feeding and/or spawning.

(3) Primary spawning areas and depths for major species where applicable.

c. Figures and tables showing:

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

(2) Seasonal changes in relative abundance for principal life stages of major species or species groups at each sampling site.

(3) Seasonal use of sampling areas, i.e., migration, feeding, and/or spawning.

(4) Seasonal changes in food habits for principal life stages of major species or species groups.

(5) Life history table of major species or species groups to include:

(a) spawning areas.

(b) spawning time.

(c) growth rates (including larval stages).

(d) age class composition.

(e) foraging areas (where applicable).

(f) food habits by principal life stages.

d. Photographs (as possible) showing:

(1) Littoral zone habitat types.

(2) Spawning habits and substrates for major species (where possible)

D. Other Non-digital Data - none

E. Data Submission Schedule - Attached

XI. Information Required from Other Investigators

No information is required from other investigators in order to carry out field investigations. Information contained in copies of the OCSEAP quarterly and annual report series will suffice for assisting in preparation of necessary reports.

XII. Quality Assurance Plans

All sampling techniques, materials and calibration of instruments will be held consistant among field sampling crews and previous investigative techniques.

XIII. Sample and Voucher Specimen Archival Plans

All policies developed by the OCSEAP staff in respect to collecting, preserving, recording, labeling and submitting voucher specimens will be adhered to. Voucher specimens were obtained by this project in FY 76 and 77 and plans are to continue this practice during FY 78 studies. However, any policy development should be made practical, since in many cases individuals carrying out such policies are working in isolated areas with minimal storage area and transport capability.

XIV. Logistics Requirements - Attached

XV. Management Plan

A. Commercial Fisheries OCS State Coordinator, Peter Jackson, technical supervisor and overall coordination with other OCS projects.

B. R.U.19 Principal Investigator, Louis Barton, 12 months program coordinator technical and field supervision and 5 months data summary, analysis and report preparation.

C. Artic-Yukon-Kuskokwim Regional Supervisor, Ronald Regnart, 1 month administrative supervision.

D. Artic-Yukon-Kuskokwim Regional Research Supervisor, Bill Arvey, 2 months technical and administrative supervision assistance.

E. Arctic Area Biologist, Fritz Kuhlman, 1 month logistic support and supervision assistance.

An Activity Milestone Chart is attached.

XVI. Outlook

Assuming that the research proposed for FY78 is successfully carried out, then a final year of limited sampling in Port Clarence to fill data gaps would be conducted in FY79. Such sampling could be conducted periodically by a single 2-man crew. Cost would be minimal (about $10,000) with most expense arising from temporary salaries.

Pending FY78 feasibility studies for trophic relationship investigations in the Golovin Bay, Moses Point and Elim areas, a major plateau level of sampling may be initiated in those areas in FY79 (about $150,000) and then phased out in FY80. The objectives and expected data products of these investigations would hold consistent with FY78 Port Clarence studies.

In FY79 limited sampling in the Yukon River Delta would possibly be initiated to assist in planning a trophic relationship study the following year. In that same year (FY79) some of the logistical problems which would be expected for detailed studies in this area would be examined and initial steps made to solve these prior to a major plateau level of effort in FY80. Such activities would include a reconnaissance of the study area for location of a field office, purchase, transportation and fabrication of a cabin from which to operate and coordinate field sampling and store equipment. This would entail aerial and ground reconnaissance for site selection and freighting a rigid wall precut cabin into the study area from Anchorage to Nenana and then via barge from Nenana. Cost of the FY79 Yukon River Delta work would be about $25,000.

Work in the Yukon River Delta would reach plateau level in FY80 with a final year of sampling probably conducted in FY81. Field activities of these studies would be designed to determine the seasonal distribution and movement by species into and within the study area, growth and relative maturity of major species and trophic relationships of major species. Expected data products would hold consistent with those of the FY78 Port Clarence investigations.

In FY80 work in the nearshore waters (within one half mile of shore) of the Yukon River Delta would be carried out by not less than three 2-man mobile crews (about $150,000). In addition sampling the offshore waters of the delta complex would be conducted, possibly via large vessel. Actual cost would depend upon charter rates. Offshore sampling would be with variable mesh gillnets, townets and purse seines to examine the distribution and seasonal movement of fish species associated with the delta complex as well as collect specimens for subsequent stomach analysis. It is felt that the Yukon River Delta, in terms of biomass of fish produced, is perhaps the most important ecosystem in the Norton Sound/Kotzebue Sound areas. By lying near the proposed Norton Sound lease area, the Yukon River Delta is subject to possible impact from oil exploration and development. Consequently, major contamination of this area in the case of oil spills could have devastating effects upon fishery resources common to the area.

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 papa. 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

1. 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 the Principal Investigator's salary requested in the budget.

2. Beyond the personnel listed in item XV - management plan, all field personnel hired on a temporary basis will be selected from applications submitted to ADF&G for employment prior to field investigations. Temporary personnel presently working under R.U.19 in Norton Sound will be solicited for further work pending approval of proposed FY78 work.

3. Other persons authorized to conduct negotiations:

   Peter Jackson
   OCS Coordinator
   Alaska Department of Fish and Game
   Commercial Fisheries Division
   Kodiak, Alaska 99615
   Phone number 486-5751/59

   Steven Pennoyer
   Chief Research Scientist
   Alaska Department of Fish and Game
   Commercial Fisheries Division
   Subport Building
   Juneau, Alaska 99801
   Phone number 465-4224

4. The Alaska Department of Fish and Game, Division of Commercial Fisheries is presently conducting four OCSEAP funded studies as follows:

   1. R.U.19: Finfish Resource Surveys in Kotzebue Sound and Norton Sound.

   2. R.U.512: Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System.

   3. R.U.486: Demersal Fish and Shellfish Assessment in Selected Estuary Systems of Kodiak Island.

   4. R.U.19: Forage Fish Assessment Surveys, Southern Bering Sea.

Renewal guidance has been received and FY78 project work statements are being submitted for items 1, 2 & 3 above plus three additional proposals as follows:

1. Characterization of spawning forage fish stocks on Kodiak Island with emphasis on the east side. R.U.# not assigned.

2. Cooperative finfish assessment surveys in the Kodiak and lower Cook Inlet areas. R.U.# not assigned.

3. Assessment, life history, and inter-species relationships of nearshore fish communities in selected buy systems of the Aleutian Island Lease area. R.U.486.

Table 1

Definition and Range of File Type 57 Digital Data Parameters
Utilized in Studies Proposed for R.U. 19 in FY 78

Record Type Headers - Identical for all Record Types

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
1-3	File Type	I3	XXX	~~023~~ 057
4-9	File Identification	I6	XXXXXX	050178-093078
10	Record Type	I4	X	1-4

Record Type 1

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-16	Survey Date	I6	XXXXXX	780501-780930
17-20	Time Begun	I4	XXXX	0001-2400
21-23	Elasped Time	I3	XX.X	00.1-10.0
24-30	Latitude Survey Begun	A7	XXXXXXA	623000N-670000N
39-45	Latitude Survey End	A7	XXXXXXA	623000N-670000N
31-38	Longitude Survey Begun	A8	XXXXXXXA	1600000W-1690000W
46-53	Longitude Survey End	A8	XXXXXXXA	1600000W-1690000W
54-59	Aircraft Number	A6	XXXXXX	N/A
60	Aircraft Type	I1	X	1-9
61-74	Observer - Last Number	A14	XXXXXXXXXXXXXX	N/A

Record Type 2

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-13	Census Area	I3	XXX	031-048
14-20	Latitude of Census Area	A7	XXXXXXA	623000n-670000N
21-28	Longitude of Census Area	A8	XXXXXXXA	1600000W-1690000W
29-31	Length of Census Area	I3	XXX km	015-250
32-34	Altitude	I3	XXX M	050-600
35-37	Airspeed	I3	XXX km/hr	100-300
38	Cloud Cover	I1	X	0-9

Record Type 2 (cont.)

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
39	Visibility	I1	X	0-9
40	Sea State	I1	X	0-9
41-42	Weather Code	I2	X	0-9
43-44	Wind Direction	I2	XX	0-9
45	Air Roughness	I1	X	1-3
46	Fishing Type Seen	I1	X	1-4
47	Fishing Gear Seen	I1	X	1-4
48	Tide	I1	X	1-4
49	Survey Rating Index	I1	X	1-5
50	Turbidity	I1		

Record Type 3

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-13	Census Area	I3	XXX	031-048
14-17	School Number	I4	XXXX	0000-0500
18-24	Latitude	A7	XXXXXXA	623000N-670000N
25-32	Longitude	A8	XXXXXXXA	1600000W-1690000W
33-36	School Location	I4	XXXXM	0-1500
37-46	School Species	I10	XXXXXXXXXX	N/A [1/]
47	School Activity	I1	X	1-3
48-52	School Size	I5	XXXXXM[2]	(Not Used)
53	Beach Type	I1	X	1-5
54	Biota Type	I1	X	1-5
56	School Size Index	A1	A	S,L,M,U
57-58	No Schools Seen	A2	XX	0-50

1/ NODC Taxonomic Code - March, 1977.

Record Type 4

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
11-13	Census Area	I3	XXX	031-048
14-76	Explanatory Text	A63	XXX...XX	N/A
77-80	Sequence Number	I4	XXXX	N/A

Table 1
Definition of File Type 23 Digital Data Parameters
Utilized in Proposed Work for R.U. 19 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	050178-113078
10	Record Type	I1	X	1-4

Record Type 1 - Haul 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	AX	N/A
17-19	Haul or Set Number	I3	XXX	0-999
29-35	Latitude	A7	XX.XX.XXA	623000N-670000N
36-43	Longitude	A8	XXX.XX.XXA	1600000W-1690000W
44-49	Date (GMT)	I6	XXXXXX	80501-780930
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.	00.1-24.0
63	Performance Code	I1	X	0-8
70-73	Mean Bottom Depth	I4	XXXX M	0-100
76	Sounding Record	I1	X (Blank)	1-5
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

Not used in this study.

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	0-99
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	0-20
100-104	Sequence Number	I5	XXXXX	N/A

Record Type 4 - Species Catch Record

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	XXXXXXXXXX	1/
34-41	Total Weight by Species	I8	XXXXXX.XX kg.	2/

Record Type 4 (cont.)

COLUMNS	IDENTIFICATION	ATTRIBUTES	FORMAT	RANGE
42	Weight Determination	I1	X	1-2
43-48	Total Number of Species	I6	XXXXXX	N/A
49	Number Determination	I1	X	1-3
50-59	Total Weight by Species	I10	XXXXXX.XXXX kg.	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 single fish are frequent and more decimal places are necessary, the total weight by species will be recorded in columns 50-59.

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)
Herring aerial surveys	disketts	1,500 lines	57	Yes	Jun 78 - Sept 78	Dec 78
Pelagic & demersal finfish	disketts	5,000 lines	23	Yes	Oct 77 - Sept 78	Dec 77 & Dec 78

MILESTONE CHART

RU #: 19 PI: Louis H. Barton

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			
Hiring field personnel							X	X										
Field sampling	X	X		X		X			X	X	X	X						
Planning effort							X	X										
Equipment purchase	X	X																
Processing digital data	X	X											X	X				
Submission of digital data			X												X			
Summary of field data	X	X				X						X	X					
Analysis of field data		X	X			X							X	X	X	X		
Stomach analysis 1/	°	X°	X°								°	X°	X°	°				
Close down field camps		X										X 2/		X 3/				
Open up field camps									X									
Preparation of quarterly reports			X						X			X			X			
Preparation of annual reports				X	X	X										X	X	X
Preparation of Fy 79 project proposal							X		X									

1/ X - if contracted out.
° - if analyzed by ADF&G.

2/ If not refunded in FY 79.
3/ If refunded in FY 79.

RFx41-19-569

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

Louis H. Barton
Alaska Department of Fish & Game
Commercial Fisheries Division
333 Raspberry Road
Anchorage, Alaska 99502

Reference: Research Unit #19

Dear Mr. Barton:

Required Proposal Revisions for FY 78

Your FY 78 renewal proposal entitled "Finfish Resource Surveys in Norton Sound" 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. The overall funding level should be reduced to $59,000 for science, $0 for logistics. This funding level must not be exceeded.

2. FY 1978 efforts should be restricted to the completion of laboratory processing and analyses of data obtained in FY 76-77 with the interpretation and reporting of the results. No field work should be performed during FY 78. Approximately $9,000 should be allocated for the preparation of a final report on the Southeastern Bering Sea component of the research while the remaining $50,000 should be used to prepare a comprehensive final report on results of the Norton Sound - Kotzebue Sound investigations.

3. The narrative portions of the final reports should describe methods, spatial and temporal intensity of sampling, current status of knowledge, descriptions of statistical treatment, and results, including, as appropriate, discussion and conclusions on:

   a. Spatial-temporal distribution of spawning forage fish species - within and between areas, years and seasons.

   b. Spatial-temporal distribution of onshore and nearshore-shallow pelagic finfish species - within and between years, areas and seasons.

c. Spatial-temporal distribution of offshore pelagic fish species.

d. Food habits and age-growth analyses of selected species.

e. Data gaps and needs for additional studies.

4. Visual and digital data products should conform to those in the FY 77 proposal or subsequently negotiated.

5. Please submit a revised milestone chart showing the altered research plan for the Norton-Kotzebue and Southeastern Bering Study areas separately with anticipated dates for data submissions and major events in the final report production cycles.

6. Please submit a revised budget.

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 September 2, 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

STATE OF ALASKA

JAY S. HAMMOND, Governor

DEPARTMENT OF FISH & GAME

P. O. BOX 686 — KODIAK 99615

October 5, 1977

Mr. Laurie Jarvela
NOAA/OCSEAP Project Office
P. O. Box 1808
Juneau, Alaska 99802

Dear Laurie:

Regarding your letter of September 27, 1977 requesting a statement describing the rationale and cost breakdown for the autumn 77 field studies for R.U. 19 - Finfish Resource Surveys in Norton Sound:

Our purpose in requesting extension of ongoing Norton Sound studies into the fall is to facilitate completion of the seasonal data continuum originally desired by OCSEAP on the distribution, abundance, timing and species composition of nearshore finfish stocks in specified areas initiated in FY 77. Termination of this work in October would have precluded this seasonal continuum initiated immediately following the spring 1977 breakup. Objectives for this extended work are unchanged from those stated in our FY 77 work statement for R.U. 19. With the FY 77 funds remaining in R.U. 19 (due to termination of the large vessel charter because of ice conditions), existence of FY 77 carry-over monies, and the fact that FY 77 field crews are still in the field, this extended work can be accomplished for $10 K in addition to the $50 K available for project wrap-up and completion.

Extension of FY 77 studies by R.U. 19 through November of FY 78 would accomplish the following:

1. Continue ongoing nearshore finfish assessment in the Golovin Bay and Port Clarence studies through November (or freeze-up) as per FY 77 objectives and methodology described in our work statement.

2. Continue ongoing assessment of the spatial and temporal distribution of spawning herring and capelin stocks by aerial surveillance on the Seward Peninsula with emphasis on species identification of schools seen.

Results of these fall FY 78 studies will be analyzed during FY 78 and incorporated into the R.U. 19 project completion report due September 30, 1978. This report would permit analyses and comparisons between two successive seasons, one being complete from break-up to freeze-up.

MILESTONE CHART

RU #: 119 - Norton Sound PI: Louis H. Barton

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

MAJOR MILESTONES	1977 O	1977 N	1977 D	1978 J	1978 F	1978 M	1978 A	1978 M	1978 J	1978 J	1978 A	1978 S	1978 O	1978 N	1978 D
Keypunching and verifying of FY 77 Finfish assessment data - File Type 023	X	X													
Keypunching and verifying of FY 77 forage fish assessment data - File Type 057	X	X													
Submission of FY 77 digital data (File Type 057 and 023) to NODC for archiving			X												
Analysis of FY 77 data in preparation for report	X	X	X	X	X										
Preparation of project completion report			X	X	X	X	X	X	X						
Finalization and editing of project completion report									X	X	X	X			
Submission of project completion report to Juneau Project Office												X			
Final review of FY 77 digital data prior to submission for keypunching - File Type 023 and 057	X														

MILESTONE CHART

RU #: 119 Extension PI: Irving Warner

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
Final review and submission of File Type 057 data for keypunching	X														
Preparation of initial draft of project completion report	X														
Editing and revision of project completion report	X	X													
Completion and final review of project completion report		X													
Submission of project completion report to OCSEAP		X													
Submission of digital File Type 057 data to NODC		X													
Analysis of FY 77 data in preparation for project completion report															

ASSESSMENT OF POTENTIAL INTERACTIONS OF
MICROORGANISMS AND POLLUTANTS FROM
PETROLEUM DEVELOPMENT

RU 29

Principal Investigator: Ronald M. Atlas, Ph.D.

Department of Biology
University of Louisville
Louisville, KY 40208

Cost:

Dates: October 1, 1977 - September 30, 1978

Ronald M. Atlas
Principal Investigator
502 588-6773

John Dillon
~~Vice~~ President
502 588-6153

TECHNICAL PROPOSAL

I. Assessment of Potential Interactions of Microorganisms and Pollutants from Petroleum Development.

RU #29
Contract # 03-5-022-85
Dates: October 1, 1977 - September 30, 1978

II. Principal Investigator: Ronald M. Atlas

III. Total Costs $158,800

Distribution of effort by lease area: 50% Beaufort Sea
50% Lower Cook Inlet

IV. Background

Microbiological research in the Beaufort Sea was commenced in FY 75 but was discontinued during FY 77, mostly for fiscal reasons. During the first year of the work seasonal and spacial distributions of microorganisms between Pt. Barrow and Prudhoe Bay were determined and some work on hydrocarbon biodegradation was carried out. A recent OCSEAP-sponsored workshop on microbiology pointed out the many deficiencies in our understanding of microbiological processes and biodegradation of oil and recommended continuation of these studies in the Beaufort Sea. The fate of petroleum in Arctic marine sediments and under sea ice has not previously been extensively studied.

Microbiological research in the Cook Inlet was commenced in FY 77. During the first year of the work distribution of microbial populations were determined and some work on biodegradation was carried out. A recent OCSEAP-sponsored workshop on microbiology pointed out the many deficiencies in our understanding of microbiological processes and biodegradation of oil and recommended continuation of these studies in the Lower Cook Inlet.

V. Objectives

Determine the distribution of microbiological populations in the Beaufort Sea and assess the potential interaction of microorganisms and pollutants produced by petroleum development on the outer continental shelf. Specifically:

1) Determine the processes of incorporating petroleum in the bottom sediments and the biodegradation in these sediments.

2) Determine the processes of biodegradation and weathering of petroleum in and under sea ice.

3) Determine geographical distributions and densities of microbial populations between Prudhoe Bay and Barter Island.

Determine the distribution of microbiological populations in Lower Cook Inlet and adjacent areas and assess the potential interaction of microorganisms and pollutants produced by petroleum development on the outer continental shelf. Specifically:

1) Determine seasonal and geographical distribution and densities of microbial populations in sediment and water.

2) Determine the potential rates limiting factors of the processes of biodegradation and weathering of petroleum in water and sediment.

3) In coordination with Project RU190 examine denitrification processes and the influence of petroleum hydrocarbons on nitrogen cycling.

VI. General Strategy and Approach

Beaufort Sea sediment and ice will be exposed to Prudhoe crude oil by establishing small contained spillages. For sediment open plexiglas trays will be used and for sea ice open stainless steel cylinders. For sediment studies an area near Pt. Barrow not subject to bottom ice scouring will be used. Both under and over ice spillage studies will be conducted in a nearby area. Under ice spillages will be established during periods of ice growth and ice acretion.

After various periods of exposure replicate samples will be recovered, the residual petroleum hydrocarbons and other lipids extracted with solvent and the extracted components analyzed as described below. Microbial hydrocarbon utilizing populations in the oil treated samples will be enumerated, characterized by numerical taxonomic procedures and compared with populations of hydrocarbon utilizing populations in adjacent unoiled samples.

Additionally samples will be collected from a ship cruise in the Beaufort Sea east of Prudhoe Bay. Densities of microbial populations will be determined by direct epifluorescent counting and by viable plate count procedures. Numerical taxonomic characterization and cluster analyses will be performed on heterotrophic microorganisms isolated from water and sediment samples. Rates of oil biodegradation potentials will be determined by measuring the rate of $^{14}CO_2$ release from Prudhoe crude oil spiked with various ^{14}C radiolabelled hydrocarbons.

In lower Cook Inlet water and sediment samples will be collected from ship cruises. Densities of microbial populations will be determined by direct epifluorescent counting and by viable plate count procedures. Numerical taxonomic characterization and cluster analyses will be performed on microorganisms isolated from water and sediment samples. Cluster analyses will also be completed on isolates from previous sampling cruises. Rates of oil biodegradation potentials will be determined by measuring the rate of $^{14}CO_2$ release from Cook Inlet crude oil spiked with various ^{14}C radiolabelled hydrocarbons. Also studies on denitrification will be conducted by placing sediment samples in vials with and without crude oil replacing the atmosphere of the vial with helium and measuring the rate of N_2O and N_2 gas evolution.

VII. Sampling methods.

In the Beaufort Sea one summer cruise between Prudhoe Bay and Barter Island is planned for sampling and characterization of microbial populations. Water will be collected with Niskin sterile water samplers. Sediment will be collected with a grab sampler. Approximately twenty stations will be sampled in this area. Experimental sediment oil spillages are presently being established near Pt. Barrow. It is planned to have divers recover replicate samples during the winter (November-February), spring (May-June) and summer (August-September). During periods of oil-treated sediment recovery, experimental under and over ice contained spillages will be established and periodically sampled. Oil will be recovered from ice by cutting or coring an ice block containing the oil. The position of the oil in the ice will be determined visually and by sectioning the ice core and performing chemical analyses for the presence of hydrocarbons.

In Cook Inlet samples will be collected during one late summer and one late winter cruise. Samples will be collected along established transects and will include collection of beach samples. Water and sediment samples will be collected as described above. Sampling transects will be extended through the east and west entrances of Cook Inlet to Kodiak Island. Since the NOAA vessels generally depart Kodiak Island, this additional sampling is a logical extension of present sampling allowing for comparison with microbial populations in adjacent connected water masses. Approximately twenty stations will be sampled on each cruise in Cook Inlet.

VIII. Analytical methods.

Microorganisms will be enumerated and characterized by procedures described in previous reports of this project. Total numbers of microorganisms will be determined by direct counting procedures. A variety of selective media and incubation conditions will be employed to enumerate physiologically differentiated microbial populations. Heterotrophic microorganisms selected at random from representative samples will be extensively characterized using morphological, physiological, biochemical and nutritional tests. Cluster analyses will be performed to determine the taxonomic groupings of microorganisms in sampled areas. Average linkage sorting will be used in addition to single linkage analyses. Results of cluster analyses will be used to calculate microbial diversity indices. Hydrocarbon utilizing microorganisms will be enumerated by plating and MPN procedures. For MPN procedures release of $^{14}CO_2$ from ^{14}C hydrocarbon spiked oil will be used to score positive tubes. Counts in excess of double poisoned controls will be required to establish positive $^{14}CO_2$ production.

VIII. (Continued)

Oil biodegradation potential will be determined as described in previous reports of this project. Cook Inlet or Prudhoe crude oil spiked with ^{14}C radiolabelled hydrocarbons (hexadecane, decane, pristane, naphthalene or benzanthracene) will be used.

For analyses of crude oil exposed in sediment and over or under sea ice in the Beaufort Sea, the oil will be recovered by Soxlett or liquid-liquid extraction with ether. Recovered oil will be analysed by gas chromatography using packed Apiezon L columns and temperature programming to determine the rates of degradative loss of resolvable components. Also, the persistence of resolvable hydrocarbons adsorbed onto sediment will be determined by this method. For detailed identification of persistent hydrocarbons gas chromatographic-mass spectrometry will be used. GC-MS analyses will also be used to identify new compounds which accumulate due to microbial degradation and biosynthesis. The accumulation of such compounds has been found in tundra soils and freshwater lake sediments exposed to petroleum hydrocarbons. The identification of these compounds has not been determined and potential toxicities of these products are totally unknown. Mass spectrometry will also be used to determine the composition of residual petroleum according to major hydrocarbon classes. Programs for compositional analyses of petroleum residues and identification of persistent hydrocarbons and products are available through the NIH computer facilities.

IX. Anticipated problems.

Problems have been encountered with obtaining nutrient analyses. New arrangements for these analyses through Project RU190 should overcome these problems. Last minute changes in ship scheduling have also created problems in this project. The major anticipated problem is with weather and ice conditions in the Beaufort Sea. Ice conditions will determine the extent and location of sampling that can actually be conducted in the Beaufort Sea.

X. 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)
Oil degradation rates	Disks at NIH	1000 tracks	special	Yes		
Densities of microbial populations	"	"	"	"	(Oct. 1 - Dec. 31/78 (Jan. 1 - Mar. 31/78 (Apr. 1 - June 30/78 (July 1 - Sept. 30/78	Jan. 31/78 Apr. 30/78 July 30/78 Oct. 30/78
Characterization of microbial isolates	"	"	"	"		

* Submission dates are for enumeration data only, prior to analysis.

X. (Continued)

Products - Beaufort Sea

Narratives of methods and results, including tables of species, densities and geographic location of microorganisms. Tables of rates of hydrocarbon biodegradation. Table of chemical composition of petroleum residues under ice and in sediment and any new products that accumulate. Cluster analysis of microorganisms in the Beaufort Sea samples. To be included in quarterly reports and in reports in the scientific literature.

Digital data: Population counts and distributions (Disc. storage at NIH).

Visual data: Maps of seasonal distribution of microorganisms. Graphs of composition, biodegradation rates, etc.

Products - Cook Inlet

Narratives of methods and results, including tables of species, densities and geographic location of microorganisms by season. Tables of rates of hydrocarbon biodegradation. Cluster analysis, of microorganisms in Lower Cook Inlet samples will provide information on physiological groups present in water and sediments. These groups include organisms capable of organic degradation and hydrocarbon degradation. To be included in quarterly reports and in reports in the scientific literature.

Digital data: Microbial population counts and distributions. (Data are on computer disc storage at NIH, Washington, D. C.).

Visual data: Maps of seasonal and geographic distribution of microorganisms. Graphs of species composition, biodegradation rates, etc.

XI. Information required from other investigators.

The work in this project will be closely coordinated cruise samples shared with Dr. Morita's project RU 190. Nutrient analyses including inorganic N, organic N, and organic C will have to be supplied through Dr. Morita's project or other NOAA OCSEAP supported source. Dr. Morita has contacted the Juneau project office regarding the need for these nutrient analyses. Salinity, temperature and accurate positional data will be required from vessel personnel on each cruise. Data analyses will have to be provided through separate interagency agreement with NIH.

XII. Quality assurance plans.

Instruments used in the analysis of the petroleum residues will be routinely checked with internal standards. Statistical analyses of variance will be used on replicate samples to determine the level of significance of results. Numerous computer checks are built into the NIH data storage and analysis system to assure accurate entry of the data.

XIII. Sample archival.

Any necessary archival of isolated microbial strains will be made by deposition with the American Type Culture Collection, Rockville, MD.

For OCSEAP use only:
RU #
Discipline
Area of Operation

BEAUFORT SEA

XIV. 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 Louisville PRINCIPAL INVESTIGATOR Ronald Atlas

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. Plover Pt. for in situ oil exposure experiments, transects from Prudhoe Bay planned for FY 76 Glacier Cruise maximum 15 stations.

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. For shipboard sampling water and sediment will be collected with Niskin sterile water and bottom grab sampler.

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.)
Summer when ice conditions permit.

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.)
≈10

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback?
Can coordinate with other.
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. 1 hr. 1 station

6. What equipment and personnel would you expect the ship to provide? Bottom sampling grab and winch. STD costs. positional data

7. What is the approximate weight and volume of equipment you will bring?
1000 lbs 200 cu. ft.

8. Will your data or equipment require special handling? Yes If yes, please describe: fragile. Media must be refrigerated.

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. CO_2 for dry ice.

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. Glacier or equivalent 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 NA

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 - to be named

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)

Barrow - NARL
divers 2 persons/day **Total 120 man days**
for 3 samplings

For preparation intransit to shipcruise
and return. 2 persons/day **Total 30 man days**

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

NARL - require laboratory facilities

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

?

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?

NOAA through NARL will have to provide vehicle and labor support for diving operations including assistance in cutting hole in ice, assistants for tending safety lines and heated hut for diving operations.

Will require wet lab and incubator space at NARL and aboard sampling vessel.

For OCSEAP use only.
RU #
Discipline
Area of Operation

COOK INLET

LOGISTICS REQUIREMENTS

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

STITUTION University of Louisville PRINCIPAL INVESTIGATOR Ronald Atlas

SHIP SUPPORT

. Delineate proposed tracks and/or sampling grids, by leg, on a chart of the area. Include a list of proposed station geographic positions. Sampling grid in Cook Inlet used on previous operations. Also samples along transect from Kodiak to Cook Inlet.

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. For shipboard sampling, water and sediment will be collected with Niskin sterile water and bottom grab sampler.

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.) Fall - Oct. - Nov./77 Spring - March 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.) 10

5. Do you consider your investigation to be the principal one for the operation thus requiring other activities to piggyback or could you piggyback? Can coordinate.

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. 1 hr 1 station, longer periods for collecting beach samples.

6. What equipment and personnel would you expect the ship to provide? Bottom grab and winch. STD costs. positional data.

7. What is the approximate weight and volume of equipment you will bring? 1000 lbs 200 cu. ft.

8. Will your data or equipment require special handling? Yes If yes, please describe: fragile media requires refrigeration.

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. CO_2 for dry ice.

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. NOAA Miller Freeman or Discoverer. Need wet lab space, incubators and stable platform.

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

NA

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 Dr. & Mrs. Tatsuo Kaneko

XVI. Outlook.

Assuming that the proposed work for FY 78 is completed according to the milestone schedule, taxonomic analyses of samples collected in the Beaufort Sea during summer 78 will remain to be completed. An additional winter sampling east of Prudhoe Bay during winter 78-79 will be desirable. Overall sampling should be seasonal. Future field efforts should fill in the gap between Cook Inlet and the Beaufort Sea by gradually extending the sampling north to the Aleutians and into the Bering Sea and south into the Chukchi Sea to the Bering Sea. These studies should continue to identify the distribution of microbial populations in potential continental shelf petroleum lease areas. Studies should include taxonomic characterization of heterotrophic, including hydrocarbon utilizing, populations. Oil biodegradation potential experiments should be conducted simultaneously in new areas of study. Sufficient replicate oiled sediment samples are being placed in the Beaufort Sea to allow for multi-year recovery and long-term analyses of persistence of petroleum hydrocarbons in Arctic marine sediments. Future experiments on the fate of petroleum should concentrate in areas of likely active development in the near future. Future equipment needs are unknown at this time. Logistic requirements should be similar to FY 78. Costs for continuation of this project in FY 79 should be at approximately the same level as proposed for FY 78.

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. At the option of the Project Office the P.I. will be 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. Data will be provided in the form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13) through NIH under interagency agreement.

5. 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.

6. 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.

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

8. 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.

9. 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."

XV. RU #: 29 PI: Ronald Atlas

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			
Complete numerical taxonomic analyses on Beaufort Sea and Cook Inlet isolates from FY 75-77 & deposit data at NIH	X																	
Ship cruise in Cook Inlet	X						X											
Quarterly report			X						X			X						
Deposit enumeration data from previous Cook Inlet cruise.			X						X									
Collect oiled sediment samples in Beaufort Sea.				X				X			X							
Complete biodegradation potential and numerical taxonomic analyses from previous Cook Inlet cruise						X						X						
Annual report						X												
Beaufort Sea cruise											X							
Deposit enumeration data from Beaufort Sea cruise												X						
Initial GC & MS analyses of petroleum residues from Beaufort Sea sediment and ice.												X						

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COMPLETION OF PETROLEUM IN MARINE TISSUE INTERCOMPARISON STUDY

Research Unit 43

Stephen N. Chesler, Ph.D.
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Willie E. May
Stephen A. Wise, Ph.D.

Trace Organic Analysis Group
Bioorganic Standards Section
Analytical Chemistry Division
National Bureau of Standards
Washington, D.C. 20234

October 1, 1977 - September 30, 1978

Technical Proposal

I. Title and Research Unit

Completion of petroleum in marine tissue intercomparison program: Renewal of Research Unit 43.

II. Principal Investigator(s)

S.N. Chesler, Ph.D.
H.S. Hertz, Ph.D.
W.E. May
S.A. Wise, Ph.D.

III. Cost of Proposal

Total 50 K

IV. Background

This work will complete the intercomparison studies conducted by the National Bureau of Standards (NBS). In FY 77 samples of Alaskan and Santa Barbara sediments were sent to participating laboratories for determination of hydrocarbon content. The results are being compiled and evaluated by NBS. Samples of homogenized Mytilus will be distributed. In FY 78 work on the Mytilus intercomparison exercise will be completed.

These exercises are being conducted to investigate the comparibility of analytical data obtained by participating laboratories.

V. Objectives

This research will complete the intercalibration exercises initiated in FY 77. Any environmental assessment of petroleum hydrocarbons in the Alaskan Continental Shelf must be accompanied by interlaboratory comparison data in order to properly assess the comparability of numbers generated by different laboratories.

VI. General Strategy and Approach

Results from the Mytilus intercomparison exercise will be collected and analyzed by NBS. Additional laboratory work on the Mytilus samples will be conducted as necessary. A report will be issued to NOAA giving the results of the intercomparison exercise.

VII. Sampling Methods

N/A

VIII. Analytical Methods

Methods for Mytilus analysis employed by NBS, will be a modification of the methods published in Technical Note #889. Copies of this Technical Note have been supplied to NOAA.

IX. Anticipated Problems

As experience in FY 76 and 77 has shown, a large percentage of OCSEAP/NOAA principal investigators do not enthusiastically or willingly support the intercomparison program, nor does the Project Office actively enforce this part of the principal investigators' contracts.

X. Deliverable Products

A. Digital data

Exempted

B. Narative Reports

The required quarterly and annual reports will be issued.

XI. Information Required from Other Investigators

We will require the analytical data obtained from the analysis of the *Mytilus* intercomparison samples.

XII. Quality Assurance Plans

Aliquots of *Mytilus* samples sent to participating laboratories will have been analyzed in replicate by NBS to assure sample homogeneity.

Instruments (LC and GC) in the laboratory are calibrated through the use of standard solutions of hydrocarbons. Mass spectrometer calibration is accomplished through the use of perfluorotributylamine (PFTBA).

XIII. Special Sample and Voucher Specimen Archival Plans

N/A

XIV. Logistics Requirements

N/A

XV. Management Plan

The project will be managed by the four P.I.'s. In addition to actual laboratory participation they will supervise the support staff and compile the quarterly reports.

1) Send homogenized *Mytilus* tissue to participating laboratories 7/77

2) NBS report to NOAA on results of second sediment intercalibration exercise 10/77

3) Return of mussel intercomparison exercise results to NBS and completion of detailed lab analysis by NBS. 11/77

4) NBS report to NOAA on results of *Mytilus* intercomparison exercise. 2/78

XVI. Outlook

All work will be completed by the end of FY 78. No further efforts are expected after the termination of the FY 78 contract.

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."

Research Unit 48

PROPOSAL
CURRENT MAPPING RADAR PROGRAM

submitted to

NOAA/ERL/Outer Continental Shelf Environmental Assessment Program

by

Donald Barrick

NOAA/ERL/Wave Propagation Laboratory
Boulder, Colorado 80302

I. CURRENT MAPPING RADAR PROGRAM

RU-48

OCT 1 1977 to SEPT 30 1978

II. PRINCIPAL INVESTIGATOR

Donald Barrick

III. COST OF PROPOSAL

Total	149,707.24

Distribution of Effort 100% Lower Cook Inlet.

IV. BACKGROUND

During FY 77, the current-mapping radar system developed under RU 48 has been undergoing field testing in the Gulf Stream off Florida. Simultaneous two-site current maps have been generated during October-December, 1976 by combining the data from two sites, one at Fort Lauderdale and other Miami. Field work for initial system calibration through direct surface current measurements made during radar operations was completed during March-April 1977.

Alaskan field testing of the current-mapping radar system have been conducted in Lower Cook Inlet for about a 6-week period during the summer of 1977. Field operations were concluded in mid-July.

These tests were successful, and we propose to operate the prototype system from additional sites in Lower Cook Inlet (probably the western side) to measure nearshore and offshore currents during the summer 1978. This effort would be co-ordinated with the physical oceanographic and meteorological studies to be conducted under Research Units 138 and 367.

V. OBJECTIVES

The objectives of this study are to produce synoptic maps of both offshore and nearshore currents in selected regions of the Lower Cook Inlet lease area. Specifically these objectives are:

1. To complete the analysis and interpretation of data collected from the eastern portion of Lower Cook Inlet during FY 77 field testing.
2. To undertake similar field studies within the western portion of Lower Cook Inlet.
3. To obtain correlations between observed currents and free drifting buoys and drogues.

4. To obtain correlations between observed currents and local meteorological disturbances.

5. To determine the spatial variability of tidal and non-tidal currents within Lower Cook Inlet.

6. To provide model input data for future studies to be conducted on Lower Cook Inlet.

VI. STRATEGY AND APPROACH

The current-mapping radar system employs two low-power portable HF radar systems whose signals from shore are Bragg-scattered from ocean waves that serve as tracers. The return signals detected by the receiving units are Doppler shifted a known amount by the waves' phase velocity. The actually observed Doppler shift will differ from that induced solely by waves in proportion to the ocean current velocity in which the wave field is embedded. Signals from each of two geographically separated radar units, scattered from the same point on the ocean surface, are used to construct a complete current vector for that point. Vectors will be constructed on a 3-km-square grid, and maps of the near-surface current field will be generated by an on-site minicomputer.

Tests to date indicate that the radar system can provide current data out to about 70 km from the coast, with an optimum spacing between paired units of 40 km. With additional use of various numerical techniques, the coverage can extend for about 120 km along a line drawn between the two radars providing the shoreline geometry is favorable.

VII. SAMPLING METHODS

With the radar data, one can make surface current estimates over an area of up to 75x75 km, depending upon the spacing between them. The resolution is approximately a 3x3 km area. In addition, sampling can be done as often as every 2 min. This frequent sampling would probably not be done. We will look at this year's Lower Cook Inlet data to determine what an optimum sampling scheme for summer of 1978 will be. This will be done by observing the time variation of current within individual range cells. From preliminary analysis of the 1977 data, sampling every 3 hours for several days may be done. How long we can obtain continuous sampling depends on the personnel available, equipment reliability, and logistic support.

VIII. ANALYTICAL METHODS

Some of the analytical methods are described in the paper by Barrick et al., 1977, others have not been documented at this time.

Since this radar technique is unique, much of the analysis will depend on the type of physical phenomenon we observe in the data. For example, in trying to obtain tidal components, we may use standard tide gauge derived Fourier components to help us determine the amplitude for some of these components. Much of this will be resolved in the analysis of the 1977 Cook Inlet data.

IX. ANTICIPATED PROBLEMS

The main problems will be associated with the logistics and safety of the personnel. We are including a summary of our anticipated logistics requirements.

X. DELIVERABLE PRODUCTS

A. Digital Data

(1) Any of the raw data from 1978 Lower Cook Inlet observations from which surface current can be obtained will be given to OCSEAP if needed. We will give the selected and interpreted data tapes to OCSEAP in whatever formats needed.

(2) We do plan to process as much data as possible for other scientific as well as OCSEAP purposes. However, there is no possibility of reducing all the data we collect. All our field data is recorded on 9 track magnetic tape, 800 BPI, NRZI, in ANSI standard file structure. We do not have the funds to reformat all of these tapes. Select 1977 Lower Cook data runs which illustrate the significant current features will be processed and put in archive formats. These will be negotiated with and approved by the contract monitor. Since much of the interest by OCSEAP is the low flow conditions, we will concentrate our efforts on the analysis of data obtained during those conditions.

B. Narrative Reports

A report will be provided describing the field operation and calibration procedures for the current-mapping radar system. The report will contain hard copies of coastal radar current maps for selected times and averaging periods.

C. Visual Data

Hard copies of radar-current maps for certain selected sampling intervals.

D. Other Data - N.A.

E. June, July Data 1977

Some will be processed, and analyzed and turned into the Project Office in the 3rd Quarterly Report. The summer 1978 data will be processed and analyzed during the winter of 1978.

XI. If any comparisons with other surface currents are to be made, they must be done by setting up a ranging system on a large boat

($\sim$ 50 ft) and drifters deployed. This may be done with support from the OCSEAP support office in conjunction with PMEL if they will be doing drifter studies in the area. Contacts have been made with the Ocean Physics Groups at PMEL (RU 138 and 367).

XII. QUALITY ASSURANCE PLANS

During the summer of 1977, the h-f radar systems were operated in Lower Cook Inlet. During part of this time, surface drifters were traced using a ship with a minimum range system. These results show good agreement between radar and drifter-derived currents and the results will be presented in a special report. Further intercomparisons of this type should be minimized, particularly if the operations are on the west side of Lower Cook Inlet where logistics will present severe problems.

1. The radar equipment will be fully tested prior to shipment to Alaska and in Alaska prior to final deployment.
2. After final testing there will be no equipment modification (except for repairs), or design changes during field operations.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMENS ARCHIVAL PLANS

N.A.

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
Surface currents	tapes & maps	2 tidal cycles	--	Yes	June & July 1977	March 1978
Surface currents	tapes & maps	2 tidal cycles	--	Yes	June & July 1977	Nov. 1978

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)

   2 flights per week - Homer, Alaska to Augustine Island Alaska for support plus possible one or two flights during the duration in case of emergency.

2. Describe types of observations to be made.

   Transportation 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)

   NA

4. How many days of flight operations are required and how many flight hours per day?
   See special logistics section for breakdown.
   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 one.

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?

   NA

8. What type of aircraft is best suited for the purpose?
   Float plane - Otter for equipment set up & possibly a helicopter.

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

   Totem Helicopter.

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

    $240 Otter - $300 Helicopter

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

    2 to 6

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

    Homer

5/20/77

G. 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)

Shuttle equipment on Augustine, See detailed logistics plan.

2. Describe types of observations to be made.

Radar surface current observations between the South West side of Augustine Island and the mainland.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

NA

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

Total flight hours?

5. How many people are required on board for each flight (exclusive of the pilot)?

2 to 3

6. What are the weights and dimensions of equipment or supplies to be transported?

2400# - 4 pieces (4x3x3) ft.

7. What type of helicopter do you recommend for your operations and why?

No recommendations.

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?

$300/hour

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

Homer

11. Will special navigation and communications be required?

Two transceivers to communicate.

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)

Please see the special section of logistics that is apended at the end of this work statement.

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?

$26.00. Based on established commercial rates. Each person would take care of all his personal requirements such as food, sleeping bags, cooking utensils. OCSEAP would provide basic shelter.

CODAR ALASKA 78

LOGISTICS

A. GENERAL

To obtain surface current data in the genral area of Cook inlet, as defined by OCSEAP Boulder on December 16, 1977, it appears necessary to occupy a site on Augustine Island and one to the south on the mainland.

For reasons of area coverage, angle of intersect, H. F. propagation and all other radar based constraints the south-eastern corner of Augustine Island is the most appropriate. [Site approximately 59° 20' North, 153° 22' West.]

Given this choice of location, the nature of the logistic support necessary can be fairly well defined and the costs reasonably well estimated.

An initial choice for the southern site would be the small headland (name unknown) approximately 10 miles to the S.W. of SHAW ISLAND.
[Site approximately 58° 52' North, 153° 15' West.] This site location provides the added benefit of some data from within KAMISHAK BAY.

However, the nature and cost of the logistic support for this site is not greatly affected by its exact location; and hence, final selection of location can be delayed.

The nature of the logistic support for the southern site is however very much influenced by the type (weight) of the accommodation chosen for equipment and personnel.

The costs for the logistics are based on an initial time frame of June 7 to July 13 from Homer, Alaska out to the field sites and return. With a week allowed each for set-up/check-out and tear-down/repacking a three week data taking span is covered. Pre and post Homer time and costs are estimated.

Processing of the data at these field sites is not considered as viable proposition; hence, it is anticipated that the existing equipment trailer will be based in Homer as a processing/logistics and communication base. To meet the time frame above, it will be necessary for the van/trailer to depart Boulder May 30 and return approximately July 22.

The bandwidth requirements for telemetry of raw data, especially for 24 hour data runs, preclude an H.F. line to Homer; and hence, the data is expected to be recorded on magnetic tape and transported to Homer by air whenever possible.

Some intersite V.H.F. telemetry transmission are however expected.

The installation/removal of the two sites are sufficiently different to warrant separate treatment. The operational and emergency requirements have some commonality.

B. AUGUSTINE ISLAND

1) Installation/Removal

The site selected can only be reached by helicopter as it is unsuitable for the landing of ships/boats and float or land planes (when transporting heavy payloads). If a large (NOAA) helicopter could be dedicated for the project this conceivably would solve the problem. However as no such guarantee exists, we must consider the use of a small helicopter carrying out ferry service from some other landing point on the island. This landing point could be that for a landing craft or float plane.

The points to be considered are weather/payload and the time/cost product.

As Augustine Island has no dangerous animal problem, suitable tents would seem to be sufficient for accommodation provided that attention is paid to secure anchoring in high winds. Thus, the payload burden is reduced. The lagoon on the western side of the island is reportedly tenable by float plane under most weather conditions. The locally available De Havilland Otter can carry 2000 + lbs. gross internal or external rack load from Homer and 800 lbs. sling load on Augustine. The small helicopter (Bell 206) can carry 650 lbs.

For the CODAR equipment, generators, communications, accommodations, food, and water requirements, three Otter loads should suffice. A fourth Otter load (installation only) will be necessary for the transportation of the seven barrels of fuel that will be required. These requirements are generators (diesel) 3 barrels. Helicopter (JP4) 3 barrels.

Back-up generator and cook stoves (unleaded gas) 1 barrel. The diesel can use helicopter JP4 if necessary but not visa/versa.

Thus, the transportation of the various equipments and supplies to the Augustine site would appear to be best completed over a two-day period with the float plane making two round trips per day and the helicopter making one round trip per day with several trips per day as shuttle on Augustine.

Four personnel on Augustine and two in Homer would seem to be the optimum number for this two-day "heavy" phase.

2) Operational Conditions

As the site can only be reached by helicopter on a regular basis, then the more routine flights need by helicopter only.

These flights are needed for:

a) personnel change

b) food and water requirements

c) data tape transportation

d) equipment reparis (transport of key personnel & parts).

Based on our best knowledge to date, we envision one scheduled flight per week and unscheduled flights averaging one flight per week. These non-heavy payload flights are expected to occupy the middle four week period of the total field program.

C. SOUTHSITE

1) Installation/Removal

The southernmost site will need light helicopter transportation from any barge or float plane landing point. However, tents are not suitable for this site due to wild animal situation. The need is for two small buildings approximately 10' x 10' x 8' each.

The choice amounts to two prefabricated metal buildings (garden sheds) or plywood and lumber huts.

Two metal buildings plus wooden bases constitute one Otter load, and two plywood buildings constitute two Otter loads. The wooden buildings are preferred due to better insulation, greater strength and shorter erection time. As other requirements for equipment and fuel are similar to Augustine, this raises the number of Otter loads to a total of six for this site. For this size payload, a landing barge would appear to be about $600 cheaper (1 day round trip plus one day unload versus 7.5 hours of Otter time).

However, the advantages of flexibility with weather conditions are given up. The float plane can operate at short notice and can take advantage of the various lakes in the region, whereas the barge may very well have to seek shelter for one or two days.

It is felt that the cost differential in favor of the barge is not warranted in view of its relative inflexibility.

For the first two days of the "heavy" installation, the same four persons at site with two at Homer would seem appropriate. For the remainder of the operation, we anticipate a reduction to three.

2) Operations

This station is expected to be serviceable by both helicopters or float plane and Zodiac.

Obviously, the helicopter which is essential for Augustine could complete the triangle and service both sites. However, for those flights that are to the southern site only, the smaller float plane (Beaver) is more economic (under half cost) than the helicopter and can carry nearly twice the payload.

Extended helicopter flights over water tend to cause greater concern for safety than fixed wind aircraft.

Additionally, it is not completely out of the question to air drop spare parts to Augustine via the small float plane and on certain days when weather permits it is possible that a float plane could land near the Augustine site.

Hence, we propose to combine the operations budgets for Augustine and Southsite by maintaining the scheduled once per week flight (two sites) by helicopter and deleting two of the unscheduled helicopter flights and substituting four small (Beaver) float plane flights. A Zodiac or similar boat is however considered a very probable requirement at the south site.

D. EMERGENCY CONSIDERATIONS

We need to consider at least three possible forms of emergency

a) personnel at either site becoming seriously sick or injured such that they require immediate hospitalization.

b) circumstances within the family of personnel that require the immediate return of personnel to the mainland.

c) the small but finite probability of the need to evacuate Augustine Island due to volcanic activity.

The probability of an emergency arising is low but cannot be ignored.

One emergency helicopter flight is included in the budget. However, we should not limit ourselves to the availability or response time of the commercial helicopters. Coast guard and other NOAA units are of course possibilities. However, we feel a need to have at least some internal fall back position. On Augustine Island it would take a three to eight mile hike over rough terrain to reach a reliable float plane landing area. For a seriously injured man this is out of the question.

The south site will probably need a rubber craft for routine work. Hence we propose this be upgraded to approximately 18 feet and equipped with two motors (40 HP each) together with emergency equipment. Both boats should have 300 feet of anchor line and anchor.

E. USE OF LAND

We prefer the Juneau Project Office to handle the permission to occupy any sites. Clearance for a possible alternative site on Cape Douglas 58° 52' North, 153° 16' West should also be sought. The locations we believe to be inside a National Monument area.

F. COMMUNICATIONS

Site to site (VHF) and site to Homer (HF) communication equipment is on hand and adequate. Additionally, the H.F. equipment has the capability to communicate with the float planes and the public telephone system. Authorization for frequency usage is the only potential limitation and this will be researched through the appropriate offices in Boulder. The

H.F. equipment has the capability to operate off of batteries and these will be installed for emergency purposes. However, the helicopters do not carry H.F. comm. They use VHF F.M. (Marine) and VHF AM (Air).

As considerable helicopter work is anticipated, a VHF FM (Marine Band) transceiver should be obtained for each site with channels compatible with the helicopter.

G. TELEMETRY

This is previously referenced.

A limited amount of telemetry is possible between sites as required. VHF transmissions to Homer cannot be guaranteed and H.F. bandwidth allocations are too narrow for usable data rates.

H. ZODIAC BOATS

The requirement is now for two boats and 3 meters. The most economic approach is for OCSEAP to supply these from sources in Alaska. The one barrel (55 gals. per site) of gasoline intended for back-up generator/cook stoves should cover the fuel requirement.

REFRIGERATION

With the anticipated frequency of aircraft communication to Homer, ice chests are practicable, thus avoiding propane fuel problems.

The commercially produced 2" wall styrofoam boxes when covered with an additional 2" layer of styrofoam can maintain ice from 5 to 7 days.

With two boxes located at each site and a third used for transhipment of fresh ice and groceries, individual food preferences can be easily handled.

GENERATORS

The 5 kw generators that OCSEAP has available have adequate capacity and are most welcome. The reliability and lower fuel consumption compared to gasoline are desirable factors. However as only two are available (one per site), we will provide our existing 2.5 kw gasoline units as back-up. OCSEAP should provide spare parts and service manuals for the diesel generators.

ACCOMMODATIONS AND CAMPING EQUIPMENT

We anticipate that the NOAA facility at Elmendorf Air Force Base can provide a considerable portion of the camp gear requirements.

Sleeping bags, sheets, folding tables, cooking utensils, water containers, lanterns, shovels, axes, power cables and rope represent some of the requirements.

We propose the purchase of two suitable tents (with wooden floors) for the Augustine site and the local manufacture of two collapsable plywood huts. These huts can be made ahead of time in Homer and the local contractor can dimension the various pieces to fit inside the Otter float plane.

The diesel generators have enough reserve capacity for small electric heaters and hot plates.

OTHER INFORMATION

A. Dr. Donald Barrick is Chief of the Sea State Stuides group at the NOAA Wave Propagation Laboratory. His qualifications are on file in an earlier proposal with OCSEAP.

B. Other overlapping activities. None

C. The P.I. will actively lead the proposed work and will take full responsibility for the completion of all objectives. His salary is committed from NOAA and he will spend the equivalent of 25 percent of his time on the project.

D. Personnel. These are the same people listed on last year's proposal. OCSEAP has their resumes on file.

E. Other relevant information. None.

F. Other persons authorized to conduct negotiations. None.

CODAR ALASKA 78

Tentative SCHEDULE

May 30 (Tues.)	Van/Trailer depart Boulder for Tacoma. Persons A & B
May 31	------------------------------
June 1	Crate other equipment for air freight. Persons C & D
June 2	Van/Trailer arrive Tacoma by mid-afternoon. Deliver vehicles to Totem Ocean trailer express. (A & B) shipping dept. (Boulder) Pick up air freight crates (C & D assist). A & B pick-up any PMEL supplied items (VHF marine radios etc.).
June 3	A & B shop Seattle for any camping items needed by project & personnel.
June 4	------------------------------
June 5	Shipping Dept. air freight Denver to Anchorage. A & B depart Seattle for Anchorage. C & D depart Boulder (Denver) for Anchorage (direct). A & B or C & D receive G.S.A. or rented pick-up truck.
June 6	A, B, C, & D select items from NOAA warehouse at Elmendorf A.F.B. Load pick-up truck. Other Anchorage shopping as necessary.
June 7	A & B receive Van/Trailer from Totem Ocean Depart Anchorage for Homer. C & D receive air freight at Anchorage Airport. Depart Anchorage for Homer. E & F depart Boulder (overnight Anchorage).

June 8	E & F Homer (air) A, B, C. D, E, & F uncrate equipment. Unload trailer of iste gear. Receive pre-fab wooden huts. Stage loads for Otter float plane in co-operation with Kachemak Air Services. (Staging area Alaska Fish & Game facility?) Time will be allocated to check out in Alaska and this may slip.
June 9 June 10 June 11 June 12	<u>Site Flights</u> Augustine Island - 4 Otter trips (over 4 days) South site 6 Otter trips Helicopter one round trip per day with many hops at sites. A, C, D, & F in Field B & E at Homer. Follow Kachemak air advice due weather concerning sequence (however Augustine Island is suggested first). On last flights, leave A & F at Augustine B, C, & D at South site. One hut erected at South site. One or both tents at Augustine. G arrive Homer.
June 13 June 14	Equipment hook up both sites 2nd hut at South site Trailer installed at Homer (power, radio antennas, telephone etc.) Test & debug as far as possible H & I arrive Homer.
June 15 (evening)	Target Date for Data taking - 1st schedule operations flight. A & B return Homer for R&R. H. to South site - I to Augustine
June 16	1st data tapes to Homer
June 17	Make 1st cut at personnel rotation schedule
June 18	1st Data week
June 19	
June 20	2nd scheduled flight
June 21	
June 22	Helicopter to both sites
June 23	2nd Data week
June 24	
June 25	
June 26	
June 27	
June 28	3rd scheduled flight - helo to both sites
June 29	

June 30	
July 1	3rd data week
July 2	
July 3	4th Scheduled flight. Helo. to both sites
July 4	
July 5	Decision time re: further OPS
July 6	
July 7	
July 8	
July 9	Site removal
July 10	
July 11	Repack (Homer).
July 12	
July 13	Return to Anchorage
July 14	Van/Trailer to Totem.
July 15	Two persons to Seattle - Other to Boulder
July 16	
July 17	
July 18	Van/Trailer unload from freighter (Tacoma).
July 19	
July 20	
July 21	
July 22	Van/Trailer arrive in Boulder

Within the operations (data) period
June 15 → July 6 two additional unscheduled helicopter flights and four unscheduled Beaver float plane flights -- plus one emergency helicopter or float plane flight are proposed.

XV. MANAGEMENT PLAN

Some of the data taken during the June-July 1977 period will be analyzed and interpreted. Any improvements to the radar system will be checked out in Boulder, Colorado prior to deployment in the field. The deployment will begin on or about June 1, 1978 in the western part of Lower Cook Inlet with data taking beginning around June 15, 1978. During the period of June 15, 1978 to July 15, 1978, we will take radar data and also coordinate with the drifter study being undertaken by the PMEL group.

After the measurement program is completed (around July 15, 1978), the radars will be shipped back to Boulder, Colorado.

XVI OUTLOOK

1. Nature of final results and data products. Surface current data processing an analysis for the summer 1978 field trip will be done fiscal year 1979. The output will be similar to those listed in X.A, X.B, X.C. of this proposal.

2. Significant Milestones. The analysis of surface current data obtained in the western part of Lower Cook Inlet and further measurements in other BLM lease areas.

3. Cost by Fiscal Year. This will depend on where the next area is and the amount of data processing. Probably on the order of \$200 to \$250 K.

4. No major equipment purchases anticipated.

5. Location of Future Field Efforts. Wherever it is jointly suitable by OCSEAP and WPL.

6. About the same logistics requirements as FY 78.

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 Program Office the PI is prepared to travel to the Program 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 Program 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 Program 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 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. 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 #: 48 PI: Donald Barrick

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
Analysis of the 1977 Cook Inlet Data						Δ		Δ							
Equipment modification completed							Δ								
Shipping and set up of radars in W.L.C.									Δ						
Data Taking									Δ	Δ					
Return of equipment to Boulder.										Δ					

△ Planned Completion Date ▲ Actual Completion Date

Barrick, D. E., Evans, M. W., and Weber, B. L., 1977, Ocean surface currents mapped by radar, Science, 198, p 138.

Proposal for extension of funding
of Gulf of Alaska Research Unit - 59
"Coastal Morphology, Sedimentation and Oil Spill Vulnerability"

Principal Investigator: Miles O. Hayes, Director
Coastal Research Division
Department of Geology
University of South Carolina
Columbia, S. C. 29208

Task D-4: Evaluate present rates of change in coastal morphology with particular emphasis on rates and patterns of man-induced changes; locate areas where coastal morphology is likely to be changed by man's activities; and evaluate the effect of the changes, if any. The relative susceptibility of different coastal areas will be evaluated.

Study 1: Oil spill vulnerability of the coast of Kodiak Island, Alaska. Cost: $30,000

Study 2: Effects of ice processes on the morphology and sediments and potential oil spill impacts of the shoreline of Kotzebue Sound, Alaska. Cost: $30,000.

Total cost: $60,000

Study 3: Completion of oil spill vulnerability study of the Beaufort Sea coast.

Donald T. Secor
Donald T. Secor
Chairman, Geology Department

B A Daetwyler
B. A. Daetwyler
Vice President, Finance

TECHNICAL PROPOSAL

I. Coastal Morphology, Sedimentation and Oil Spill Vulnerability

Research Unit #59
Contract #03-5-022-82
1 October 1977 - 1 October 1978

II. Principal Investigator - Miles O. Hayes

III. Cost of Proposal:

A. Science: $60,000
B. Field support provided by Juneau office for Kotzebue and Kodiak studies.
C. Distribution:

Kodiak Island - $30,000
Kotzebue Sound - $30,000
Beaufort Sea - (logistics provided by Arctic Office)

IV. Background: In all areas, an Oil Spill Vulnerability Classification will be applied to the shoreline environments. The classification is explained below.

A PROPOSED ENVIRONMENTAL VULNERABILITY CLASSIFICATION

On the basis of two case studies and careful review of the literature, a scale of environmental vulnerability to oil spill impacts has been derived. This scale relates primarily to the longevity of oil in each environment. The subtleties of chemical weathering of the oil within each environment have not yet been studied in enough detail to be incorporated into the vulnerability scale. Preliminary studies have concluded that chemical weathering processes are more active on high energy coasts than on low energy coasts, although the details of this environmental classification are rather obscure. Also, although biodegradation rates are thought to be slower in cold temperature, little documentation exists to verify that notion.

Coastal environments are listed and discussed below in order of increasing vulnerability in case of oil spills:

1. Straight, rocky headlands:

Most areas of this type are exposed to maximum wave energy. Waves reflect off the rocky scarps with great force, readily dispersing the oil. In fact, waves reflecting off the scarps at high tide tend to generate a surficial return flow that keeps the oil off the rocks (Urquiola spill, Spain).

2. Eroding wave-cut platforms:

   These areas are also swept clean by wave erosion. All the areas of this type at the Metula spill site (Chile) had been cleaned of oil after one year. The rate of removal of the oil would be a function of the wave climate. In general, no clean-up procedures are needed for this type of coast.

3. Flat, fine-grained sandy beaches:

   Beaches of this type are generally flat and hard-packed. Oil that is emplaced on such beaches will not penetrate the fine sand. Instead, it usually forms a thin layer on the surface that can readily be scraped off by a motorized elevated scraper or some other type of road machinery. Furthermore, these types of beaches change slowly, so burial of oil by new deposition would take place at a slow rate.

4. Steeper, medium-to-coarse-grained sandy beaches:

   On these beaches, the depth of penetration would be greater than for the fine-grained beaches (though still only a few centimeters), and rates of burial of the oil would be greatly increased. Based on earlier studies by our group in numerous localities, it is possible for oil to be buried as much as 50-100 cm within a period of a few days on beaches of this class. In this type of situation, removal of the oil becomes a serious problem, inasmuch as it would be necessary to destroy the beach in order to remove the oil. Another problem is that burial of the oil preserves it for release at a later date when the beach erodes as part of the natural beach cycle, thus assuring long-term pollution of the environment.

5. Impermeable muddy tidal flats (exposed to winds and currents):

   One of the major surprises of the study of the Metula site (Chile) was the discovery that oil did not readily stick to the surfaces of mud flats. Also, penetration into the sediments was essentially non-existent. Therefore, if an oiled tidal flat is subject to winds and some currents, the oil will tend to be eventually removed, although not at the rapid rate encountered on exposed beaches.

6. Mixed sand and gravel beaches:

   On beaches of this type, the oil may penetrate several centimeters, and rates of burial are quite high (a few days in Spain). The longevity of the oil at the *Metula* site, particularly on the low-tide terraces and berm top areas, attests to the high susceptibility of these beaches to long-term spill damage.

7. Gravel beaches:

   Pure gravel beaches have large penetration depths (up to 45 cm in Spain). Furthermore, rapid burial is also possible. A heavily-oiled gravel beach would be impossible to clean up without completely removing the gravel.

8. Sheltered rocky headlands:

   Our experience in Spain indicates that oil tends to stick to rough rocky surfaces. In the absence of abrasion of wave action, oil could remain on such areas for years, with only chemical and biological processes left to degrade it.

9. Protected estuarine tidal flats:

   Once oil reaches a backwater, protected, estuarine tidal flat, chemical and biogenic processes must degrade the oil if it is to be removed.

10. Protected estuarine salt marshes:

    In sheltered estuaries, oil from a spill may have long-term deleterious effects. We observed oil from the *Metula* on the salt marshes of East Estuary, on the south shore of the Strait of Magellan, that had shown essentially no change in 1½ years. We predict a life span of at least 10 years for that oil.

These concepts have been applied to the Northern Gulf of Alaska (Final Report in press) and to lower Cook Inlet in our study for the Alaskan Dept. of Fish and Game.

The Coastal Research Division of the Department of Geology has been studying numerous oil spills in coastal environments for the past several years. These studies include the following:

List of Spills Studied

Carrier	Location	Amount & Type of Product	Kms of beach Affected	Dates of OSAT Field Study
Metula	Strait of Magellan	51,000 tons spilled 40,000 tons deposited on beaches (Saudi Arabian crude)	225 km	12-20 Aug. '75 Jan-Mar. '76 Aug. '76 (still active_
Urquiola	La Coruna, Spain	90,000 tons spilled 25-30,000 tons on beaches (Arabian crude)	125 km	17 May-20 June 1976 (still active)
Jakob Maersk	Porto, Portugal	80,000 tons spilled 20,000 on beaches (Arabian crude)	40 km	6-9 June '76
Bouchard #65	Buzzards Bay, Mass.	81,000 gals #2 fuel oil	5-10 km	30 Jan-2 Feb. '77 17-18 June, '77
Ethyl H.	Hudson River, New York	420,000 gals #6 residual fuel oil	Sporadic shoreline contact	6-7 Feb. '77

As a result of these studies, funded by various Federal agencies and a number of advanced graduate level seminars, the personnel involved have developed an oil spill assessment team (OSAT). This group is presently very active publishing results and continuing studies as new spills occur. The personnel involved with the summer 1976 field session in the Kotzebue Sound-Chukchi Sea area, M. O. Hayes, C. H. Ruby, and L. G. Ward, are all members of OSAT. These members, plus possible additional field personnel, will participate in the 1978 field work and analysis.

With this in mind, the primary emphasis of this year's field work in Kotzebue Sound and the Beaufort Sea will be to more precisely define the effects of oil spills within arctic environments. These arctic environments are very poorly understood; however, the greatly increased development of these areas with regard to petroleum exploration makes them likely areas for potential oil spills. Our studies in the ice-filled Hudson River (Ethyl H. spill, see above) and frozen Buzzards Day (Bouchard, #65 spill, see above) provided considerable insight into the processes and cleanup difficulties characteristic of these environs. As a result of these studies, we feel that we are now in a much more informed position to analyze the arctic environment with regard to potential oil spill impacts.

Objectives:

For Kodiak Island:

1. Collect field data on the intertidal sedimentary environments of Kodiak Island. This would include measurements on the morphology, grain size, sedimentation rates, beach slope, vegetational characteristics, wave energies and longshore currents.
2. These data would be combined in an atlas format to produce maps of oil spill vulnerability of this entire coastal zone.

For Kotzebue Sound:

1. Collect field data on the intertidal sedimentary environments of Kotzebue Sound. This would include measurements on the morphology, grain size, sedimentation rates, beach slope, vegetational characteristics, wave energies and longshore currents.
2. These data would be combined in an atlas format to produce maps of oil spill vulnerability of this entire coastal zone.
3. The interaction of ice and potential oil spills within Kotzebue Sound will be detailed, especially the "release pathways" for trapped oil during breakup.

For Beaufort Sea coast:

1. Complete work on a 100 km section just east of Pt. Barrow. Work plan is the same as that proposed for Kodiak Island.

Strategy, Approach and Sampling Techniques

Zonal method

For the proposed general appraisal of the shoreline of Kodiak Island and Kotzebue Sound, we would utilize the zonal method developed over the past few years by Hayes and associates of the Coastal Research Division at the University of South Carolina (Hayes *et al*. 1973).[1]

Very briefly, the zonal method consists of the following essential steps:

1. After the selection of a single, large physiographic unit as the study area (e.g. Kodiak Island coast), extensive studies of aerial photographs, maps and charts precedes the field work.
2. Field work begins by aerial reconnaissance of the entire area during which the shoreline is photographed in detail.
3. Based upon observations during the aerial reconnaissance, a station interval is selected. Stations will be located approximately every 10 km along a straight-line shoreline configuration on 1:250,000 topographic maps.
4. Approximately ten stations, representative of the various types of coastal morphology identified during the reconnaissance would be selected for detailed study.

At each detailed study site (zonal station), the following studies would be carried out:

a. Construction of a three-dimensional block diagram of the shore zone by measuring two or more intertidal beach profiles.
b. Estimation of grain size and composition at regular intervals along one of the profile lines.
c. Detailed topographic surveys and statistical studies of features within the zone, both on the ground and from the air.
d. Detailed sketches of the zone. These are important becaue they force the observer to carefully inspect all aspects of the morphology and sediments within the zone.

Biological Considerations

Biological field studies would not be performed as part of the project. In recognizing the importance of the faunal communities in any oil spill vulnerability classification, however, we would incorporate published and unpublished data on

[1]Hayes, Miles O., Owens, E. H., Hubbard, D. K., and Abele, R. W., 1973, The investigation of form and processes in the coastal zone: in Coates, D. R., ed., Coastal Geomorphology, Pubs. in Geomorphology, Binghamton, N. Y., p. 11-41.

coastal biota. On the basis of these pre-existing data, a biological susceptibility scheme would be superimposed on the residence time vulnerability classification derived from sedimentological studies.

Process Measurements

Oil spill vulnerability is, to a large extent, a function of physical process intensity, e.g. wave action and tidal range. Process variability within the study area would be assessed by (1) the morphologic response to processes, e.g. storm-tide lines, the degree of beach and berm development, etc., (2) hindcasting of storm wave energies, (3) direct measurements of wave heights, wave angles and longshore current velocities at the zonal sites, and (4) a thorough review of existing literature.

Freeze-up Studies in Kotzebue Sound

A field study period will be initiated during freeze-up in Kotzebue Sound. This study will include the following:

A. Detailed analysis of the development of shore fast ice within different environments:

1. Cuspate foreland (Point Hope area)
2. Rock headlands (Cape Thompson)
3. Microtidal barrier islands (Cape Prince of Wales to Cape Espenberg)
4. Retreating tundra cliffs (numerous throughout the study area).
5. Deltas (Kobuk, Noatak and Buckland River deltas).
6. Narrow barriers confining lagoons (Cape Thompson to Sheshalik Spit).

B. The field program at these study sites will include:

1. Attempt to land at each sub-environment to study ice features characteristic of that site.
2. Measurements of ice thickness and variability.
3. Mode of ice attachment to the shore.
4. Sediment interaction, both marine and aeolian.
5. Trenching of the beach face.
6. Back beach effects.
7. Profiles of the beach and the ice (permanent profiles were emplaced during the summer 1976 field season).
8. Complete photography of the area.

C. Re-profiling of selected permanent profiles established during summer 1976.

D. Correlation of ice movement within Kotzebue Sound with active process parameters (tides, winds and river runoff).

Analytical Methods

All sediment samples will be analyzed for grain size by sieving or with a settling tube. These data will be synthesized by computer and analyzed to determine grain size trends along the shorelines of Kotzebue Sound and Kodiak Island. All relevant vertical aerial photographs from available sources will be analyzed to determine:

1. Long term shoreline changes, especially any wave-induced changes.
2. Typical ice break-up patterns and dispersal trends (Kotzebue Sound).

Problems (see Logistics section)

Deliverable Products

A. Digital data:

Magnetic tapes of all sediment grain size analyses for both areas.

Magnetic tapes of all beach profiles measured. Our current computer programs are already designed to meet OCSEAP requirements.

B. Narrative Reports:

We anticipate a number of publications related to this project, in addition to quarterly and annual reports.

C. Visual data:

Maps will be constructed as follows:

1. Beach morphology maps of both areas.
2. Application of our Oil Spill Vulnerability Index to the morphological base map.
3. Map of ice breakup patterns.

D. Other non-digital data - None

E. Data submission schedule: All data collection will be done during June - August and October - November 1978. Data will be submitted in quarterly reports. Expected final report date - April 1979. Digital data will be submitted with the quarterly report for December 1978.

Information from other investigators None

Quality Assurance Plans

All sediment samples are splitprior to analysis and stored within the Department of Geology at the University of South Carolina.

Logistics Requirements

Most of the work could be done with a Cessna 182 float plane, Cessna 180 fixed wing aircraft or helicopter procured by NOAA from local flying services in Kotzebue Sound and on Kodiak Island. A crew of three people plus pilot could do the data collection needed for the oil spill vulnerability map in about 3 or 4 weeks of working time. A detailed field schedule is attached.

The Kodiak Island work (June 19 - July 16) will require a helicopter, full time. Stations will be set up at 10 and 15 km intervals along the shoreline. Kodiak will be our base for these studies.

The Kotzebue Sound work (July 17 - August 7) will require a Cessna 180 aircraft. We suggest Kenai Air Service, Box 3921, Kenai, Alaska. We have worked with this firm before with excellent results. We require 4 hours of flight time per day for the Kotzebue Sound work. Our bases will be Kotzebue and Shishmaref.

The Beaufort coast work will take 7 days (Aug. 8 - Aug. 15). We will require a float plane or helicopter full time for this week. The NARL will be our base for that work.

Finally, during the freeze-up studies in the fall (approx. Oct. 20 - Nov. 14), we will require a helicopter, full time. About 4 hours of actual flight time per day will be needed.

Management Plans

All aspects of the project will be managed directly by the principal investigator. Field crews will consist of qualified graduate students using these projects for M.S. or Ph.D. problems.

Outlook

It is our desire to continue our regional studies of coastal morphology and sedimentation in all critical areas of the Alaskan coast. In particular, we would like to continue determining the relative vulnerability to oil spill impacts of the various coastal environments present.

In view of the present status of lease sales and potential offshore exploration, we feel that the following areas should be studied during FY-79:

1. The south shore of the Kenai Peninsula and Montague Island.

2. The southern coast of the Alaska Peninsula between Cape Douglas and the Shumagin Islands.

The two areas would be studied for approximately the same funding level as the FY-78 budget ($60,000).

Publication and Data Processing Schedule

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 24-13) 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.

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)

See section on Logistics. Flight lines are highly variable and difficult to predict (Maps are enclosed).

2. Describe types of observations to be made.

Aerial reconnaissance of shoreline. Detailed photography. Transport to sample sites.

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)

We require a Cessna 180, helicopter or float plane full time for the duration of the field work. June 19 - Aug. 21, 1978. See section on Logistics.

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

64 flight days @ 4 hours/day

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? Given our unpredictable schedule, piggybacking is considered impossible.

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?

Cameras (60 lbs) Profiling equipment (30 lbs)

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

Cessna 180, helicopter, float plane; see Logistics for details.

9. Do you recommend a source for the aircraft?

If "yes" please name the source and the reason for your recommendation.

Kenai Air Service (for Kotzebue work) See Logistics section

NOAA helicopter (for Kodiak & Beaufort work)

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

approx. $100/hr.

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

3

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

Kotzebue, Kodiak and Barrow

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)

See B1

2. Describe types of observations to be made.

See B2

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

See B3

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

for Kodiak 28 days (4 hrs/day)

for Beaufort 14 days (4 hrs/day)

Total flight hours?

5. How many people are required on board for each flight (exclusive of the pilot)?

3

6. What are the weights and dimensions of equipment or supplies to be transported?

Approx. 100 lbs. (cameras and profile rods, approx. 150 cm long)

7. What type of helicopter do you recommend for your operations and why?

No preference

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?

Unknown

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

Kotzebue, Kodiak and Barrow

11. Will special navigation and communications be required?

No

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)

   Quarters and subsistance for 4 persons on Kodiak Island from June 19 to July 17 '78 Total man days - 112

   Quarters and subsistance for 4 persons in Kotzebue from July 16 to august 17 '78. Total man days 84

   Quarters and subsistance for 3 persons in Barrow from August 8 - August 22 '78. Total man days 42

   Quarters and subsistence in Kotzebue for 2 persons from Oct. 21 - Nov. 14, '78. Total man days 63

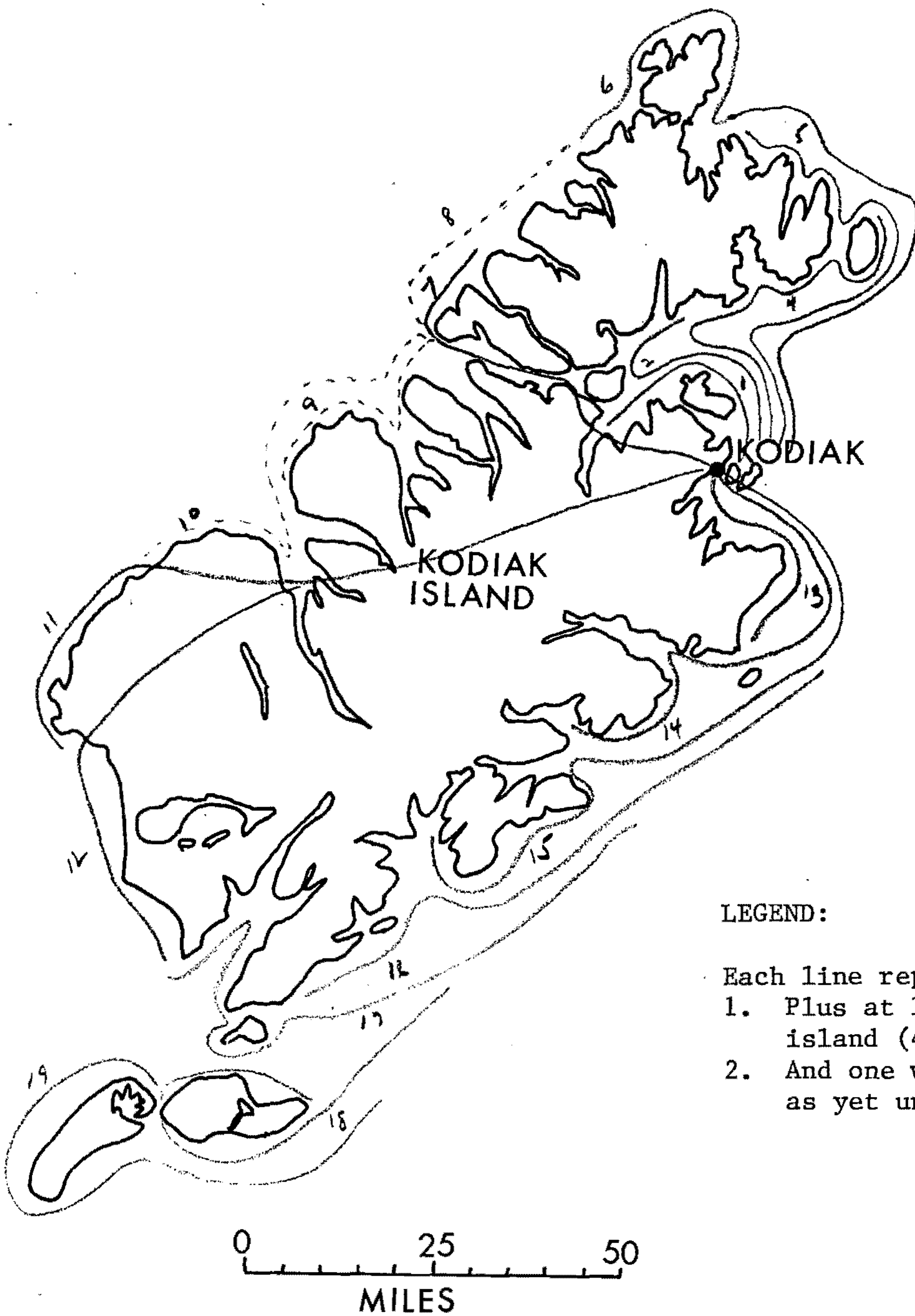
2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation.

   None

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

   Unknown

   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?



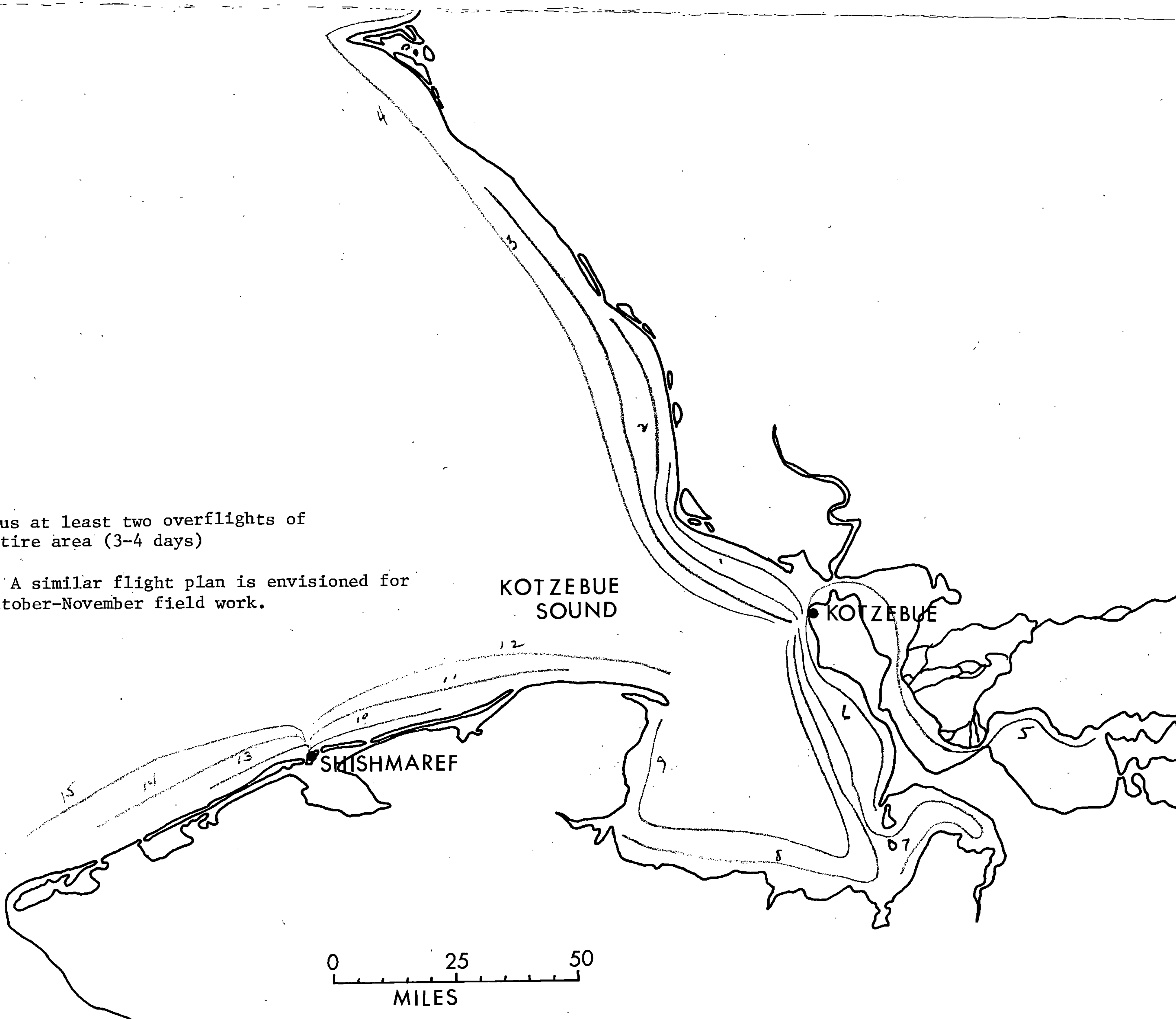
LEGEND:

Each line represents one day flight line.

1. Plus at least 2 overflights of entire island (4 days).
2. And one week of work in special areas, as yet undetermined.

1. Plus at least two overflights of entire area (3-4 days)

Note: A similar flight plan is envisioned for the October-November field work.



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 (Mo/Yr to Mo/Yr)	Submission (Mo/Yr)
Sediment samples	1 tape	300	073	Yes	6/78 to 7/78	12/78
Beach profiles	1 tape	200	09	Yes	6/78 to 10/78	12/78

MILESTONE CHART

RU #: 59　　　PI: Miles O. Hayes

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			
Kodiak field work - June 19 - July 16									X	X								
Kotzebue Sound field work - July 16 - Aug. 7										X	X							
Barrow field work - Aug. 8 - Aug. 22											X							
Kotzebue field work Oct. 21 - Nov. 14													X	X				
Dec. 78 Analysis and submission of sediment-sample grain data															X			
Analysis and submission of beahc profile data - Dec. 78															X			
Final report - April 1979																		

BASELINE CHARACTERIZATION OF MARINE MAMMALS IN THE BERING SEA

Research Unit 67

Principal Investigators

Howard W. Braham

David J. Rugh

Contract Period

1 October 1977 - 30 September 1978

Marine Mammal Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic & Atmospheric Administration
7600 Sand Point Way, N.E.
Seattle, Washington 98115

26 October 1977

Marine Mammals of the Bering Sea
Research Unit 67
R7120804
Contract period 1 October 1977 to 30 September 1978

Principal Investigator: Howard W. Braham, PhD
Principal Investigator: David J. Rugh

Cost:

C. Total 36.9 K

Background:

A. Eastern Aleutian Islands pinniped study. With the exception of the northern fur seal (*Callorhinus ursinus*), the northern sea lion (*Eumetopias jubatus*) and harbor seal (*Phoca vitulina richardii*) are the most abundant, and the most dependent species of marine mammal on resources (i.e. food and space) of the eastern Aleutian Islands. Quantification of the population biology of these species is continuing (see RU 67 1976-77 Annual Report), but to achieve the kind of understanding necessary for management decisions relevant to the potential impact of oil and gas exploration, precise estimates of abundance and related biological factors (seasonal movements, habitat dependence, trophic relationships, etc.) must be made.

Three field seasons (1975-77) have been completed on this study. At the present time we have good data for some rookeries and hauling grounds for *Eumetopias* during the breeding season (June-August), but very little data exist for the other seasons. The same is true for *Phoca*. The most important data gap still present, however, has to do with precision with regard to the ways in which sighting data are collected. Most data are obtained during aerial surveys. Previous studies have shown that a large percentage of the animals surveyed are missed. Such factors as animals "hiding", animals out of view of the camera, or poor estimates made by observers contribute to an underestimate of the animals present (Pennycuick and Western, 1972; Caughley, 1974; Norton-Griffiths, 1976). The accuracy and precision of the Aleutian Islands pinniped study must be determined if reliable estimates of abundance are to be obtained for use in population analyses. Future sampling during the monitoring phase of OCSEAP requires that we have a best estimate of the variation due to survey methodology. During the 1977 field season we conducted a preliminary study of ground truth census reliability by having ground crew members count sea lions while an aerial survey team made photographic and visual estimates. This was the first comprehensive testing program ever accomplished on pinnipeds. The results look encouraging (i.e. our aerial estimates are proving to be reliable when compared to most land counts); however, the 1977 work was preliminary.

B. Ice seal study. Distribution and abundance data on ice seals (bearded seal, *Erignathus barbatus*; larga seal, *Phoca largha*; ringed seal, *Phoca hispida*; and ribbon seal, *Phoca fasciata*) have been independently collected by three investigators (Mr. John Burns, OCSEAP RU's 230 and 231; Dr. Genadi Fedoseev, USSR; and us, RU 67) over the past two years (FY 76-77). These data require statistical synthesis. All of the species listed above breed and feed in at least three oil lease areas (Bristol Bay, St. George and Norton basins), and thus critical periods of their annual cycle (March-June) need to be clarified. Analysis of the combined data will provide a single source for comparing seasonal distribution and abundance in the Bering Sea. Data from Dr. Fedoseev and Mr. Burns are being reviewed for clarity and format compatibility. Because of the variation in the way each data unit was collected (i.e. procedures were not standardized), several months will be required before a workable union of the data will occur. We expect that it will take two persons full time during FY78 to complete an analysis of these data.

C. Cetacean study. Other than opportunistic pelagic sightings, very little data has been collected on the 17 species of cetaceans known to occur in the Bering Sea. Many larger cetaceans, such as the California gray whale (*Eschrichtius robustus*), migrate to the Bering and Chukchi Seas in summer to feed in the porductive shallow waters. The gray whale is believed to feed almost exclusively in the northern seas during the summer and to fast the remainder of the year. Since this large baleen whale feeds on small organisms low in the trophic scheme and does so within one-half mile of the shore during migration, it is potentially sensitive to perturbations in the food web such as would occur during a major oil spill. Consequently, it is important to assess and identify areas where these animals are most vulnerable to oil development activities (e.g. drilling and tanker traffic).

A study on gray whales will not only further the baseline characterization of cetaceans, but will lead to a better understanding of the trophic dynamics of the Bering Sea. During 1976 and 1977 we determined that this species should be more intensively studied because of its 1) close proximity to land during migration and feeding; 2) dependence upon shallow biologically productive waters during migration; 3) migration through six (6) oil lease areas, where presumably most of the entire population can be found from April through October; and 4) status as an endangered species per the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Additional field work is required to identify the timing and movement of migration, dependence on feeding areas, and population parameters such as seasonal abundance.

Objectives:

A. Eastern Aleutian Islands pinniped study.

1. To summarize existing data on the population distribution and abundance of *Eumetopias jubatus* and *Phoca vitulina richardii* from the north side of the Alaska peninsula and the Fox Islands (eastern Aleutian Islands).

2. To itemize future research needs and develop these within an efficient study scheme.

B. Ice seal study.

1. To obtain sighting data collected on ice seals from OCSEAP contracted and non-contracted groups, and to evaluate these data with regard to seasonal distribution and abundance.

2. To identify migration patterns, potential "critical" habitats or times of the year for each species, and potential breeding locations.

3. To complete a final report for this study covering the population biology of ice inhabiting phocid seals.

C. Cetacean study.

1. To summarize the scientific knowledge dealing with distribution and abundance of whales in the Bering Sea.

2. Information will be supplied regarding gray whales, and a justification for continued research outlined.

D. General.

1. To catalogue and computerize all sighting records from aerial and land surveys collected since 1975 and submit data to EDS for archiving.

2. As with RU 68 and RU 69, a complete processing of data is needed, including computer programming, data documentation, quality control analysis (i.e. checking and editing), statistical analysis, interpretation and write-up.

General Strategy and Approach:

The principal objective of the eastern Aleutian Island study for FY78 will be to clarify the population biology of the northern sea lion and the land-breeding harbor seal. The approach, then, will be to summarize our data and to integrate them with the literature, making a comprehensive overview of these species in the study area. Two important findings have already been made — to be detailed at the conclusion of the FY78 contract period. Briefly, they are 1) a 40-50% decline in northern sea lions in the study area since 1956; and 2) a variation in harbor seal data which indicates that land-based studies are essential if a more reliable assessment of abundance is to be made.

Some of the data collected since 1975 have not been finalized for computer processing. It will take several more months before analysis can take place because of the large volume of data in our entire program (4 RU's and 6 projects). A more detailed look at the kinds of things we must do involving data management and time and personnel needs is outlined later.

Analysis of ice seal data will be accomplished principally through computer analysis and graphic display. Graphic display will allow discussion of the qualitative aspects of the spatial and temporal arrangements of individuals and species by grouping. This kind of "analysis" will be vital to the more limiting statistical treatment of the data. Population abundance estimates via computer analysis will be standardized. Data collected by Dr. Genadi Fedoseev and Mr. John Burns will be included where appropriate (with the Investigators' approval).

Summarization of the cetacean data, in particular California gray whale data, will be accomplished as outlined in RU 68.

As stated earlier, the volume of data collected under RU 67 is enormous. Some 77 aerial survey flight days have been logged, covering approximately 450 hours of flight time. Since 1975, approximately 50,000 data records have been processed. A data record is a computer card; six cards are required for a single sighting. About 50% of these sightings were made during the ice seal surveys. Because of format changes, and indecision by the various OCSEAP managers with regard to format finalization, most of these 50,000 records are not ready for computer analysis. As such, much effort remains in preparing the data for summary write up. We have recognized five phases of data processing which must be accomplished before any written product covering our work can be made. The following outline and subject-time graph summarize the kinds of effort needed to accomplish the requests in the guidelines, as well as the personnel necessary to complete the report(s). These planned activities cover research units 67, 68 and 69; a minimum of nine people (3 per research unit) are needed to complete our work.

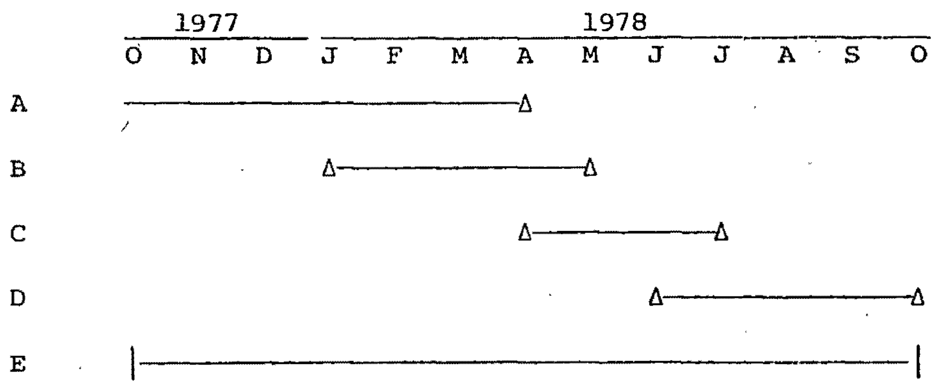
A. Management preparation: finalize OCSEAP formatting; complete data documentation; identify tests; write checks program and format accessing programs; list/check/edit data through computer processing and by hand; rework EDS program. (6 months work; 2 full time employees)

B. Data preparation: complete land study format; write quality control programs; complete mapping procedures/programming; finalize cataloguing procedures; complete (upgrade) computer accessing and analytical capabilities. (4 months work; 2 full time employees)

C. Data analysis: plotting-mapping; data documentation for interpretation; literature review. (3 months work; 2 full time employees)

D. Report writing and manuscript preparation, including graphic arts and review period. (4 months work; 2 full time employees)

E. Administrative overseeing of RU 67 in data management and Marine Mammal Division coordination. (12 months work; 1 part time employee)



Sampling Methods:

N/A

Analytical Methods:

Much of the field analytical methods are new or untested, and thus not readily referenced. For example, comparing ground counts with aerial photographs is a rather straightforward procedure. Statistical analysis of the ice seal data will follow that produced in our FY77 annual report and in Braham and Krogman, 1977. Programs are being developed which will allow effort/unit-area to be compared with sighting data. This analysis will provide a more complete method of determining relative abundance and temporal distribution. Continued effort will be spent on final checking of data collected since 1975.

Anticipated Problems:

None

Deliverable Products:

Digital products. (See original proposal, Table 1, for an explanation.)

Table 1.

Type	Media	Volume	Format	By PI	Collection Period	Submission Period
E. Aleutian pinniped study	Tape	16K	025,026,027	yes	1975-77	by 1 July 1978
Cetacean study	Tape	11K	026/027	yes	1968-77	by 1 Oct. 1978
Ice seal study	Tape	22K	026	yes	1976-77	by 1 Apr. 1978

Narrative reports. A list of reports/publications (completed, planned or in preparation) follows:

Fiscus, D. H., H. W. Braham, R. W. Mercer, R. D. Everitt, B. D. Krogman, P. D. McGuire, C. E. Peterson, R. M. Sonntag and D. E. Withrow. 1976. Seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska. Processed report, U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Mar. Mamm. Div., Seattle, WA. 238 p.

Severinghaus, N. C., and M. K. Nerini. 1977. An annotated bibliography on marine mammals of Alaska. Processed report, U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Mar. Mamm. Div., Seattle, WA. 125 p.

Braham, H. W., and B. D. Krogman. 1977. Population biology of the bowhead (Balaena mysticetus) and beluga (Delphinapterus leucas) whale in the Bering, Chukchi and Beaufort Seas. Processed report, U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Mar. Mamm. Div., Seattle, WA. 29 p.

Braham, H. W., and B. D. Krogman. Spring distribution and abundance of the Pacific walrus, Odobenus rosmarus. (In preparation)

Braham, H. W., G. A. Fedoseev, J. J. Burns, and B. D. Krogman. Distribution and abundance of Phocine seals and walruses in the Bering Sea pack ice in the spring, 1976. (In preparation as a book chapter, U. S.- U. S. S. R. Convention for Environmental Conservation of Marine Mammals)

Braham, H. W., D. J. Rugh, and R. D. Everitt. Population status of the northern sea lion, Eumetopias jubatus, in the eastern Aleutian Islands, Alaska. (In preparation)

Braham, H. W. Migration of the gray whale, Eschrichtius robustus, in Alaska. (In preparation)

Braham, H. W., R. D. Everitt, and C. H. Fiscus. Harbor seal, Phoca vitulina richardii, populations of the north side of the Alaska peninsula, and the eastern Aleutian Islands. (planned)

Visual data.

No anticipated visual aids are planned other than distribution charts and maps to be included in reports.

Other non-digital data.

None.

Data submission schedule.

For data collected prior to 1978, and submission dates, see Table 1.

Information Required from Other Investigators:

Needs:

1. Quantitative description of the benthic infauna and epifauna for the near-shore areas of the Alaska coast throughout the Gulf of Alaska, south and north coast of the Alaska Peninsula, north Bristol Bay-Kuskokwim-Nunivak area, Yukon delta region, St. Lawrence Island and northern Bering/southern Chukchi Seas. Initial contact has been made with other P.I.'s, but inclusive data are not available.

2. Detailed description of water current patterns, particularly nearshore throughout Alaska, and especially the patterns near Unimak Pass and Elton Pass (Nunivak Island). Some information on currents has been obtained.

3. Information on patterns of movements and seasonal distribution of demersal and spawning fishes in the St. George basin and along the north coast of the Alaska Peninsula, Norton and Kotzebue Sound. Some information is available, particularly for Bristol Bay.

4. A comprehensive review of the baseline characterization of marine mammals in the Bering Sea cannot be made unless pelagic sighting data for all species encountered have been sent to us for evaluation. To date, most investigators have been cooperative; others have not.

We ask that the Juneau Project Office identify who has marine mammal sighting data collected as part of OCSEAP, and that contact be made by us or Project Office staff to insure that all data are included in our data bank for analysis. We further request that any data collected between 1975 and 1977 (that have not yet been sent to us) be submitted prior to 1 February 1978 to insure inclusion in the final report.

Quality Assurance Plans:

A review of quality control procedures in data management was made during the summer of 1977. The following revised schedule for insuring quality control of data was adopted:

The in-house computer format was revised so as to more closely parallel all raw data measurements. After coding onto keypunch abstracts, data are 100% visually checked with raw data. After punching, a listing from punched cards is again 100% rechecked with the raw data. All data are run through a comprehensive quality control program, which identifies all logic errors and questionable data. From these tests our error rate in checking data will equal zero. Finally, an expanded data management document is being written which will detail all quality control tests performed on our data. This report will be submitted with the Data Documentation Forms during EDS submission, or as a separate data management product. In either case, we expect it to be available for the FY 78 annual report.

Specimen Archival Plan:

None

Logistic Requirements:

None

Management Plan:

The principal investigators will take an active role in the project by spending approximately 33% and 100% of their time on this RU, on data management and analysis, write-up, and in the administration of personnel and budgetary considerations.

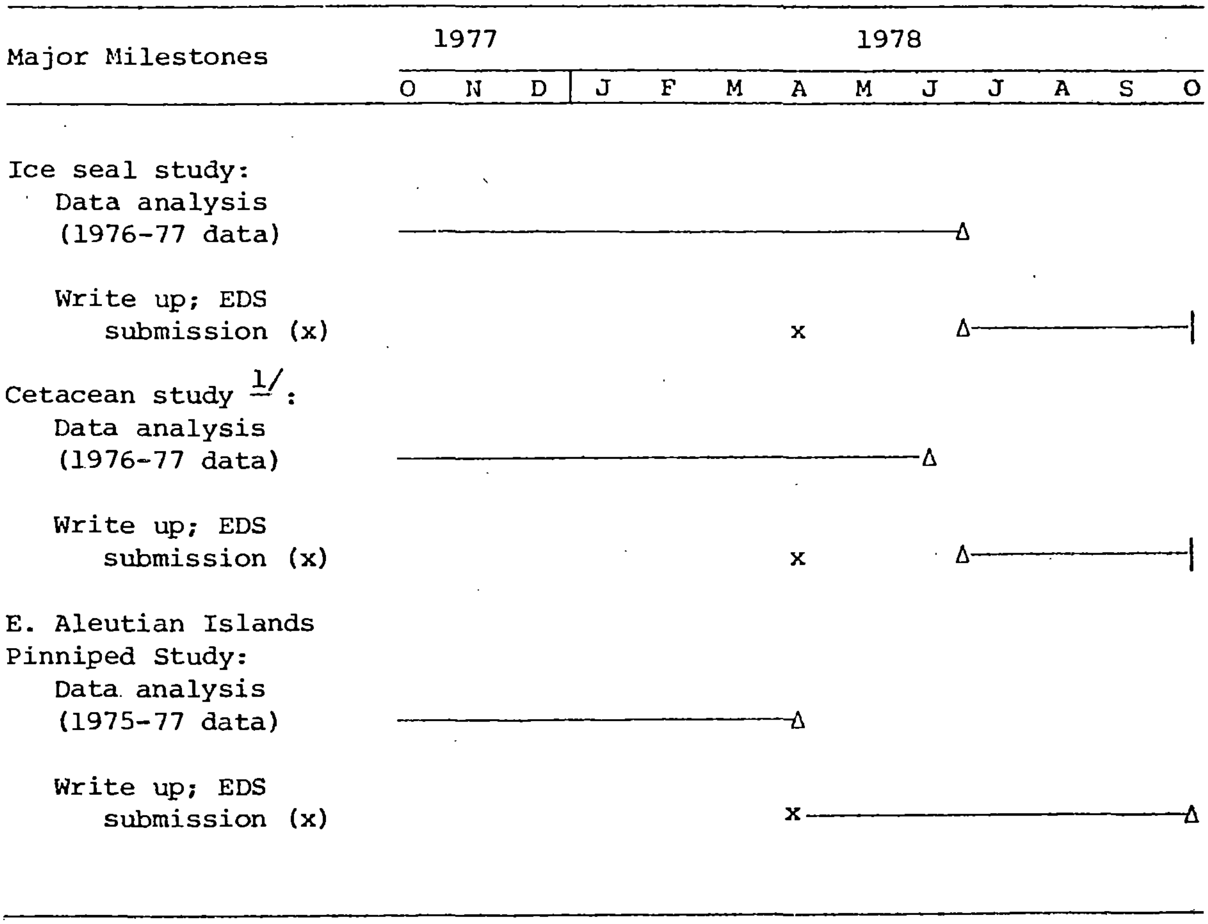
Outlook:

See RU 67 original proposal dated 10 June 1977.

"Standard Statements":

Accepted. See original proposal dated 10 June 1977.

MILESTONE CHART



1/ Data presentation for the Bering Sea project (RU 67) will be included in the Gulf of Alaska project (RU 68) final report, except for one species, the California gray whale.

List of References

Braham, H. W., and B. D. Krogman. (In prep.) Distribution and abundance of the Pacific walrus (Odobenus rosmarus) from Spring 1976 aerial surveys. Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Marine Mammal Division, Seattle, Washington.

Caughley, G. 1974. Bias in aerial survey. J. Wildl. Manage. 38(4):921-933.

Norton-Griffiths, M. 1976. Further aspects of bias in aerial survey of large mammals. J. Wildl. Manage. 40(2):368-371.

Pennycuick, C. J., and D. Western. 1972. An investigation of some sources of bias in transect sampling of large mammal populations. E. Afr. Wildl. J. 10(3):175-191.

R.U. #67

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Ice Seal Study (1976-77 data):															
Raw data converted to in-house format				▲ 100%											
Keypunch abstracts coded and checked				▲ 100%											
Keypunching completed and verified				▲ 90%	▲ 100%										
Final quality check of data (computer check)				▲ 20%			▲ 60%		▲ 100%						
Convert to 026 format											▲ 100%				
Submit to EDS (archival)											▲ 100%				
Cetacean Study 1/(1976-77 data):															
Raw data converted to in-house format				▲ 100%											
Keypunch abstracts coded and checked				▲ 100%											
Keypunch completed and verified				▲ 90%	▲ 100%										
Final quality check of data (computer check)				▲ 20%			▲ 60%		▲ 100%						
Convert to 026 foramt											▲ 100%				
Submit to EDS (archival)											▲ 100%				
E. Aleutian Islands Pinniped Study (1975-77)															
Raw data converted to in-house format				▲ 100%											
Keypunch abstracts coded and checked				▲ 100%											
Keypunching completed and verified				▲ 90%		▲ 100%									
Final quality check of data (computer check)				▲ 20%		▲ 60%			▲ 100%						
Convert to 026 format											▲ 100%				
Submit to EDS (archival)											▲ 100%				
Quarterly report			▲			▲			▲						
Final report												▲			

1/ Data presentation for the Bering Sea Project (R.U. 67) will be included in the Gulf of Alaska project (R.U. 68) final report except for one species, the gray whale

R.U. #67

NARRATIVE REPORTS	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Indicate the following for each narrative report/manuscript to be generated under R.U. 67 listed below:															
A/In preparation (indicate progress by showing % completion/month)															
B/Submit for agency (NMFS) review															
C/Final report in printing															
D/Submission to OCSEAP															
1. Distribution and abundance of Phocine seals and walruses in the Bering Sea pack ice in the spring, 1976.				A	20%	40%	60%	80%	100%	B	C	D			
2. Population status of the northern sea lion, *Eumetepias jubatus*, in the eastern Aleutian Islands, Alaska.				A 20%	40%	60%	80%	100%	B	C	—	D			
3. Harbor seal, *Phoca vitulina richardii*, populations of the north side of the Alaska peninsula, and the eastern Aleutian Islands.				A 30%	70%	100%	B	C	—	D					

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SEASONAL DISTRIBUTION AND RELATIVE ABUNDANCE OF MARINE MAMMALS IN THE WESTERN GULF OF ALASKA

Research Unit 68

Principal Investigators

Howard W. Braham, PhD

Lt. Roger W. Mercer

Contract Period

1 October 1977 - 30 September 1978

Marine Mammal Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

29 October 1977

Seasonal Distribution and Relative Abundance of Marine Mammals in the Western Gulf of Alaska.
Research Unit 68
R7120806
Contract period 1 October 1977 to 30 September 1978

Principal Investigator: Howard W. Braham, Ph. D.
Principal Investigator: Roger W. Mercer, Lt., NOAA Corps

Cost:

Total	36.7K
Distribution by lease area	
1. Aleutian Islands	50%
2. Kodiak	20%
3. Bering Sea	20%
4. NEGOA	10%

Background:

A great deal of marine mammal sighting data has been collected from the Gulf of Alaska-Aleutian Shelf and the Bering Sea since 1972 as part of research unit 68 and the Platforms of Opportunity Program (POP, an on-going NOAA program). About 10% of these data were coded and presented in an unsolicited "final report" for the NEGOA (Fiscus, et al., 1976). As of autumn 1977 about 60% of the data collected through 1976 are coded. The remainder could be coded and available for processing by June 1978. Additionally, approximately 6,500 sighting records have been sent to us from POP and OCSEAP vessel observers that have not been completely logged.

With the great volume of data now in our files, and as yet not in final form for presentation, we are requesting a contract to cover the costs of personnel, data processing, and final report preparation for all marine mammal data in our files collected aboard ships working in the Gulf of Alaska and southern Bering Sea.

Objectives:

Our year-end objective for FY78 will be to prepare a final report to include sighting data on marine mammals from the Gulf of Alaska and southern Bering Sea, covering or including the following topics or products:

1. Seasonal distribution and relative abundance where a sufficient data base exists for each species.
2. Population compositions, where data exist, to include such information as age and/or sex and group size.
3. Estimates of population size beyond relative abundance, should sufficient temporal and spatial information exist for either local or more widely distributed populations.
4. Submittal on magnetic tape of all data that have been finalized.

5. Submittal of a detailed report to include a literature search for each marine mammal species, including research methodology, results, conclusions and needs for additional research.

General Strategy:

Since this will be the final phase of data reduction and analysis for RU 68, a comprehensive review of the literature will be integrated with sighting data to obtain an overview of marine mammal distribution and abundance. To accomplish these aims final data preparation will be emphasized during the first half of the contract period. POP data will be carefully evaluated for accuracy and coded (which includes final logging) with a 100% independent check, and a 10% random check of keypunched data. Sightings will be plotted by species and season. These will be accompanied by seasonal transect plots. These comparisons are necessary to evaluate relative abundance and seasonal variation.

From the sighting records an evaluation will be made of species trends with regard to areas where petroleum development is anticipated. Visual aids will be developed that relate to important habitats by species, as well as major migration routes, foraging areas and breeding grounds. Naturally, an evaluation of these important factors is dependent upon the quantity and quality of the data sent to us. In many cases we cannot provide quality control assurance except where we have either collected the data ourselves, or extracted apparently reliable information from data sent to us.

Data currently in our files will be processed according to the following monetary apportionment:

Aleutian Islands	50%
Kodiak Shelf	20%
Bering Sea	20%
NEGOA	10%

For reporting purposes, the Aleutian Islands area is that bounded by 155° and 170° W. Longitude south of the Alaska Peninsula; the Kodiak Shelf bounded by 148° and 155° W. Longitude exclusive of Cook Inlet; NEGOA within 136° and 148° W. Longitude; and the Bering Sea area, for RU 68 reporting purposes, is south of 60° N. Latitude and east of 170° W. Longitude.

Sampling Methods:

N/A

Analytical Methods:

Most POP data are gathered by volunteer observers (those not employed by the Marine Mammal Division). As such, no sampling scheme was used to collect these data, and because many observers were not trained by us, some data are unreliable. Therefore, well defined quality control measures have been developed and will be applied to all data that will be reported. The data that will be presented are considered reliable, and accurate according to species identification, location and time of sighting and number of animals seen. These are the key parameters to better predict distribution and relative abundance.

Distribution will be reported through charts by species and season; the only analysis performed, then, will be in a qualitative narrative fashion. Relative abundance estimates will be made based on a percent composition of individual species to all species, by time. Where effort data exist (that is, the amount of time spent looking for animals) a more rigorous analysis of the number of animals per time or space will be made. These kinds of measurements are, in effect, relative abundance estimates. Absolute abundance cannot be determined; however, where sufficient historical information exists, a best estimate of the numbers of animals by population will be provided. The developmental aspects of more detailed analytical methods are not necessary considering the kind of information at our disposal.

Anticipated Problems:

Occasionally field data are not received from volunteer observers for several months after they have returned from an ocean voyage. Consequently, some data (<15%) may be submitted to EDS up to a year after collected.

Deliverable Products:

A. Digital data

1. a. Transects: Beginning and end positions in degrees, minutes, seconds latitude and longitude; water surface temperature; visibility; begin and end times and dates to hours and minutes accuracy; length of transect and elapsed time; vessel name.

   b. Sighting records: Position in latitude and longitude; date and time (time zone specified); species (positive or tentative identification); number of animals; behavior ("027" codes); direction headed (NW, E, S, SE); relative initial range and bearing; visibility code; platform ID; time zone; comments.

2. See below.

Data Type	Collection Period	Media	Est. Volume	Format	Formatting by PI	Submission
Pelagic sightings of marine mammals	unprocessed data 1972-76	tape	15K	027	yes	1 Jan. 1977
Pelagic sightings of marine mammals	1977	tape	7K	027	yes	1 July 1978

B. Narrative reports: The following list of completed or planned reports/ manuscripts have been or will be generated from data collected under RU 68.

Fiscus, C. H., H. W. Braham, R. W. Mercer, R. D. Everitt, B. D. Krogman, P. D. McGuire, C. E. Peterson, R. M. Sonntag and D. E. Withrow. 1976. Seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska. Processed report, U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Mar. Mamm. Div., Seattle, WA. 238 p.

Severinghaus, N. C., and M. K. Nerini. 1977. An annotated bibliography on marine mammals of Alaska. Processed report, U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Mar. Mamm. Div., Seattle, WA. 125 p.

Braham, H. W. Spring migration of the California gray whale, *Eschrichtius robustus*, in Alaska. (manuscript)

Braham, H. W., R. W. Mercer, and T. W. Bray. Preliminary evaluation of Dall porpoise (*Phocoenoides dallii*) distribution in Alaska. (in preparation)

Braham, H. W., and R. W. Mercer. Cetacea distribution in the Gulf of Alaska and southern Bering Sea. (planned)

C. Visual data

1. Plots of marine mammal sightings, species by season.
2. Plots of transect data.
3. Plots of the ratio of individual species to all species sighted by season and location.
4. Plots of sighting data collected only during transect work.
5. Tables of individual species by time and location.
6. Density plots of key species (to be determined) for time and location.
7. Charts of "critical" habitats for selected species if data are suggestive of this.
8. Charts of major migration routes, feeding areas and potential breeding grounds if data are suggestive of these.

D. Non-digital data

None.

E. Data submission schedule

See A. 2. above. Also, data will be submitted quarterly as they are finalized and processed. Because of the nature of the data that are still coming in, we cannot provide a detailed list at this time as to which data or cruises will be submitted during which quarters. However, all 1972-77 data that are finalized will be in the Juneau Project Office by 1 October 1978.

Information from Other Investigators:

A comprehensive review of the baseline characterization of marine mammals in the Gulf of Alaska and southern Bering Sea cannot be made unless pelagic sighting data for all species encountered have been sent to us for evaluation. To date, most investigators have been cooperative; others have not. We ask that the Juneau Project Office identify who has marine mammal sighting data collected as part of OCSEAP, and that contact be made by us or Project Office staff to insure that all data are included in our data bank for analysis. We further request that any data collected between 1975 and 1977 (that has not yet been sent to us) be submitted prior to 1 February 1978 to insure inclusion in the final report.

Quality Assurance Plans:

A review of quality control procedures in data management was made during the summer of 1977. The following revised schedule for insuring quality control of data was adopted:

The in-house computer format was revised so as to more closely parallel all raw data measurements. After coding onto keypunch abstracts, data are 100% visually checked with raw data. After punching, a listing from punched cards is again 100% rechecked with the raw data. All data are run through a comprehensive quality control program, which identifies all logic errors and questionable data. From these tests our error rate in checking data will equal zero. Finally, an expanded data management document is being written which will detail all quality control tests performed on our data. This report will be submitted with the Data Documentation Forms during EDS submission, or as a separate data management product. In either case, we expect it to be available for the FY 78 annual report.

Specimen Archival Plan:

None

Logistic Requirements:

None

Management Plan:

The principal investigators will take an active role in the project by spending approximately 33% and 100% of their time on this RU, on data management and analysis, write-up, and in the administration of personnel and budgetary considerations.

Milestone Chart

	1977			1978								
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Data coding, EDS submission				Δ			Δ			Δ		
Data analysis and report preparation	—	—	—	Δ	—	—	Δ	—	—	Δ	—	*

*final report termination date

Outlook:

N/A

References

Fiscus, C. H., H. W. Braham, R. W. Mercer, R. D. Everitt, B. D. Krogman, P. D. McGuire, C. E. Peterson, R. M. Sonntag and D. E. Withrow. 1976. Seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska. Processed Report, Northwest and Alaska Fish. Center, Natl. Mar. Fish. Serv., Natl. Ocean. Atmos. Admin., Seattle, WA. 238 p.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Receipt of all data (raw)			Δ 100%												
Raw data logged and converted to in-house format				Δ 100%											
Keypunch abstract coded and checked				Δ 100%											
Keypunching completed and verified					Δ 100%										
Final quality check of data (computer check)					Δ 80%	Δ 100%									
Convert to 027 OCSEAP format					Δ 80%		Δ 100%								
Submit to EDS (archival)					Δ 80%		Δ 100%								
Quarterly reports			Δ			Δ			Δ						
Final report												Δ			
Progress of all plots, charts, and tables to be submitted under contract				Δ 10%		Δ 30%		Δ 50%				Δ 100%			
Completion of data management document			Δ 50%	Δ 70%	Δ 100%										
Indicate the following for each narrative report/manuscript to be generated under R.U. 68 listed below:															
A/In preparation (indicate progress by showing % completion/month)															
B/Submit for agency (NMFS) review															
C/Final report in printing															
D/Submission to OCSEAP															
1. Spring migration of the California gray whale, *Eschrichtius robustus* in Alaska (Manuscript)					A 25%	50%	75%	100%	B	—	C	D			
2. Preliminary evaluation of Dall porpoise (*Phocoenoides dallii*) distribution in Alaska		A	—	50%	90%		100%	—	B		C	D			
3. Cetacea distribution in the Gulf of Alaska and Southern Bering Sea							A 20%	100%	B	—	C	D			

DISTRIBUTION AND ABUNDANCE OF BOWHEAD AND BELUGA WHALES IN THE ARCTIC OCEAN

Research Unit 69

Principal Investigators

Howard W. Braham

Bruce D. Krogman

Fiscal Year 1978

1 October 1977 - 30 September 1978

Marine Mammal Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way, N. E.
Seattle, Washington 98115

26 October 1977

I. Distribution and Abundance of Bowhead and Beluga Whales in the Arctic Ocean.
Research Unit 69.
Contract Period 1 October 1977 to 30 September 1978
Contract Number R7120807

II. Principal Investigators: Howard W. Braham
Bruce D. Krogman

III. Cost:

Total	34.4K
Distribution of effort	
1. Chukchi Sea	60%
2. Beaufort Sea	40%

IV. Background

During FY 76 and FY 77 data were collected on bowhead and beluga whale migratory patterns through the Bering, Chukchi and Beaufort Seas using aerial surveys and field counting stations. Research methods were tested and found reliable. The rapidly changing environmental conditions caused some surveys to be aborted. Preliminary interpretation of FY 76-77 data provides some new information on the distribution and abundance of both species but too little time has been spent in the study area to detect population fluctuations.

V. Objectives

The main objective for research conducted during FY 78 will be to synthesize results from FY 76 and FY 77 field research. Specifically, objectives will be to:

A. Provide estimates of abundance for the Bering-Chukchi-Beaufort Seas stocks.

B. Determine seasonal distribution and relative abundance.

C. Delineate migratory patterns.

D. Evaluate data base and idenfity information gaps.

VI. General Strategy

No field work will be conducted during FY 78.

Laboratory analysis of FY 76 and FY 77 field data will continue. Analytical strategy will be similar to that described in Braham and Krogman, 1977. Data is first summarized as tables and charts. Population abundance index is derived from ice camp data; distributional information acquired from charts based on results of aerial survey. Inference is drawn from maps regarding migratory patterns.

A literature search is continuing for all reports with topics relating to bowhead whales. OCS reports and other publications are being reviewed with the intent of identifying potential oil-whale disturbance factors which may result from offshore oil development.

VII. Sampling Methods

N/A

VIII. Analytical Methods

N/A

IX. Anticipated Problems

None

X. Deliverable Products

A. Digital products

Data Type	Volume (No. of Records)	Format	Collection Period	Submission Period
Ice station whale counts	100	027	Spring FY 76, FY 77	Spring FY 78
Aerial survey counts	10,000	026	Fall FY 75; Spring and Fall FY 76, FY 77	Spring FY 78

B. Narrative reports

Braham, H. W., and B. D. Krogman. Population biology of the bowhead (Balaena mysticetus) and beluga (Delphinapterus leucas) whale in the Bering, Chukchi and Beaufort Seas. Processed report, Northwest and Alaska Fisheries Center, Natl. Mar. Fish. Serv., Natl. Oceanic Atmos. Admin., Seattle, WA. 29 p.

Krogman, B. D., and R. D. Everitt. Reproductive behavior in bowhead whales (Balaena mysticetus). (in preparation)

C. Visual Data

N/A

D. Other Non-Digital Data

N/A

E. Data Submission Schedule

All backlogged data collected over the past three years will have been checked, and will be submitted before April 1978 (annual report).

XI. Information Required from Other Investigators

A. Ice lead conditions from Pt. Hope to Pt. Barrow in April-June for 1975-1977 are needed. Also, the location of offshore leads from Pt. Barrow to Banks Island April-July 1975-1977.

B. The surface and midwater zooplankton species composition and assembleges in the central Chukchi and eastern Beaufort Seas. The composition in the nearshore area just east of Barrow July-September is most pertinent.

XII. Quality Assurance Plans

A review of quality control procedures in data management was made during the summer of 1977. The following revised schedule for insuring quality control of data was adopted:

The in-house computer format was revised so as to more closely parallel all raw data measurements. After coding onto keypunch abstracts, data are 100% visually checked with raw data. After punching, a listing from punched cards is again 100% rechecked with the raw data. All data are run through a comprehensive quality control program, whcih identifies all logic errors and questionable data. From these tests our error rate in checking data will equal zero. Finally, an expanded data management document is being written which will detail all quality control tests performed on our data. This report will be submitted with the Data Documentation Forms during EDS submission, or as a separate data management product. In either case, we expect it to be available for the FY 78 annual report.

XIII. Special Vouchering

N/A

XIV. Logistic Requirements

N/A

XV. Management Plan

The principal investigators will allocate 35% and 100%, respectively, of their time in the data analysis, report preparation and administration of personnel and budgets.

XVI. Outlook

The data collected during FY 76-77 have helped identify migratory corridors as well as the temporal distribution and abundance of the bowhead and beluga whale. From these studies, an understanding of habitat use and an estimate of the size of the bowhead and beluga populations can be obtained. To assess vulnerability of these species to oil development, more refined information is needed on their feeding habits and reproductive biology.

XVII. "Standard Statements"

Accepted. See original proposal dated 10 June 1977.

MILESTONE CHART

Major Milestones	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Data processing & related programming	—	—	—	—	Δ										
Data quality control and submission to EDS					—	—	Δ								
Analysis, literature search, & report writing	—	—	—	—	—	—	Δ								
Quarterly reports				Δ			Δ			Δ			Δ		

R. U. #69

MAJOR MILESTONES	1977			1978											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Raw data logged and converted to in-house format					▲ 50%	▲ 100%									
Keyunch abstracts coded and checked					▲ 50%	▲ 100%									
Keypunching completed and verified					▲ 50%	▲ 100%									
Final quality check of data (computer check)							▲ 20%	▲ 75%	▲ 100%						
1/ Develop ice-station format				▲ 70%	▲ 100%										
2/ Convert data to OCS format											▲				
3/ Submit to EDS (archival)											▲				
Quarterly report			▲			▲			▲						
Final report												▲			
Indicate the following for each narrative report/manuscript to be generated under R.U. 69/70 listed below:															
A/In preparation (indicate progress by showing % completion/month)															
B/Submit for agency (NMFS) review															
C/Final report in printing															
D/Submission to OCSEAP.															
1. Population Biology of the Bowhead (Balaena mysticetus) and Beluga (Delphinapterus leucas) whale in the Bering, Chukchi and Beaufort Seas.				A	20%	40%	60%	80%	100%	B	C	D			
2. Spring distrubution and abundance of the Pacific walrus (Odobenus rosmarus).				A	20%	40%	60%	80%	100%	B	C	D			

1/ Develope ice-station format.

I am developing a computer format for coding field data collected while making counts of whales moving by fixed points on land or shore fast ice. The numeric designation 026 already applies to the aerial survey format used for collecting marine mammal information. I suggest a new number be designated for this new format. In my opinion, the survey information we collect under RU69 cannot be translated to either the 026 or the 027 (shipboard) formats.

2/ Convert to OCS format.

3/ Submit to EDS (archival)

2/ requires one computer run, and will be done all at once as part of 3/.

PROPOSAL NO.: UCSD- 0854

A.

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

University of California, San Diego
Mail Code A-010
La Jolla, California 92093
Telephone (714) 452-4570

PROPOSAL FOR RESEARCH TO BE CONDUCTED UNDER THE SPONSORSHIP OF

U.S. DEPARTMENT OF COMMERCE, NOAA

TASK NUMBER 71

TITLE OF PROPOSAL: EFFECTS OF OILING ON TEMPERATURE REGULATION IN SEA OTTERS

PROJECT PERIOD: 1 year From: 10/1/77 Through: 9/30/78

AMOUNT REQUESTED: $62,773.

AGENCY CONTRACT OR GRANT NO.: NOAA 03-7-022-35130

PRINCIPAL INVESTIGATOR:
(NAME, TITLE, ADDRESS & TELEPHONE)
Dr.Gerald L. Kooyman
Associate Res.Physiologist

Co-Principal Investigator:
Dr. Walter F. Garey
Assistant Res.Physiologist

Physiological Research Laboratory
Scripps Institution of Oceanography
University of California,San Diego
La Jolla, California 92093
(714) 452-2937

Make checks payable to The Regents of the University of California and mail to Accounting (Fiscal) Officer, UCSD

OFFICER TO WHOM AWARD DOCUMENTS SHOULD BE MAILED:

N. J. Sattler,
Assistant Manager
Contract and Grant Administration, A-010

Signature________ Date:________
Typed Name & Title: Gerald L. Kooyman, Associate Res.Physiologist — Walter F. Garey, Assistant Res. Physiologist

Signature________ Date:________
Typed Name & Title: Fred N. White, Director, Physiol. Res. Laboratory

OFFICIALS AUTHORIZED TO SIGN FOR INSTITUTION:

Signature W. A. Nierenberg Date: 6/28/77
Typed Name & Title: William A. Nierenberg, Director
Scripps Institution of Oceanography, UCSD

Signature________ Date:________
Typed Name & Title:

(71475-179)

C. Technical Proposal Form

I. Title and Task Statement Number

Effects of Oiling on Temperature Regulation in Sea Otters
Research Unit Number: 71
Contract Number: Renewal of 03-7-022-35130
Proposed Dates of Contract: 10/1/77 - 9/30/78

II Principal Investigator(s)

Dr. G. L. Kooyman
Dr. W. A. Garey*

III. Cost of Proposal

C. Total - 62,773.

IV. Background: Outline the relationship and relevance of the proposed research to other scientific efforts in the area of interest, and how the proposed work relates to research previously conducted.

This project represents an extension of studies that began with the investigations of diving and feeding behavior, and thermoregulatory effects of oil pollution in fur seals. In this species which relies on fur for insulation against cold sea water, the effects of oiling were profound. It is thought, but not measured, that sea otters are even more dependent on their fur for insulation. The results will provide an answer to such questions as well as help in providing basic information on the general aspects of respiration in all marine mammals. Furthermore, determination of the characteristics of diving, and measurements of the energetics involved will help to provide general information on the energy requirements of the various marine mammals and their different modes of propulsion.

V. Objectives: List the most important objectives of this research project. Indicate specifically the relevance of these objectives to an environmental assessment of the Alaskan Continental Shelf that will provide information for decision making during leasing and development.

1. Energy requirements of normal sea otters at various water temperatures.
2. Energy requirements of sea otters after oiling.
3. Appropriate procedures for rehabilitating oiled sea otters.
4. At sea behavior and energetics of sea otters.

These objectives will provide a data base from which the assessment of any kind of oil contamination, or other activity which may alter the nature of the otter's food sources can be derived. In addition, relative to oil contamination the difficulties and costs of

*Appointment extension pending.

protecting from oiling, and the rehabilitating of oiled otters can be estimated.

VI. General Strategy: Discuss your strategy to meet the objectives described in the task statement.

It is predicted that oil will have an impact on sea otters through increasing their maintenance costs due to increased heat loss in air and in water as a result of pelage contamination. The magnitude of this increase will also vary between neonates and adults. External oil may also impair their diving and feeding abilities.. Kenyon (1974) noted that malnutrition was common in contaminated fur seals. Finally we would anticipate direct metabolic effects of ingested oil. This proposed research will continue physiological research on sea otters, and will include an analysis and evaluation of other studies on the effects of oil pollution on sea otters.

Two otters are presently being studied at the Physiological Research Laboratory, Scripps Institution of Oceanography. After conditioning the otters accepted confinement in the metabolic test chamber, their normal metabolic rates are begin measured at a variety of water temperatures. The otters will be oiled by brushing a liberal amount of oil on their dorsal surface. Metabolic measurements will be repeated several hours after their pelts are oil-fouled. In the interim they will be allowed to swim in a small tank to remove excess oil and volatiles. At this time Dr. Sam McGinnis will conduct some of heat flux measurements which are pertinent to an independent project. Immediately thereafter the otters will be anesthetized (for ease of handling; safety, and thoroughness) and their fur will be cleaned of oil with a detergent. After 1 or 2 days recovery from anesthesia,maintenance metabolic rates will again be measured at intervals for 2 or 3 more weeks. Data will be analyzed to show changes in metabolic rates associated with alteration due to oil of the insulative properties of the fur, and changes associated with the cleansing process. Results will be compared with data from past studies on northern fur seals, and with the results of other investigators on these and other species.

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).

The sampling procedures will be the same as those recently used for fur seals and used previously in metabolic rates in penguins (Kooyman,G.L., R.L.Gentry, W.P.Bergman and H.T.Hammel, 1976, Comp. Biochem. Physiol. 54A: 75-80).

The thermal neutral zone will be determined in four sea otters conditioned to "rest" in the metabolic test chamber. The principle variable measured in these tests is oxygen consumed, and body and skin temperature. The control thermal neutral zone will be compared to otters after oiling and after cleaning. Furthermore, the continous sampling ability of our method will permit us to determine the average whole body heat conductance for a 10 to 12 hr run. This will include the important activity (mainly grooming) periods. The changes in whole body conductance during exposure to various water temperatures before and after oiling will indicate the metabolic costs of oil on the fur.

These same sampling procedures will be repeated after the oiled animals have been anesthetized and cleaned.

VIII. Analytical Methods: What methods of analysis are contemplated? Provide literature references. (Complete only if applicable.)

Oxygen consumption will be determined by well known procedures outlined in Kooyman et al. (ibid) and Depocas and Hart (1957). The key instruments are an AE1 electronic oxygen analyzer and an accurate gas meter. Body and skin temperatures will be obtained by ratiotelemtry.

IX. Anticipated Problems: Discuss any anticipated major difficulties associated with the task and recommend solutions.

Technically no major difficulties are anticipated with regard to equipment. The metabolic test chamber is available and functioning, and most essential equipment is on hand.

The logistic problems associated with obtaining a permit to experiment on otters, or in capturing and transporting otters could delay this project. Also, the maintenance of the otters after cleaning could require a considerable amount of time.

X. Deliverable products: Identify products to be generated as a result of this project.

This project will produce a narrative report containing a thorough description of all procedures used and of all measurements taken during physiological studies of sea otters. The final report will include an analysis of prior fur seal research, studies of oil pollution effects on marine mammals by other investigators, and recommendation for future research.

Progress of this project will be reported on every 3 months unless special problems require more frequent reports.

XI. Information Required from Other Investigators.

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

No new data are required of other researchers to successfully complete the proposed work. Research presently reported in the literature will be reviewed for comparison studies. Metabolism and Thermal Regulation in the Sea Otter by Morrison, P.M.Rosenmann and J.A.Estes, (1974, Physiol. Zool. 47: 218-229) will serve as a basis of comparison for the studies.

XII. Quality Assurance Plans

Briefly describe procedures and/or methods and schedule to be used for the calibration and intercomparison of instruments, techniques and analytical results.

The AE1 oxygen analyzer is easily calibrated daily by flushing the sensing cell with outside dry air and then reducing the pressure within the cell by a precisely known amount which is determined with a water manometer. The deviation from the predicted value is the factor for the analyzer on any given day. This has become a standard method of calibrating electronic O_2 analyzers and was originally devised by Prof. H. T. Hammel, a member of PRL Staff.

The telemetry pills will be calibrated against a bureau of standards thermometer.

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.

No specific samples will be collected which should be kept for future reference.

XIV. Logistics Requirements: If the PI proposes to furnish logistics support, cost chargeable to the OCSEAP should be clearly identified in the Cost Proposal Form, Section CPF-4a. If the program subsequently furnishes the support, these charges can then be easily removed. If logistics support is not to be provided otherwise but will be provided by the program, then the estimated costs of logistics support to be provided by OCSEAP should be included in Section CPF-4b of the Cost Proposal Form. Questions regarding the form should be directed to the Project Office Logistics Coordinators (907) 586-7438 (Sub-Arctic), and (907) 479-7371 (Arctic). The OCSEAP Logistics Officer in Boulder is at (303) 499-1000 ext. 6562 (FTS 323-6562).

Logistic requirements exist only for transportation of sea otters from Monterey to San Diego, California. However, should the marine mammal commission rule that the two additional otters that may be requested should be collected in Alaska then major logistic requirements will be necessary.

Ship Support N/A

1. Ship type: 2. Ship days required:

3. Calendar Period: Optimum Days Acceptable Alternatives

4. Observations to be made:

5. Provide on a separate page a chart of operations area with cruise tracks and stations marked.

6. Number of scientists on board:

7. Special equipment required:

Aircraft Support: Fixed Wing or Helicopter N/A

1. Aircraft Type: 2. Aircraft hours required:

3. Calendar Period: Optimum Days Acceptable Alternatives

4. Provide on a separate page a chart of operations area with flight tracks and stations marked.

5. Observations to be made:

6. Number of scientists on board:

7. Special equipment required:

Quarters and Subsistence Support

1. Location: Monterey, Calif. 2. Period: Intermittent Oct to May

3. Number of personnel per day: 4 4. Total man days per period: 40

5. Can you provide this support? Yes

Special Logistics Problems: If you anticipate any, how do you propose to solve them?

1. Otters for this study can be provided by other researchers working in California. The only logistic requirement will be to fly or drive the animals to San Diego. If California animals are not allowed, two will be captured near Cordova, Alaska. Mr. Ancel Johnson, U.S. Department of Interior has volunteered his boat, nets and expertise to help in the capture, and will allow us to house the animals in his holding facility until transportation is arranged. A chartered boat will be necessary to take the animals to Cordova where a chartered Aleutian Goose will pick them up for transport to San Diego.

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

The Principal Investigator shall actively lead and supervise the proposed work. Dr. G. L. Kooyman will submit quarterly and final reports to OCSEAP format and forward them to Boulder.

Activity/Milestone Chart

October, 1977

Renewal of the contract.

October, 1977 to June, 1978

Continue metabolic tests and submit quarterly reports.

July-August, 1978

Complete analysis of metabolic results and finalize report.
Initiate tests of an appropriate depth recorder pack.
Initiate tests of feasibility of training otters for determinations of metabolic rates while swimming.

XVI. Outlook: Assuming that the research proposed for FY78 is successfully carried out, please outline the remainder of the research effort which is required to complete the work or to reach the first major plateau of accomplishment before changing direction. This should be less detailed than the FY78 proposal, but should include a rough estimate of:

1. The nature of the final results and data products.

The final results of this project will yield a quantitative evaluation of the metabolic costs of the sea otter for general maintenance and for foraging, plus the impact that contamination of the otter's fur coat with crude oil may have on these metabolic requirements. In addition, some general concepts and procedures for the rehabilitation of oiled sea otters should evolve from this study.

2. Significant milestones.

A. Successful completion of the general metabolic requirements of the sea otter.

B. Development of a successful procedure for rehabilitating oiled sea otters.

C. Development of methods and determination of specific foraging activities of the sea otter.

D. Successful training and then analysis of specific swimming requirements.

3. Cost by fiscal year.

About $60,000/year.

4. Additional major equipment required.

Depth-time recorders.

5. Location of future field efforts (if applicable).

Prince William Sound, Alaska

6. Logistics requirements, if they are expected to differ greatly from FY78.

Transport, housing, boat rentals and diving equipment for Prince William Sound study of diving activities.

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 speciamen 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."

PUBLICATIONS AND LITERATURE REFERENCES

(List representative Personal Publications, continuing with *Pertinent Literature References*, as applicable, for all professional personnel, engaged on the project, beginning with the Principal Investigator.)

NAME: G. L. Kooyman

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(List representative Personal Publications, continuing with *Pertinent Literature References,* as applicable, for all professional personnel, engaged on the project, beginning with the Principal Investigator.)

NAME: Walter F. Garey

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Publication - W.F.Garey (Cont'd.)

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

RFx41-71-664

AUG 19 1977

Dr. Gerald L. Kooyman
University of California, San Diego
Scripps Institution of Oceanography
P.O. Box 1529
La Jolla, California 92037

Reference: Research Unit #71
Guidance Letter RFx41-71-549

Dear Dr. Kooyman:

Your FY 78 renewal proposal entitled "Effects of Oiling on Temperature Regulation in Sea Otters," and letter in response to guidance have been reviewed in the Juneau Project Office. The original proposal is judged acceptable with the addenda in your letter of 4 August 1977 at your requested funding level of $62,773. We will instruct our Contracting Office to initiate contracting procedures based on the above items.

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

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

UNIVERSITY OF CAMBRIDGE

TEL. No. 0223 68665

DEPARTMENT OF ANATOMY
DOWNING ST.
CAMBRIDGE
CB2 3DY

4th August, 1977

Ms. Susan J. Anderson,
OCSEAP,
Bering Sea-Gulf of Alaska Project Office,
P.O. Box 1808,
Juneau,
Alaska 99802.

Dear Susan,

This letter is in response to the letter of 21 July and our phone conversation of 3 August 1977.

The following are my revisions, or assessments of the proposed objectives within the 21 July letter:

1. Quarterly and final reports will be submitted by the Principal Investigator to the Juneau Project Office.

2. Assessment of the objective revisions in 21 July letter:

   A. "The potential long-term effects of accumulated petroleum ingested during grooming of oil-fouled fur".

   I would not be willing to study this problem because: (1) I have no competence in the area of pathology of the G.I. tract; and (2) it is doubtful that otters can be maintained for a long-term after oiling.

   B. "The effects of oiling on neonate and juvenile sea otters as compared to adults".

   Again I am not willing to commit myself to such a project for the following reasons: (1) I see no clear logic in expecting that the effects in juveniles at least in a thermoregulatory sense, would be significantly different from the adults. (2) The problems of collecting and maintaining near term females and the neonates would be exceptionally great. (3) I have no permits for holding neonates and the time required to get them, based on past experience, would require at least 9 months. Therefore, the likelihood of being able to do such experiments in FY 78 is remote.

C. I. The effects of oil on diving and feeding behaviour of sea otters.
II. Are the animals able to detect and avoid floating oil either on or beneath the water surface?"

For a variety of reasons this is an Alaskan field project. Part I would most logically be conducted after the California work is completed so that manpower resources are not stretched too broadly. This work would require also a considerable amount of design and testing as suggested in the original renewal proposal. A proper way of attaching recorders could be accomplished in the summer of 1978 at Scripps and by using the otters involved in the thermoregulatory studies. Possibly a 'preliminary' test in Alaska could be accomplished in late summer. Then at least 3 or 4 months would be necessary to construct the recorders and make preparations for a major field study.

Part II is not within my scope of expertise. However, I believe that Dr. Don Siniff of the University of Minnesota conducted some studies of this nature this past summer. I suggest that you contact him about the results of this project.

In summary I view any one of these revisions as major research efforts considering all aspects from collection, experimental design and set up, rehabilitation of otters, and data analysis.

Only the initial phases of C. Part I would fit into the present budget estimates for FY 78.

3. In the past few weeks, with the assistance of Dr. Lanney Cornell (Sea World) we placed pills in the vaginal vault of both otters. After the vagina is sutured shut it should be possible to keep the pill in place for 30 days, the battery life of the telemetry unit. What needs to be confirmed is that the vaginal temperature is similar to deep body temperature. For this test we are waiting to coordinate an experiment with Dr. Sam McGinnis (California State University at Hayward) who has smaller units that we feel are safer to place in the stomach. The smaller unit reduces the risk of an intestinal block.

On 31 July Dr. Walter Garey took a new position. However, although he was especially valuable to the project his departure was anticipated and we expect to fill his position with an equally qualified person as soon as the employment procedures of the University will permit.

Sincerely,

G. L. Kooyman

G.L. Kooyman
Assoc. Res. Physiologist,
Scripps Institution of Oceanography

Title: Lethal and sublethal effects on selected Alaskan marine species after acute and long-term exposure to oil and oil components. OCSEAP Research Unit #72.

Principal Investigators:
Stanley D. Rice
John F. Karinen
Sid Korn
(in collaboration with William D. MacLeod)

Total Cost of Proposal: $300.0k

Period of Work: October 1, 1977 to September 30, 1978.

Institution and Department:
Auke Bay Laboratory, Northwest and Alaska Fisheries Center, Physiology-Bioassay Section (in collaboration with the NOAA Analytical Laboratory in Seattle, Washington under the Direction of William D. MacLeod).

Required Signatures:

Principal Investigators

Name Stanley D. Rice Date September 25, 1977

Name John F. Karinen Date September 25, 1977

Name SID KORN Date September 25, 1977

Address: NOAA, National Marine Fisheries Service
Auke Bay Laboratory
P.O. Box 155
Auke Bay, Alaska 99821

Telephone Number: 789-7231

Required Organization Approval

Name A. T. Pruter Date 10/12/77

Address: Northwest Fisheries Center
2725 Montlake Blvd. E.
Seattle, WA 98112

Telephone Number: 442-4760

Organization Financial Officer

Name N/A Date

Address:

Telephone Number:

Technical Proposal

I. Title and Task Statement Number

Lethal and sublethal effects on selected Alaskan marine species after acute and long-term exposure to oil and oil components.
OCSEAP Research Unit #72.

II. Principal Investigators

Stanley D. Rice
John F. Karinen
Sid Korn

III. Cost of Proposal

Total	$300k
Geographic distribution	Not Applicable

IV. Background: The studies to be described are basically continuations of our previous contract, but with new species, temperatures, longer exposures, or with more detail and refinement. Often we are conducting the "natural" next steps such as 30 days exposures rather than 4 day exposures. We are getting further from the crude scans of toxicity and more involved in longer flow-through exposures, while looking for more information on which components of oil are toxic, and what are the mechanisms of toxicity. We will conduct fewer projects by number, but most will be at a higher level of intensity.

V. Objectives: We have developed specific objectives around five major objectives or themes.

A. Toxic components and synergism of toxic components: We will continue our efforts of investigating the contribution of toxic components with the objective of determining which compounds are primarily responsible for most of the observed toxicity. Studies evaluating, and probably eliminating phenol, naphthol, and heterocycles as major contributers to toxicity have been completed in FY 77, and the write-up will continue into FY 78.

1. Compare the toxicity of WSF's with synthetically produced WSF's. Exposures are flow-through, analyses by GC, and animals are pink salmon fry and

Eualus shrimp. These animals are relatively sensitive, small, have good laboratory survival, and represent a fish and crustacean. The rational for this experiment is: if the toxicity of the WSF and synthetic WSF with only about eight aromatic hydrocarbons are approximately equal, and if the GC measurements verify that the compositions of the aromatic hydrocarbons are equivalent, then compounds that are not measured by our GC procedure can be eliminated as significant contributors to the toxicity of WSF's. Many researchers believe aromatics to be most important, but conclusive direct evidence is lacking. This project was delayed, but began in FY 77, and will require about 2 man years of effort in FY 78 to finish.

2. Synergistic effects of toluene and naphthalene: Several current studies with fish and shrimp larvae strongly suggest that toluene and naphthalene have different mechanisms of toxicity, indicating that the toxicants probably have synergistic effects. If the toxicities are synergistic, this would help explain why simplistic experiments with single compounds have underestimated the toxicities of WSF. Specifically:

a. Determine if toluene and naphthalene have synergistic toxicities to pink salmon fry and Eualus shrimp under flow-through conditions. (1 man year).

b. Determine if toluene and naphthalene have synergistic effects on uptake and/or depuration in pink salmon fry and Eualus shrimp. (1/2 man year).

If these experiments demonstrate that these two toxicants are synergistic, further experiments investigating synergism will be in order--with temperature, dispersants, other compounds, etc--in FY 79 and later. A representative fish and crustacean were chosen because it is conceivable that the two aromatics may have synergistic toxicities to one species but not both species.

B. Larvae: We have conducted tests with crustacean larvae, before and during molting, including uptake-depuration tests. We will continue a significant effort examining the overall sensitivity of eggs and larvae.

1. Determine the sensitivity of eggs and larvae from several noncommercial species (such as barnacles, mussels, snails, sea urchins, etc). This project was cancelled in FY 77, when Civil Service delayed the hiring of Chris Broderson. (She is now on as permanent). Exposures will be static for these microscopic larvae, and will include WSF, toluene, and naphthalene. These animals are generally not important commercially, but as larvae, are important food organisms for the near-shore ecosystem and commercial species. We have tested crustacean larvae, as have others, but very little has been done with eggs and larvae from animals in other phyla. (1 man year).

2. Determine what concentrations cause larvae to be unable to swim. A variety of species will be tested with WSF, toluene, and naphthalene. Inability to swim will be interpreted as equivalent to death in the natural environment. This experiment is necessary because we have found large discrepancies in concentrations that cause "no motion death" in larvae of different species and life stages of crustaceans. Crustacean and noncrustacean larvae will be tested. (1/2 man year).

3. Determine the uptake and retention of hydrocarbons into new and old eggs carried by Eualus shrimp. Exposures will be WSF and isotope, and analyses by GC and liquid scintillation. Shrimp apparently have less ability to metabolize aromatic hydrocarbons, especially the embryonic forms. It is hypothesized that hydrocarbons absorbed into eggs may be retained for an unusually long time. (1/2 man year).

C. Sensitivity increase of smolts in seawater. Through bioassays, we have found that the sentivity of seawater adapted pink salmon, Dolly Varden, and sockeye was greater than sensitivity in fresh water when exposed to WSF, toluene, and naphthalene. First attempts at explaining this phenomenon through uptake and excretion experiments did not answer the question completely. Total effort-1/2 man year.

1. Determine the uptake of isotopes into tissues of freshwater and seawater adapted salmonid smolts. Although whole body uptake was essentially the same, the uptake into different tissues may be different. Dr. Robert Thomas (Chico State University) will be co-investigator for this experiment.

2. Determine the osmotic and ionic composition of blood in freshwater and seawater adapted smolts exposed to toluene and naphthalene. This should give data relevant to osmotic and ionic regulating interference by the toxicants. Dr. W. Stickle (LSU, Baton Rouge) will be co-investigator of this experiment, and has necessary analytical equipment; atomic absorption, flame photometer.

D. Long-term exposures: Long-term exposures have recently been possible because of the refinements made with flow-through exposures. Most flow-through tests to date have been crude attempts, with little or no verification of stable concentrations during exposure. We will conduct long-term exposures and compare the results with species we have previously tested in short-term exposures. Total effort - 2 man years.

1. Determine the effects of flow-through toluene and naphthalene exposures on growth and survival of pink salmon fry exposed at different temperatures. Tests will be 40 days long, with samples of fish taken at 10 day intervals for determination of effects on growth. This test will be replicated at three temperatures, to determine the effect of temperature on long-term exposures, because earlier tests have shown a dramatic difference between toluene and naphthalene at different exposures. Pink fry were chosen because they are economically important and grow well in the lab.

2. Determine the survival of one tolerant and one sensitive species to flow-through exposures of toluene, naphthalene, and WSF. Final selection of the species depends on current tests, but will probably be _Eualus_ shrimp and _Hemigrapsus_ crab.

E. Test the effect of intermittent air exposures on the sensitivity of intertidal species to toluene, naphthalene, and WSF. Exposure to air during and after exposure to toxicants may be an additional stress on intertidal animals, and cause decreased survival. Total effort - 1/2 man year.

1. Determine the sensitivity of several intertidal species to toluene and several intertidal species to toluene and naphthalene exposures, with and without intermittent exposure to air.

2. Determine the uptake, and especially the depuration pattern of intertidal animals exposed to labeled toluene and naphthelene, with and without exposure to air.

F. Dispersant testing: Literature review, R&D on methods of analysis and exposure will be probed. This will be a tooling-up exercise in preparation for expanded testing in FY 79. We intend to conduct a literature survey and identify the dispersants of interests in the fall, and conduct some preliminary tests with dispersants on fish and shrimp in the summer of FY 78. (1/2 man year). Main objective of the preliminary test will be the development of satisfactory exposure-dosing set-up, and methods of analysis.

G. Writing up of previous results. Some time will be spent finishing manuscripts from FY 77 research projects, primarily in the fall by the supervisors. (3/4 man year).

VI. General Strategy and Approach:

We approach the general problems such as temperature effects from at least three different but related tacts. First, we examine the acute toxicity of selected aromatics and eventually WSF's (all flow-through exposures) at each experimental temperature. Second, we measure the uptake-depuration patterns at each experimental temperature. Third, we attempt some evaluation of sublethal physiological effects of the toxicant at each temperature. Most studies involve comparisons between two aromatic components (toluene, naphthalene) and two species (pink salmon, shrimp). If the experimental variable (such as temperature) does affect toxicity, we should observe the differences in the bioassay tests. The tests will confirm if the affect applies equally to both components and both species. Supplementary data on uptake and sublethal physiological effects that should reinforce the observation and permit first attempts at understanding and interpretating the data.

The uptake experiments with isotopes are relatively inexpensive for analyses compared to analyses by GC for animals exposed to WSF's. After many isotope exposure experiments, the experimental design, conditions, times, and animals can be selected for the more detailed GC analyses which are very costly. We use Roubal's extraction procedure for estimating quantities of isotope that have been transformed to a metabolite.

VII. Sampling Methods: Not applicable to laboratory tests.

VIII. Analytical Methods:

1. WSF:

    a. Gas chromatography--Cheatham et al. in preparation. Standard type GC method, but our column has been run in the GC-MS system at Seattle for verification of output.

    b. Gas chromatography--mass spec. MacLeod. (Seattle lab may run some samples if needed).

    c. IR analyses by Gruenfeld 1973. (Toluene, naphthalene)

2. Pure compounds:

    a. UV spectrophotometry. (Neff and Anderson 1975)

3. Isotopes of pure compounds by liquid scintillation.

4. Tissue analyses:

    a. Isotopes by liquid scintillation. Total metabolites determined by method of Roubal.

    b. GC-MS for tissues exposed to WSF. (Seattle lab--MacLeod)

5. Metabolic rate measurements:

    a. Standard oxygen consumption rates--Gilson.

    b. CO_2 production from labeled glucose substrates.

6. Blood ions in salinity experiment:

    a. Chloride by a chloride titrator, Na, K, Ca by flame photometry.

IX. Anticipated problems:

Experimental and anlytical space has always been less than we desired but increases in FY 77 and some in FY 78 along with some reduction in people and funds will help alleviate this stress. The research schedule (mostly spring and summer studies) require intensive supervision of temporary employees to insure high quality in the experiments. To help alleviate our supervisory problems, our average grade level will be increased slightly, and we will have fewer nonexperienced technicians in FY 78. Furthermore, we will hire two Ph.D. supervisors to run cooperative studies on a limited basis during the summer research season of FY 78. These people will supervise two experiments for a short time, but at a time of intensive research. These people have been chosen for their proven research abilities and specific expertises they have.

Few of the experiments require substantial R&D. Therefore, most experiments should come to a productive conclusion. Our flow-through exposure systems for single components are highly evolved now, and the R&D for flow-through exposures with WSF's and synthetic WSF's are in progress now. (The early flow-through exposure set-ups that are currently published have been primitive and lacked quality control and monitoring, and are in need of further evolution.) Generally speaking, the biological measurements are pretty much straight forward and we have done them before.

The biggest problem I foresee is the inability to hire qualified people on a timely basis, a problem we have no control over. Normally, we can make adjustments to unforeseen problems by changing experimental designs or substituting a new species. However, delays in hiring caused by Civil Service preclude any adjustment flexibility, and we seem powerless to stimulate action on our personnel requests.

X. Deliverable products: In addition to required quarterly and annual reports, our data will eventually end up in scientific journals as reviewed publications.

We never start a research project unless we believe it will produce data for a scientific publication. Until this spring, our publications have been timely, and we will always reserve the fall quarter (Oct.-Dec.) for "catch up" through intensive manuscript preparation by all the intermediate and supervisory personnel.

XI. Information required from other investigators: We don't require any specific information from other investigators. We have and will continue to have coordination meetings and information exchanges with the Seattle NMFS Lab (Malins, RU #73), Tiburon Lab (Whipple, RU #389), and with Anderson (RU #454).

XII. Quality assurance plans: Our gas chromatograph column and WSF have been run in the GC-MS system at Seattle (MacLeod). Any new procedure or column will be verified through the Seattle Lab.

XIII. Special sample and voucher specimen archival: We will continue to archive samples of newly tested species in case the taxonomy becomes a problem at a later date.

XIV. Logistics requirements: None anticipated at this time.

XV. Management plan: We currently plan our projects at three levels. At the General level, as in proposals such as this, objectives are stated, and enough planning to determine feasibility, costs, and allocation of resources. Detailed Plans are drawn for each individual study. Experimental details are given, as well as logistical problems with space, collection of animals, personnel, etc. These plans are reviewed by our senior staff (Karinen, Rice, Korn, Mecklenburg, Lindsay, and others) to see if the plans are adequate, feasible, scientifically sound, and compatible with the use of the available facilities. Weekly Meetings schedule the next week's activities and coordinate the chemistry laboratory analyses with the wet laboratory tests. Allocation of support help is made at this time.

Individual laboratory technicians are all monitored by a senior staff person. Some functions are specialized, such as water analyses. We operate four service functions within our section: chemistry laboratory analyses (quality control by Lindsay); wet laboratory mix generation-cleanup (quality control by Korn); animal collection for all tests coordinated through Budke; and data management-statistics by computerized probits done by Misch.

Detailed plans for each study are due 60 days before the study begins and no later than December 15. This allows ample time for specialized construction, ordering of materials, and scheduling of experiments. When a unit of work is completed, a report with methods and results is due within 2 weeks. Manuscript assignments are then made.

	1st Q.	2nd Q.	3rd Q.	4th Q.
A. Toxic Components, Synergism				
1. Compare WSF and synthetic WSF toxicity	construct apparatus	test shrimp	test fish	
2. Synergistic effects-				
a. Bioassay	construct apparatus	test shrimp	test fish	test fish
b. Uptake-depuration		test shrimp	test fish	
B. Larvae				
1. Larval sensitivity of several species			test	test
2. Failure of larval swimming			test	
3. Uptake and retention of new and old shrimp eggs	test new eggs		test old eggs	G.C. analyses
C. Sensitivity increase in smolts adapted to S. W.				
1. Tissue uptake			test	test
2. Osmotic-ionic tests			test	test
D. Long-term exposures-				
1. Pink salmon fry growth		construct test apparatus		
2. Survival of several species	construct apparatus	test shrimp	test 2nd species	test 3rd species
E. Sensitivity of intertidal animal exposed to air				
1. Determine sensitivity		construct apparatus	test	test
2. Determine uptake-depuration				test
F. Dispersant R&D	Lit.Review			R&D
G. Writing of review work	Lit.Review			

XVI. The need for acute toxicity tests are dwindling, while the need rises for long-term exposure tests and intensive experiments.

Individual experiments are designed to provide pieces of information which when combined, will help to; (1) determine the effects of oil spills or chronic pollution will have on the ecosystem by determining lethal and sublethal effects on individual organisms, and (2) identify sensitive parameters or species which will be useful in monitoring the ecological impact of oil in the environment. We propose to continue studying these basic objectives by pursuing the following three themes:

A. Larval studies: we would increase our emphasis on larval studies because larval forms have been shown to be the life stage most sensitive to oil. Determining the relative sensitivities of larvae will help to evaluate the impact of oil on various communities.

The scan of acute toxicity of several noncommercial species will be completed in FY 78, along with more experiments involving uptake and the ability of larvae to rid themselves of hydrocarbons absorbed during egg and larval stages. Longer exposures requiring feeding, growth, and molting will be attempted with lower concentrations of pure compounds and WSF in FY 79. Exposures under different environmental conditions (salinity, temperature) will be attempted in FY 79-80. The effect of oil on energy consumption during exposure will be determined by effects on growth and/or oxygen uptake measurements. Crustacean larvae, herring, and pollack larvae will probably be the target species, since these species are economically important as a food source when adults, and are ecologically important as a food source for many species when they are larvae and juveniles.

The Auke Bay Laboratory is in the process of reprogramming, and will shift toward a heavy emphasis on larval studies. We expect to conduct similar research, such as the determination of caloric needs and efficiency for growth, <u>but during oil exposure</u>. This will take advantage of new personnel with larval expertise, and will be consistant with the goals of OCSEAP and the NMFS.

Uptake and depuration will usually be coupled with most studies since these experiments will indicate the rates at which various components of petroleum are metabolized in various species or life stages, and how tissue burdens of hydrocarbons relate to toxic and sublethal concentrations in the water. This information will be useful in evaluating the impact of oil in the environment when laboratory results and those from hydrocarbon baseline monitoring studies are compared.

B. Component and synergistic effects: the complex composition of oil suggests that many compounds probably contribute to toxicity, are likely to be synergistic and additive in nature, and research studying this general problem is likely to continue through FY 80.

Information on the relative toxicity of oil components and synergistic effects of components will be useful in determining the toxicities of different crude oils, by examining their chemical composition. This information will obviate the necessity of doing additional bioassays each time a new oil field goes into production.

The components most responsible for acute toxicity will be determined in FY 78, along with the first tests examining synergistic toxicity between components. Synergistic tests with a variety of components, and at different temperatures are likely to continue in to FY 79. We have found that the toxicity of some compounds (toluene) is affected greatly at different temperatures, while other compounds (naphthalene) are not. Tests at different temperatures, testing the synergistic effect of two compounds will be conducted in FY 79, after synergistic testing procedures are finalized in FY 78. Bioassays at various temperatures and salinities are necessary to determine the impact of spills at various times of the year and at different latitudes. Temperature has a profound effect on the toxicity of different oil components. Temperatures in Alaska waters vary by as much as 12° to 15°C between summer and winter conditions, therefore, these experiments have direct application.

Dispersant tests are also in the future, with tooling-up and R&D testing starting in FY 78. Dispersants probably change the WSF profile, and the components most responsible for toxicity may be different (assuming the new dispersants are relatively nontoxic). Dispersant tests identifying the class of compounds most responsible for toxicity and experiments examining synergistic effects will be in FY 79-80. Uptake-retention tests will be coupled with these tests.

C. Long-term exposures: the effect of long-term exposures on survival, growth, and reproductive capability will be explored in the future.

Bioassays comparing sensitive and apparently not so sensitive species in static and flow-through systems will help us further evaluate the impact of spills and chronic addition of oil to the marine environment. Enough static tests have been completed, and flow-through exposures of short and long-term are now needed. In some spills, exposures may be brief with concentrations rapidly declining while in chronic pollution, exposures will be of long duration. Animals of various phyla respond differently to oil, some being able to isolate themselves from high oil concentrations for short periods very effectively. These same animals when exposed to long-term chronic pollution appear to be much more sensitive than previously indicated by static bioassays.

The tests in FY 78 will be with feeding pink salmon fry, and other species will be tested in FY 79. These experiments will compare the prospects of vertebrate fish and invertebrates exposed to a chronic oil spill situation. A small crustacean species that molts frequently will probably be the target invertebrate. Juvenile herring, and pollack will be tested in FY 79-80. Measurements will include survival, growth, the efficiency of converting food calories into body mass.

Acquisition of new pieces of major equipment or instruments will be minimal. Upgrading our gas chromatograph (capillary columns, automatic injectors?) may be necessary. Acquisition of fiberglass tanks, waste treatment facilities, etc, will be necessary, but nothing of dramatic significance.

Our data output will remain the same. Annual and quarterly reports along with scientifically reviewed publications. Major milestones will be the identification and quantitation of the most significant toxic components of oil, and their mode of action on a variety of species when they are subjected to short and long-term exposures.

XVII. 1. Uptated 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 for 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 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 research

a. We will propose a small study on oil effects to fresh water life forms for continued funding to the Fish and Wildlife Service for less than $100k for FY 78. Many studies are similar in nature, but are restricted to fresh water forms. About $15k of this funding will be used for sample collection in HC baseline study for Prince William Sound, which is being supervised by John Karinen and Dr. William MacLeod.

b. Regular funding through NMFS provides salaries for 4-6 permanent personnel involved in OCSEAP funded research and also provides a small amount ($10k-$15k) of operating funds for physiology and fish larval rearing studies. This research compliments our OCSEAP funded study.

Statement of Intent.

Stan Rice will actively lead, coordinate and supervise the research studies in the contract. John Karinen will coordinate and administer the project, provide final quality control of research products, and supervise specific studies. Sid Korn will supervise specific portions of the project.

List of personnel assigned to project: brief resumes of key personnel. The staff collectively has over 30 years of experience with oil studies.

A. List of all personnel assigned to project

Personnel	Oil Research Experience in yrs.	Function
Karinen	6	Co-principal investigator-supervies project.
Rice	6	" " " "
Korn	6	" " " "
Lindsay	0.5	Chemical analyses of WSF's by UV and IR,
Arasmith	2	spectrophotometry and gas chromatography,
Andrews	1	preparation of synthetic WSF's, and tests.
Griffiths	-	Chem lab processing of isotope samples.
McKane	1	" " " " " "
Thomas	3	Metabolic rate studies with fish.
Moles	5	Larvae and adult uptake studies. Flow-through tests.
Misch	3	" " " " " " " "
Broderson	3	Larvae toxicity tests.
Bates	1	Flow-through toxicity tests.
Budke	-	Animal collection, diver.
Bonnett	3	Histological support of studies.
Lauren	0.5	" " " "
Stickle	1	Osmotic and ionic regulation physiologist.

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TITLE: Sublethal Effects of Petroleum Hydrocarbons and Trace Metals, Including Biotransformations, as Reflected by Morphological, Chemical, Physiological, Pathological, and Behavioral Indices

RESEARCH UNIT: 73

PRINCIPAL INVESTIGATORS: Donald C. Malins, PhD, DSc, Edward H. Gruger, Jr., PhD, Harold O. Hodgins, PhD, Neva L. Karrick, MS, Douglas D. Weber, MS

TOTAL COST OF PROPOSAL: $400,000

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June 17, 1977

TECHNICAL PROPOSAL

I. TITLE: Sublethal Effects of Petroleum Hydrocarbons and Trace Metals, Including Biotransformations, as Reflected by Morphological, Chemical, Physiological, Pathological, and Behavioral Indices

RESEARCH UNIT: 73

CONTRACT NUMBER: R7120819

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

II. PRINCIPAL INVESTIGATORS: Donald C. Malins, PhD, DSc
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Harold O. Hodgins, PhD
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III. COST OF PROPOSAL:

Total: $400,000

Distribution of effort by lease area: Totally non-lease specific area laboratory work

IV. BACKGROUND

Behavior

Many commercially important fish species, particularly pleuronectids, spend most of their life cycle in close association with bottom sediments. Recent studies conducted at the NWAFC, Seattle, show that chronic exposure of English sole to sediment contaminated with Prudhoe Bay crude oil (PBCO) results in weight loss and histological changes. In addition, starry flounder (Platichthys stellatus) and English sole (Parophrys vetulus) both demonstrate marked uptake of petroleum hydrocarbons from the environment.

Meaningful application of the above laboratory findings is partly dependent on whether flatfish can detect, and, if they have the opportunity, avoid oil contaminated areas.

The proposed studies are directed toward evaluation of avoidance of hydrocarbon contaminated sediment by commercially important flatfish species. In addition, experiments are projected to determine what behavioral modifications (e.g., increased exposure to predation, reduction in feeding activity) may be manifested by exposure to contaminated sediment at concentrations acceptable to flatfish.

At present, it appears that behavioral reactions precipitated by recognition of chemical cues are among the most sensitive to disruption by petroleum hydrocarbons. Such disruptions have been noted among marine organisms as diverse as bacteria, algae, and lower metazoans (Johnson 1977). For instance in invertebrates, hydrocarbon (chiefly aromatic) concentrations on the order of 1 ppb in seawater, inhibit chemoreceptive behaviors of a brachyuran and gastropod (Takahashi and Kittredge 1973; Jacobson and Boylan 1973). Preliminary studies conducted at the NWAFC, Seattle, show that the saltwater-soluble fraction (SWSF) of crude oil inhibits a chemotactic response related to reproduction of a nudibranch, Onchidoris bilamellata, at concentrations less than 15 ppb (OCSEAP Quarterly Report RU 73/74, June 1977). These biological disruptions were all produced by petroleum exposures of 24 hr or less.

For FY 78, proposed studies on chemoreception of invertebrates will focus on inhibition of reproductive chemotaxis of this nudibranch in relation to petroleum hydrocarbon exposures. In addition, similar experiments for evaluation of chemical dispersant effects will be initiated.

Petroleum hydrocarbons cause another disruption of nudibranch reproductive processes. Egg laying behavior and embryonic development are severely disrupted by SWSF exposures at the same concentrations as those causing chemoreceptive perturbations. It is proposed that experiments concerning nudibranch embryonic development following SWSF exposure be conducted along with those on chemotactic responses. Attempts will also be made to characterize petroleum constituents responsible for the different biological effects.

For highly mobile fish species the avoidance of polluted areas may in many instances significantly reduce the impact of a pollutant. Conversely, for species such as Pacific salmon, avoidance of certain areas (i.e., migratory routes and home spawning streams) because of pollution could result in greatly reduced reproductive success.

A preliminary field study to evaluate the effect of water-soluble, aromatic hydrocarbons on homing capabilities and home stream avoidance of adult salmon was conducted in the fall of 1976 (FY 77). A repeat of this study is projected for 1977 (FY 78) which will include: refinements in experimental design; comparison of migratory patterns of oil-exposed and control salmon using sonic tracking techniques; and detailed laboratory studies on avoidance reactions. Laboratory assays on avoidance of chemical dispersants by salmon will be initiated to determine if field studies are warranted in FY 79.

Chemistry

A significant amount of information was generated from this program and elsewhere (Varanasi and Malins 1977) on the accumulation of hydrocarbons in marine fish and invertebrates exposed to petroleum. Yet little data is available on the bioconversion of aromatic hydrocarbons in exposed marine organisms, on their tendency to accumulate aromatic metabolites, or on the transfer of aromatic hydrocarbons and metabolites through the food web. Moreover, virtually no information is available on the tendency of marine organisms to accumulate, metabolize, and excrete high molecular weight aromatic hydrocarbons or products of oxidative weathering. These aspects constitute a major defficiency in our understanding of the effects of petroleum pollution on arctic and subarctic marine life. In addition, renewed emphasis placed on the use of new chemical dispersants (Bocard et al. 1977) raises questions about their toxicity and influence on the accumulation and metabolism of hydrocarbon and metal components of petroleum. Another area of concern is the influence of toxic metals on the biological fate of petroleum, notably the high molecular weight aromatic hydrocarbon fractions and products of oxidative weathering.

In the present proposal, research activities directed toward the solution of these problems are outlined for FY 78 and areas of recommended research are suggested for FY 79 and FY 80. The overall effort should provide answers to a number of important questions related to arctic and subarctic oil drilling and transport operations.

A survey of the literature (Varanasi and Malins 1977) shows that the skin of fish, a primary site of contact with environmental contaminants, has been largely overlooked in studies concerning the fate and effect of petroleum in marine environments. Considering that certain species of fish, such as flatfish, frequently develop epidermal tumors whereas others (e.g., salmonids) rarely do (Hodgins et al. 1977), studies to investigate interactions of petroleum hydrocarbons with skin of different species of fish is of considerable importance. Preliminary studies (Varanasi 1977) from our laboratories demonstrated that skin of both saltwater adapted coho salmon, Oncorhynchus kisutch, and freshwater rainbow trout, Salmo gairdneri, accumulated significant concentrations of naphthalene and methylnaphthalene and their metabolites when the fish were force-fed parent hydrocarbons. Results on rates of uptake and discharge of the hydrocarbons and their metabolites in skin and liver revealed that the skin of salmonids is actively involved in hydrocarbon metabolism. Recently, Roubal et al. (1977) reported that, compared to coho salmon, starry flounder accumulated an order of magnitude higher concentrations of several water-soluble hydrocarbons in muscles and liver when the fish were exposed to SWSF of petroleum. A possibility exists that the skin of starry flounder, which has a high incidence of neoplasia in fish from certain areas, may also accumulate substantial amounts of hydrocarbons and may be actively involved in hydrocarbon metabolism. Future studies, planned to investigate uptake and discharge of several hydrocarbons and their metabolites in skin of different marine fish, should provide information on the degree of accumulation and retention of hydrocarbons and their electrophilic metabolites.

Pathology

In laboratory experiments conducted during the current OCSEAP contract period, English sole exposed to crude-oil-contaminated sediments for over 4 mo had a higher frequency of liver abnormalities and weight loss than did control fish on uncontaminated sediment (See OCSEAP Quarterly Report RU 73/74, June, 1977). After 4 mo, 19% of the oil-exposed group and none of the control group either died or were moribund, and in each case the affected fish was extremely emaciated. There was no detected microbial disease.

The most characteristic feature of livers in oil-exposed fish which were markedly abnormal was extensive hepatocellular lipid vacuolization.

Mild to moderate vacuolization was observed in livers from both groups, but only the oil-exposed group had the severe form, representing 21% of the fish sacrificed and examined histologically. Liver abnormalities in fish after hydrocarbon exposure have also been reported in rainbow trout (See OCSEAP Annual Report, RU 73/74, 1977) and in *Fundulus heteroclitus* (Sabo et al. 1975).

Certain hydrocarbons and trace metals which may be present in petroleum have been reported to inhibit disease resistance mechanisms in a variety of species, including fish (Robohm and Nitkowski 1974; Kripke and Weiss 1970; Stjernsward 1974). Preliminary research performed by us has demonstrated no significant differences between the survival rate of oil-exposed and non-exposed rainbow trout and coho salmon when they were challenged in laboratory experiments with *Vibrio anguillarum* (OCSEAP Annual Report, RU 73/74, 1977). However, it has been observed that starry flounder and English sole accumulated substantially higher concentrations of aromatic hydrocarbons than did coho salmon after exposure to PBCO (OCSEAP Annual Report, RU 73/74, 1977). This suggests that petroleum may affect disease resistance of flatfish more than it affects salmonid disease resistance.

In Alaskan waters, the main pathological conditions found in marine fish by members of our research group were epidermal papillomas of rock sole (*Lepidopsetta bilineata*) and flathead sole (*Hippoglossoides elassodon*); pseudobranchial tumors of cod (*Gadus macrocephalus*) and pollock (*Theragra chalcogramma*); lymphocystis of yellowfin sole (*Limanda aspera*); skin lesions in cod; and larval trematode infestations characterized by black spots in the skin of Pacific herring (*Clupea harengus pallasi*), toothed smelt (*Osmerus mordax dentex*), and saffron cod (*Eleginas gracilis*). Three of these conditions appeared to be caused by microbial pathogens: lymphocystis of yellowfin sole (viral), cod skin ulcers (bacterial), and cod ring-shaped skin lesions (viral). Bacterial and viral isolates from the above mentioned diseases are available in our laboratory. In addition, we have on hand approximately 100 other bacterial isolates from various species of fish with abnormalities from Alaskan waters (OCSEAP Annual Report, RU 332, 1977).

In the research we are presently proposing, studies will be continued to characterize the long-term pathological effects of oil exposure on marine fish, including possible effects on disease resistance mechanisms.

Morphology

During FY 76 and 77 coho salmon, chinook salmon (O. tshawytacha), starry flounder and English sole were sampled for electron microscopy after they had been subjected to various exposure regimens with petroleum components. Structural changes were observed in skin, gills, liver, eye lens (Hawkes 1977), intestine and kidney (Hawkes, unpublished data) of oil-exposed fish in comparison to nonexposed control fish. Excess mucous secretion occurred in the skin and gills and areas of epithelial sloughing were seen in the gills. Glycogen and lipid were depleted in the liver, the endoplasmic reticulum had proliferated and the frequency of myelin figures increased. Fibrosis was also noted around the sinusoids and other vascular structures of the liver.

Sloughing of the mucosa of the intestine was observed in some petroleum-exposed chinook salmon. In rainbow trout the lens volume doubled after the fish had ingested 1,000 ppm petroleum to food for 8 mo. Hydration appeared to be the primary factor contributing to size increase. Recently, blind coho salmon in net pens in Puget Sound which had been accidentally and intermittently exposed to diesel fuel oil for 3 mo were found to have hydrated and cloudy lenses. The correlation of the laboratory studies and field observations of damaged lenses after petroleum exposure illustrates the two directions this project will address: the identification of petroleum-induced cellular changes which may be deleterious and the use of such biological indicators in field situations. The proposed research includes additional studies which are both an outgrowth of our previous work and a development of new areas: specifically to identify surface structural changes in petroleum-exposed fish and larvae.

V. OBJECTIVES

The proposed multidisciplinary research involves a complementary intermeshing of activities of several phases of work: chemistry, biochemistry, biology, physiology, pathology, and ultrastructural analyses or morphology. The intermeshing of activities will yield a cohesive approach to the task objectives. That is, the results will provide information and data to evaluate the biological impact of oil developments in lease areas. The objectives embrace generally four areas of activity, plus continuation of some activities of the past year. Those four areas are (a) identification of the intermediary metabolites of petroleum constituents and determination of their retention in marine organisms with their possible transport in food chains; (b) determination of disease resistance of oil-exposed animals inoculated with potential pathogens isolated from diseased individuals collected in Alaskan waters; (c) determination of contaminant concentrations, localization, turnover rates, and alterations of cellular structure in key organs of selected species from selected exposure conditions; and (d) determination of the effects of chemical dispersants on marine animals.

In accordance with the four general objectives and continuing activities, the specific objectives of this proposal are as follows:

1. To determine the accumulation and retention of hydrocarbons and metabolic products in organisms exposed to petroleum hydrocarbons and heavy metals, including possible synergistic influence.

2. To determine the effects of petroleum constituents, including heavy metals, on the integrity and functions of skin, mucus, and egg membranes.

3. To determine if petroleum hydrocarbons present in the sediment (a) cause flatfish to avoid a contaminated area, and (b) interfere with normal feeding and activity patterns of flatfish.

4. To evaluate the effect of petroleum hydrocarbons and chemical dispersants on the reproductive processes (i.e., chemotaxis and embryological development) of a dorid nudibranch.

5. To determine whether (a) petroleum hydrocarbons present in water will modify the behavior of homing adult Pacific salmon by causing avoidance of their home stream and disrupting their homing capability, and whether (b) juvenile salmon can detect and avoid chemical dispersants/oil emulsions.

6. (a) to determine the pathological changes resulting from the exposure of various developmental stages of certain demersal marine fish to sediments contaminated with crude oil or petroleum products, and (b) to characterize effects on disease-resistance mechanisms of exposing marine fish to petroleum.

7. (a) To develop and refine ultrastructural criteria for assessing cellular damage to marine organisms at various stages of their life cycle after laboratory exposure to petroleum, and (b) to utilize morphological parameters in evaluating degree of damage to field-exposed aquatic organisms, especially marine Alaskan fish and invertebrates.

The specific objectives will provide information on the relative sensitivity of certain Alaskan marine fishes to the detrimental effects of oil contamination, with the eventual goal of approximating threshold levels of petroleum necessary to cause pathological changes. If such effects are found after petroleum exposures under conditions that realistically may be anticipated to occur environmentally, the information will be an important part of evaluating impacts of petroleum-related activities.

VI. GENERAL STRATEGY AND APPROACH

A multidisciplinary research program is proposed to provide information relating to the impact of petroleum hydrocarbons, trace metals, and chemical dispersants on arctic/subarctic marine organisms and ecosystems. The research activities will employ elements of cell biology, physiology, immunology, pathology, chemistry, behavior, and microbiology. The research is not site specific; general strategies and approaches of the program are given according to the principal disciplinary science involved, as follows:

Behavior

Flatfish Avoidance

Assessment of the effect of petroleum hydrocarbons and chemical dispersants on flatfish behavior will be conducted under laboratory conditions. The species of flatfish which will be considered for these studies are English, rock, and flathead sole, and starry flounder, all of which are of commercial importance. Experiments will be conducted in aquaria designed to provide the fish with a choice between contaminated and uncontaminated sediments. Various concentrations of PBCO will be incorporated into the sediment, which will encompass concentrations known to occur following oil spills. Results of these experiments should provide data concerning species differences in detection and avoidance of contaminated sediments, and the threshold concentrations which elicit avoidance behavior.

Concurrent studies will be conducted to assess behavior of flatfish forced to reside in contaminated sediment. Diurnal activity patterns, feeding behavior, and burying activity will be compared to behavior of control fish.

Invertebrate Chemoreception

Studies on evaluation of the effect of petroleum hydrocarbons and chemical dispersants on certain reproductive processes of an intertidal nudibranch will be conducted in the laboratory. The experimental design takes advantage of the animals chemotactic response which enhances the formation of mating aggregations. This conspecific aggregation is presumably mediated by one or more sex pheromones, and is apparently disrupted by ppb concentrations of petroleum hydrocarbons.

The dorid nudibranchs will be exposed to various concentrations of petroleum hydrocarbons and dispersants and then tested for chemotactic response to other reproductive individuals. Aliquots of eggs laid during the exposure period will be sampled regularly during the two week developmental period and compared with control eggs for spatial and temporal developmental differences.

Salmon Homing

Studies designed to evaluate the effect of petroleum hydrocarbons and chemical dispersants on salmon homing capabilities have both laboratory and field components.

In the laboratory, threshold concentrations of petroleum and chemical dispersants causing avoidance by juvenile salmon will be determined. The avoidance thresholds will be correlated with levels of detection expressed in electrophysiological responses of the olfactory system. Information gained from the laboratory experiments will then provide a basis for decisions on levels of petroleum hydrocarbons and dispersants to be used in salmon homing field studies.

The field studies proposed for FY 78 consist of two experiments. In one, an evaluation will be made of the concentrations of petroleum hydrocarbons introduced into the water which will deter spawning salmon from entering the homestream. The other is designed to determine if 16-24 hr exposures to petroleum concentrations below avoidance level thresholds cause disruption of homing capabilities. These capabilities will be evaluated on the basis of timing of return to the homestream, or disorientation and straying to other spawning sites.

Chemistry

Biotransformations of Petroleum Hydrocarbons

Studies will be continued on the determination of metabolites in flatfish because of evidence showing that these fish accumulate substantial amounts of aromatic hydrocarbons from the water column. The studies will involve animals challenged through the diet with isotopically labeled polynuclear aromatic hydrocarbons, notably methyl-substituted naphthalenes. In addition, we will determine the extent to which metabolites are transferred through a food web: that is, worms or other dietary organisms, will be administered both radioactive hydrocarbons and metabolites, and then will be fed to starry flounder. The extent of accumulation of both types of aromatic structures will then be elucidated in key tissues (e.g., liver and muscle) of the flatfish and in the whole body tissues of the dietary organisms.

Effects of Contaminants on Plankton

Selected marine planktonic organisms including larvae of commercially important species (shrimp, crab, 4 fish species) as well as the larvae and adults of holoplanktonic organisms (copepods, euphausiids) will be exposed to petroleum hydrocarbons, petroleum hydrocarbons and dispersants, and radioactively-labeled hydrocarbons and the uptake, metabolic conversion and elimination of these compounds will be measured. Metabolites will be characterized where possible and the transfer of metabolites and parent hydrocarbons will be followed through several levels of a planktonic food web (i.e., algae, copepod, shrimp larvae, larval fish).

Petroleum Hydrocarbon Metabolism in Relation to Skin and Mucus

Studies will be designed to determine the role of skin and mucus in the assimilation, metabolism, and excretion of various petroleum hydrocarbons (e.g., naphthalene, methylnaphthalenes) in fish exposed to these compounds in flowing water or diet. Several species of fish will be considered with special emphasis on coho salmon and starry flounder. Moreover, to under stand clearly the interactions of the metabolic products of hydrocarbons with subcellular components of skin, measurements on existing and induced aryl hydrocarbon hydroxylases (AHH) together with characterization and quantitation of the metabolites will be carried out. Preliminary studies of this type are in progress in our laboratory.

Interactions *in vivo* of Petroleum Hydrocarbons and Trace Metals

Present research includes the possible effects of lead and cadmium *in vivo* on petroleum aromatic hydrocarbon metabolism. If the present work shows that the relative distribution of aromatic hydrocarbon metabolites has changed due to the presence of metals, research would then focus on how metals influence the affected aromatic hydrocarbon metabolic pathways.

At present, there is little information on possible effects between petroleum hydrocarbons and heavy metals that may affect the development of fish eggs. Lead and cadmium are known to be toxic to eggs of marine species. Cadmium binds to the chorion of eggs and this may induce alterations in toxic effects of petroleum hydrocarbons on fish eggs. Petroleum hydrocarbons have been shown to alter membranes (Roubal and Collier 1975). Such changes could affect the transport of lead and cadmium across the chorion and have subsequent effects on egg viability. The proposed work would determine possible interactive effects of petroleum hydrocarbons and heavy metals (lead and cadmium) on the development of marine fish eggs, specifically of starry flounder. In addition, preliminary studies would be initiated to determine whether heavy metals alter the activity of the hatching enzymes, namely chorionases. Further, ultrastructural analyses will be performed on eggs to delineate possible morphological alterations in membranes associated with the proposed petroleum hydrocarbon metal exposures.

Pathology

Oil Contaminated Sediments

During the current contract period, the facilities and equipment needed for exposing various flatfish species to bottom sediment from Alaskan beaches experimentally contaminated with crude oil will be improved. The uptake of petroleum hydrocarbons by several species of flatfish found in Alaskan waters, such as starry flounder, rock and flathead sole, will be measured.

During the proposed contract period, representative species and life stages of flatfish will be placed in aquaria containing Alaskan beach sediment contaminated with crude oil or in aquaria containing uncontaminated sediment (See OCSEAP Annual Report, RU 73/74, 1977, for design of aquarium system). Periodically, during the 3 to 6 mo length of each experiment, all the fish will be weighed and measured; also, a subsample of individuals will be sacrificed. From these latter animals, blood will be collected for standard hematological tests, and tissue samples will be excised for histopathological examination (both light and electron microscopy) and for analyses for petroleum hydrocarbons. Test fish will be examined systematically for behavioral differences and for obvious health problems.

Disease Resistance

The effects of petroleum hydrocarbons on disease resistance mechanisms will be examined by *in vivo* and *in vitro* techniques. *In vivo* experiments will involve challenging oil-treated and control (untreated) marine fish with bacterial and viral pathogens isolated from diseased Alaskan fish by members of OCSEAP RU #332 during baseline fish disease studies in the Bering Sea and Gulf of Alaska. During a preliminary phase of the *in vivo* tests consisting of 2 to 3 mo, the above mentioned microbial pathogens will be screened for pathogenicity to flatfish and other selected marine fish species. The pathogenic microorganisms will be used in challenge experiments in which the susceptibility of groups of petroleum hydrocarbon-exposed fish, challenged with serial tenfold dilutions of a pathogen, calculated as the LD_{50}, will be compared to the susceptibility of control fish to the same microorganisms. Challenged fish will also be monitored for gross pathological, histopathological, and hematological changes.

In vitro tests will compare the humoral and cell-mediated immune responses of oil-exposed and control fish. Humoral immunity, which functions in combating bacterial infections, will be measured by a variety of procedures, including bacterial agglutination titrations for fish immunized with bacterial vaccines, and the Jerne Plaque technique for fish immunized as above or with lipopolysaccharide antigens. Cellular immunity is active during viral infections and is being actively investigated in mammals for its role in tumor immunity. Tests of effects of petroleum on cellular immunity in fish will be performed in close cooperation with a recognized authority on cellular immune responses (Dr. Jacques M. Chiller).

Morphology

Lens Abnormalities

Based on both laboratory and field observations that petroleum hydrocarbons appear to induce lens changes which range from volume increases to cataracts and blindness, further studies are proposed to define the scope of this problem and to examine some of the mechanisms involved in lens damage.

Ultrastructural Changes after Oiled-Sediment Exposures

Many samples have been taken during exposures of flatfish to petroleum in sediments (See Pathology section). These experiments have already demonstrated histological changes in the liver. We propose to examine the plastic embedded tissues from affected fish for ultrastructural changes. Dr. Bruce B. McCain is processing tissues from sediment-exposed fish for conventional (light microscope) histology. Samples from the same fish have been embedded in plastic for ultrastructural examination when the histological data indicate such analysis are appropriate.

Ultrastructural Changes in Eggs and Larval Fish

Both laboratory and field studies are planned to initiate ultrastructural investigations of unfertilized and fertilized eggs and larvae of species which are likely to be exposed to petroleum in saltwater. This phase of work includes collaborations with John Karinen and Dr. Stan Rice, Auke Bay Laboratory, NWAFC, Alaska.

Laboratory studies (in collaboration with Dr. William Reichert) on controlled exposure of fish eggs to petroleum are planned for the spring of 1978 as eggs become available. Scanning electron microscopic examinations of fertilized pollock (T. chalcogramma) and flatfish (P. vetulus) eggs, some of which have been exposed to oil-contaminated bilge water is presently underway. These eggs were collected in the Bering Sea in May 1977.

As material becomes available, we propose to continue acquiring a reference collection of Alaskan adult fish tissues, larval fish, and pelagic eggs for morphological studies.

VII. SAMPLING METHODS

Behavior

Flatfish Avoidance

Experiments on flatfish avoidance of contaminated areas make use of normal behavioral activity, i.e., burying or partially covering themselves with sediment during daylight hours, and lying on top of the sediment or swimming in the water column at night.

The experimental tanks are designed so each quadrant of the bottom is separated from the others and will contain either control or contaminated sediment. The water column extends above the quadrant partitions for fish movement from one area to another. Flatfish will be introduced into the experimental tanks and allowed to distribute overnight. Each morning the number in oil-contaminated and non-contaminated quadrants will be determined.

In concurrent experiments on flatfish confined to contaminated sediments, measurements of activity will employ mechanical or electrical monitoring of movement in relation to a diurnal cycle. Response to food, sound, and variations in light intensity will also be evaluated.

Invertebrate Chemoreception

Dorid nudibranchs will be exposed to selected chemical dispersants, aromatic hydrocarbons, and dispersant-hydrocarbon combinations. Immediately following exposure their ability to recognize and move toward an aggregate of unexposed reproductive conspecifics will be assayed in a testing apparatus (for specifics refer to OCSEAP Quarterly Report RU 73/74, June 1977).

Egg masses laid during the hydrocarbon-dispersant exposure period will continue to be exposed at the same concentration for the 15-day period normally required for development and hatching. During the development period egg aliquots will be taken daily and examined for developmental anomalies.

It is projected that threshold concentrations of hydrocarbon-dispersants causing chemotactic and developmental disruption over a 24 to 72 hr exposure period will be evaluated first. As studies progress duration of exposure will be extended and correlated with possible changes in threshold concentration.

Salmon Homing

The specific salmonid species and number of fish to be tested in the salmon homing studies cannot be precisely quantitated *a priori* due to seasonal and annual variability; however certain elements of the exposure regime for petroleum hydrocarbons have been determined. In both field and laboratory experiments salmonids will be exposed to the following model mixture of aromatic hydrocarbons and/or single molecular species of the mixture.

Aromatic species*	% by weight in mixture
benzene	7.9
toluene	56.5
ethylbenzene	2.0
m,o-xylene	9.5
p-xylene	16.6
1,2,4-trimethylbenzene	7.5

(* These six compounds were found to be consistently present at high levels in the saltwater soluble fraction of PBCO).

The chemical dispersants to be screened for detection and avoidance in laboratory experiments have yet to be determined.

A. Laboratory studies

Avoidance behavior of juvenile salmonids to petroleum hydrocarbons and chemical dispersants will be assessed in a Y-shaped choice chamber. The model mixture and dispersants alone, and in combination, will be evaluated to determine avoidance threshold concentrations and levels at which stress responses (e.g., rapid swimming and changes in opercular movements) first appear.

Concentrations of petroleum avoided in laboratory studies by juvenile salmon may have to be adjusted somewhat for the home stream avoidance field studies with adult salmon. Thus, initial field testing will use concentrations found to be within the stress-avoidance window. Avoidance threshold concentrations will also be correlated with detection thresholds as expressed by electrophysiological responses from the olfactory system of both juvenile and adult salmon.

B. Field studies

1. Studies on avoidance of the home stream by adult salmon when aromatic hydrocarbons are present in the water will be conducted in a western Washington creek at the point where it enters salt water. At the site tentatively selected there is a dam with a central spillway and on each

side there are identical fish ladders with trapping facilities at the head of each ladder. Anticipated fish species entering this stream are pink, coho and chum salmon (O. keta), plus cutthroat (S. clarkii), and steelhead trout. Testing of avoidance behavior will concentrate on the coho salmon segment of the run. During each test the model mixture of aromatic hydrocarbons will be introduced in one ladder for 16-24 hr; the other ladder will serve as a control. At the end of each test the number of fish trapped at the head of each ladder will be determined. Each ladder will alternately be used as test or control. The number of tests conducted is dependent upon the size of the run and its duration, neither of which can be predicted accurately at this time.

2. On studies designed to test possible petroleum disruption of homing orientation and capability, approximately 250 (10 replicates of 25 fish each) jack coho salmon will be captured at their homing site and exposed to the model mixture of aromatic hydrocarbons for 16-24 hr in a flow-through system. The fish will then be transported back offshore in Puget Sound and released at two or three points several miles distant from the homing site. Two-hundred-and-fifty jack coho salmon treated identically except for petroleum exposure will serve as controls. The home stream, commercial fishery, and adjacent streams will be monitored daily to determine the proportion returning and time between release and recovery. In addition, it is anticipated that from each replicate at least one fish, either oil-exposed or control, will have a sonic tag applied and its migration route plotted following release.

Biotransformations of Petroleum Hydrocarbons

Key tissues of starry flounder force-fed a radioactive polynuclear aromatic hydrocarbon (PAH) will be excised and analyzed for metabolites. Starry flounder will also be fed live food organisms containing radiotracers, and the fish will be sampled in two regimes: (1) food organisms, e.g., molluscs, which do not contain an active AHH system, will be impregnated with metabolites of PAH (e.g., 1-naphthol) and then fed to the fish; (2) food organisms containing an active AHH system will be impregnated with PAH and metabolites. After several weeks tissues of starry flounder will be collected for metabolite identification via high pressure liquid chromatography (HPLC) and related techniques. The flounder will be subsequently analyzed for transferred radioactive aromatic structures from the food web organism.

Effects of Contaminants on Plankton

Animals will be obtained using a number of different techniques. Gravid adults will be either stripped of their gametes or held until the larvae are hatched. Some animals are suitable to culture and will be kept in this manner. Plankton nets will be employed to sample seasonally available organisms.

The organisms will be tested using flow-through techniques and will be exposed to SWSF as well as radioactively-labeled hydrocarbons. The organisms and the exposure condition will be monitored to give data suitable for statistical interpretations.

Petroleum Hydrocarbon Metabolism in Relation to Skin and Mucus

A. About 20 to 30 fish (coho salmon and starry flounder) will be exposed to radioactively-labeled naphthalene and methylnaphthalene via force-feeding and in flowing water in conjunction with other investigators of this research unit. Samples of epidermal mucus and skin will be obtained as described previously (Malins et al. 1977). At each data point 4 to 6 fish will be sampled and concentrations of hydrocarbons and metabolites will be measured as described previously (Roubal et al. 1977). Data will be treated statistically to fit appropriate probability functions (Eberhardt and Gilbert 1973).

B. Characterization and quantitation of the metabolites accumulated in skin will be undertaken by thin-layer chromatography (Roubal et al. 1977, Jerina et al. 1970). Also, samples will be sent to NNAF for analyses by HPLC.

C. The AHH measurements and in vitro metabolism of naphthalene in skin microsomes will be carried out using methods described for hepatic tissues of fish (Gruger et al. 1977). Fish will be exposed to non-radioactive naphthalene or methylnaphthalene for a period of up to 6 weeks. A minimum of 6 test and 6 controls will be used for statistical treatment of the data.

Interactions *in vivo* of Petroleum Hydrocarbons and Trace Metals

Eggs from selected species will be exposed to varying concentrations of lead, cadmium, and petroleum hydrocarbons singly and in combination. The eggs will be observed from fertilization to hatching and such parameters as hatching rate, embryonic activity, viability of hatch, and time to hatching, will be followed. Chorionases from fertilized eggs will also be isolated from exposed eggs and examined for activity.

Pathology

Oil Contaminated Sediments

Depending upon the size of fish available at the time an experiment is initiated, between 40 and 60 fish will be used per aquarium for testing each sediment type or oil concentration. Each fish will be freeze-branded with a different set of symbols. Prior to oil exposure, two weeks after initial exposure, and at monthly intervals for the duration of each experiment, all the fish will be weighed and measured. Also, at these intervals, 3 to 5 fish from each aquarium will be bled for hematological testing, autopsied, and tissue specimens collected for histopathological examination and hydrocarbon analyses.

Disease Resistance

Fish to be used in disease resistance experiments will be maintained in 4 ft diameter fiberglass tanks with or without oil-contaminated sediment. Between 100 and 150 fish will be kept in each tank. After a 2 to 3 mo exposure, 50 fish from each tank will be used in challenge experiments by dividing them into 5 groups of 10 fish each. Each group will be injected intraperitoneally with a serial tenfold dilution of a suspension of a pathogen or subjected to a bacterial bath challenge. The bacteria-exposed fish will be held in special aquaria in an isolation room until completion of the challenge test.

Morphology

Tissue samples for light and electron microscopy will be processed as previously described (Hawkes 1977).

Samples will continue to be taken at regular intervals from ongoing experiments which include flatfish exposed to petroleum sediments (see Pathology section).

Samples of major organs for microscopic analysis have been collected from the most severely affected coho salmon from mariculture pens near a diesel oil spill site (Squaxin Island, Puget Sound, Washington), as well as from the least affected salmon at the site. Whole eyes and lenses from these fish are of primary interest and have been measured for volume change, prepared for microscopy, and frozen for future chemical analysis. The following samples were also taken: water samples taken at 4 depths and 2 sites, sediment samples beneath the most and least affected holding pens; tissue samples of the least- and most-exposed coho salmon from the penned area; and the edible mussel (*Mytilus edulis*). These samples have also been frozen for chemical analysis.

Fish eggs and larvae have been sampled and prepared for scanning and transmission electron microscopy from collections made by non-OCSEAP supported personnel on a NOAA cruise in the Bering Sea. We propose to continue building a reference collection of samples and subsequent micrographs of normal structure for future comparison in the event of an oil spill. In addition, laboratory studies on the effects of petroleum on egg membrane surfaces in unfertilized and fertilized eggs and larval fish would entail exposure of salmon eggs (pink or chum) and another species (e.g., starry flounder) to PBCO. The direct or possible synergistic effect of cadmium and lead on one species of fish eggs will be investigated with microscopy and energy dispersive analysis to localize trace metal accumulation in specific sites or structures of the eggs.

VIII. ANALYTICAL METHODS

Quantitative analysis of PAH and metabolites in tissues of starry flounder and food organisms will be performed by scintillation counting of radioactive fractions obtained by thin-layer chromatography and HPLC. These techniques will be augmented by gas chromatography and mass spectrometry (GC/MS) for qualitative analyses. The actual HPLC and GC/MS work will be performed by the NOAA National Analytical Facility (NNAF).

Tissue samples from animals exposed to SWSF will be analyzed by infrared spectroscopy (IR), ultraviolet spectroscopy (UV), GC, MS. These analyses will be completed by NNAF. Experiments employing radioactive material will be monitored by liquid scintillation spectrometry. Metabolic conversion will be quantified using the techniques of Roubal et al. (1977) and identification of specific metabolites will be by HPLC. The GC and MS work will be performed by the NNAF. Hydrocarbon concentrations will be monitored by IR, UV, and GC.

Concentration of hydrocarbons and their metabolites in skin and mucus will be measured by previously established methods (Roubal et al. 1977).

<u>In vitro</u> metabolism of naphthalene in skin microsomes of coho salmon and starry flounder will be carried out using the method of Jerina et al. (1970).

Native and induced AHH activity will be measured by methods previously used for hepatic tissues of fish (Gruger et al. 1977).

Characterization of metabolites will be undertaken using HPLC and thin-layer chromatography (Roubal et al. 1977, Jerina et al. 1970).

The analyses of hydrocarbons by GC and metabolites by HPLC will be done by the NNAF.

The procedures used will include liquid scintillation spectrometry to quantitate radioisotopes. Separation of compounds such as metabolites will be done by HPLC techniques and gel chromatography. Gel chromatography will be used to separate protein structures. The HPLC work will be performed by NNAF.

Pathology

Procedures used to assess the effects of exposing marine fish to oil-contaminated sediments will include the following: histopathology, utilizing both light and electron microscopy (scanning and transmission); analyses for petroleum hydrocarbons which will be performed by the NNAF; hematology, which will include measurements of hematocrit, differential leucocyte counts, total RBC and leucocyte counts, and hemoglobin determinations. Disease resistance studies will utilize standard microbiological and immunological techniques for quantitating antibody, cellular immunity, and resistance to bacteria.

Morphology

Microscopic analysis will include the following: light microscopy including histochemical staining reactions for connective tissue and acid phosphatase activity. Scanning and transmission electron microscopy for evaluation of surface and intracellular alterations.

Chemical analysis will include the following: Energy dispersive analysis (in conjunction with scanning electron microscopy) to identify inclusions and/or specific elements of interest, such as lead or cadmium in starry flounder eggs. The NNAF will employ GC/MS to identify petroleum uptake in tissues which exhibit morphological alterations.

IX. ANTICIPATED PROBLEMS

No major problems are anticipated.

X. DELIVERABLE PRODUCTS

Narrative reports and manuscripts will be prepared describing in detail all methods used together with results of the investigations. In addition, visual data in the form of figures and tables will be prepared for presentation at appropriate scientific meetings.

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS N/A

XII. QUALITY ASSURANCE PLANS

The NNAF will participate in intercalibration analyses in cooperation with other OCSEAP laboratories, e.g., Battelle Columbus. These will include tissue and sediment samples as submitted by the National Bureau of Standards. Analytical methodology, where applicable, will be fully described and made available to cooperating laboratories. Exposure techniques, as well as physiological and biochemical methods, will be the best available and will be coordinated insofar as possible with other OCSEAP projects, e.g., Battelle Northwest and NWAFC Auke Bay Laboratory.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLANS

Specimens will be frozen or placed in fixative and stored at NWAFC. These specimens will represent the species used for experimental studies.

XIV. LOGISTICS REQUIREMENTS N/A

XV. MANAGEMENT PLAN

Overall supervision of the program will be undertaken by the Director of the Environmental Conservation Division (Dr. Malins) or Dr. Gruger in his absence. In practice the program will be jointly supervised by the principal investigators as delineated on the cover sheet. Direct supervision of the various phases of research will be generally as follows:

Accumulation, metabolism, and depuration studies with petroleum hydrocarbons and metals----------------Dr. Malins

Disease and morphological studies---------------------Dr. Hodgins

Behavioral studies-------------------------------------Mr. Weber

Coordination of analytical work-----------------------Dr. Gruger

XVI. OUTLOOK

Behavior

Results of laboratory studies on flatfish avoidance of contaminated sediment should be subsequently confirmed with field evaluation. The mechanics of a field study must await a planned contamination or take advantage of an accidental oil spill. In preparation for these latter events, experiments are projected in FY 79 to test the feasability of monitoring flatfish movement using sonic tracking techniques.

The FY 78 studies on dorid nudibranchs include exposure to both petroleum hydrocarbons and chemical dispersants. If the nudibranch proves to be a model organism for evaluation of contaminants on reproductive processes of marine invertebrates, experiments on the possible synergistic effect of hydrocarbons-dispersants should be evaluated in FY 79. These studies would include threshold concentrations of contaminants causing disruptions in chemotaxis and embryonic development under a variety of exposure intervals. These studies would be completed by the end of FY 79 with no projected increase in funding over FY 78 levels or additional major equipment.

Results of studies concerning the effect of petroleum hydrocarbons on homing of Pacific salmon should provide by mid-FY 78 data in three categories: (1) Concentration of aromatic hydrocarbons present in the water which will deter adult salmon from entering their home spawning stream; (2) Possible effect of aromatic hydrocarbons on orientation and migration of adult salmon at concentrations less than those which cause avoidance; and (3) Supplemental data on studies previously conducted concerning avoidance of petroleum hydrocarbons by juvenile salmon (e.g., Rice 1973). The remainder of FY 78 will be devoted to laboratory studies on avoidance of salmon by chemical dispersants.

Assuming that the new generation of chemical dispersants are not toxic to marine life at levels projected for use, there still remains the same question of detection and avoidance by salmon and the consequences of avoidance on migratory and spawning behavior. Preliminary laboratory studies on juvenile salmon avoidance to dispersants alone, and in combination with petroleum hydrocarbons, should be completed by the end of FY 78. Provided these latter laboratory experiments indicate a potential disruption of salmon migratory behavior, field studies will be considered for FY 79; probably with an experimental design similar to that planned for the current proposal.

The data products of FY 79 will be the same as anticipated by mid FY 78. There is no expectation for increase in cost over FY 78 levels or addition of major equipment.

Chemistry

The following phases of work are of prime importance in future contract years:

A. Delineate the potential for forming toxic metabolites (e.g., arene oxides) of hydrocarbons in organisms exposed to petroleum and toxic metals (continuation of present activities); synergistic/antagonistic effects of toxic metals with each of the other two types of contaminants would be studied.

B. Determine the extent of food-web transport of hydrocarbons and metabolic products in exposure regimes which include influence of toxic metals.

C. Evaluate the potential for bottom-dwelling organisms to accumulate and metabolize petroleum components when exposed to petroleum-impregnated sediments.

D. Evaluate the influence of chemical dispersants on petroleum bioaccumulations and metabolism.

E. Evaluate the bioaccumulation and metabolism of petroleums subjected to oxidative weathering with and without presence of toxic metals.

F. Evaluate the bioaccumulation and metabolism of high molecular weight components (e.g., resinous materials) of petroleum with and without toxic metals.

Activities A, B, C, and D would be emphasized in FY 79 and be continued in FY 80; activities E and F would be initiated in FY 80, but should receive continued emphasis thereafter. The activities of FY 79 would provide a broad understanding of the biological fate of important petroleum components in the range of 1-5 benzenoid rings, with and without the influence of toxic metals and chemical dispersants; the activities of FY 80 would provide an initial understanding of the biological fate of high molecular weight compounds (e.g., resinous substances) and oxidized components of petroleum which have been almost entirely neglected. The influence of toxic metals on the biological conversions would be investigated. Considerable emphasis would be placed on eggs and larval forms in both FY 79 and FY 80. Activities A, B, C, and D would constitute a major plateau of accomplishment; activities E and F would then represent a change in the direction of the research.

A number of manuscripts describing the findings of activities A, B, C, and D would be written in FY 79; the accomplishments of activities E and F would be similarly repeated in manuscript form, starting in FY 80.

Pathology

The final results and data products anticipated are as follows:

1. Pathology - an evaluation of the pathological effects of petroleum on marine fishes will be attained by investigating the following: (a) the

relative sensitivity of different species and various developmental stages to the effects of oil, (b) the threshold levels and exposure times necessary for production of detectable abnormalities, (c) the histopathological characteristics of petroleum-induced abnormalities, and (d) the pathological effects of various fractions and/or components of petroleum and petroleum dispersants on marine fish.

2. Disease resistance - If challenge experiments with pathogens and/or in vitro tests of humoral and cell-mediated immunity conducted during FY 78 demonstrate that exposure of flatfish to petroleum or petroleum dispersants causes inhibition of disease-resistance mechanisms, then efforts will be continued to evaluate (a) threshold levels of exposure, (b) mechanisms of inhibitory effect, and (c) components of petroleum which cause the effects.

3. Data products - Data resulting from the above mentioned research will be in the form of figures, tables, photomicrographs, written narratives, and journal publications.

Milestones that will be attained and approximate times of completion are as follows:

1. Pathology - (a) Comparison of 4 species of flatfish for the pathological effects of petroleum (Middle of FY 79), (b) Estimate levels of petroleum in sediment necessary to produce detectable pathological effects on certain species (End of FY 79), (c) Characterization of the types of pathological effects caused by petroleum in certain marine fish (Middle of FY 79); and (d) Evaluate fractions of petroleum for their pathological effects and attempt to identify the compounds causing these effects (End of FY 80).

2. Disease resistance - (If experiments performed during FY 78 demonstrate that petroleum inhibits the disease-resistance mechanisms of certain

marine fish, the milestones listed below will apply. If no such inhibition is observed during FY 78, this experimental approach will be terminated.)

(a) Determine levels of petroleum and exposure times necessary to cause immunological defects in important species of fish (End of FY 79); (b) Evaluate which pathogens are aided by the defects (End of FY 79); (c) Further define, using in vitro tests, the disease resistance mechanisms which are affected by petroleum (End of FY 79); and (d) Determine which components of petroleum are responsible for disease resistance inhibition (End of FY 80).

Morphology

The final results expected are as stated in the two major objectives for FY 78: to define cellular parameters which reflect changes from exposure to petroleum and to apply these criteria to field-spill conditions in assessing the degree of damage to biota.

Significant milestones will be understanding the etiology of lens changes so that this, indeed, can be used in field evaluations. Cloudy lenses are easy to identify by visual inspection and provide an immediate estimate of severity of damage.

In addition, the continuation of sampling of rainbow trout that have been exposed to low levels of petroleum for a long period of time (2-5 yr) to ascertain if neoplasia develops is another significant data point which can be obtained only through long-term studies.

In FY 78 we are applying knowledge on structures affected by petroleum, gained from examination of model species (e.g., rainbow trout), to species (e.g., pink salmon) which may experience environmental oil contamination. Documenting the response of previously identified "target organs" or cells in the Alaskan biota is a major milestone.

COST:

FY 1979 - 525 K   FY 1980 - 575 K

Major equipment required for the proposed studies is currently available at the NWAFC.

FUTURE FIELD EFFORTS:

Sampling from Alaskan waters of organisms likely to be exposed to petroleum.

Sampling after petroleum exposure in the field, either a controlled, experimental spill or accidental spill.

XVII. 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. 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 (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 Burea 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 #: 73 PI: Malins

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

MAJOR MILESTONES	1977 O	1977 N	1977 D	1978 J	1978 F	1978 M	1978 A	1978 M	1978 J	1978 J	1978 A	1978 S	1978 O	1978 N	1978 D		
BEHAVIOR																	
Flatfish Avoidance																	
1. Development of experimental design and testing apparatus				Δ													
2. Effect of hydrocarbons on flatfish avoidance														Δ			
3. Manuscript on Item 2.															Δ		
Invertebrate Chemoreception																	
1. Effect of specific aromatics on chemotaxis and embryo development										Δ							
2. Manuscript on studies completed on Item 1.											Δ						
3. Effect of chemical dispersants and hydrocarbons-dispersants on chemotaxis and embryo development																	

MILESTONE CHART

RU #: 73 PI: Malins

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			
BEHAVIOR																		
Salmon Homing																		
1. Laboratory studies on avoidance of petroleum hydrocarbons			Δ															
2. Field studies on effects of petroleum hydrocarbons on homing capabilities					Δ													
3. Report on effect of hydrocarbons on homing						Δ												
4. Laboratory studies on avoidance of chemical dispersants													Δ					
5. Field studies on effects of chemical dispersants on homing capabilities																Δ		
CHEMISTRY																		
Biotransformations of Petroleum Hydrocarbons																		
1. Force-feeding ^{14}C-hydrocarbons/metabolites									Δ									
2. Flow-through exposures												Δ						
3. Determine cellular sites of absorption													Δ					
4. Manuscript on biotransformations											Δ							

MILESTONE CHART

RU #: 73 PI: Malins

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		
CHEMISTRY																	
Contaminants and Plankton																	
1. Acquisition of gravid adults	Δ			Δ			Δ										
2. Testing crustacean larvae							Δ										
3. Testing vertebrate larvae								Δ									
4. Testing wild planktonic forms														Δ			
5. Manuscript on plankton, etc.														Δ			
Skin and Mucus Studies																	
1. Determination of hydrocarbons and metabolites in skin of salmon and bottom fish												Δ					
2. Characterize and quantitate metabolites in skin of salmon and bottom fish												Δ					
3. Hydrocarbon metabolism determined in skin of fish (AHH activities and metabolism *in vitro*)																	

MILESTONE CHART

RU #: 73 PI: Malins

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		
CHEMISTRY																	
4. Manuscripts on skin study												Δ					
Interactions of Hydrocarbon and Trace Metals																	
1. Heavy metals and hydrocarbon metabolites	—	—	—	—	—	—	—	Δ									
2. Synergism in egg development and activity of hatching enzyme				—	—	—	—	—	—	—	—	Δ					
3. Manuscript on hydrocarbons/metals												Δ					
PATHOLOGY																	
1. Evaluate pathological effects of PBCO absorbed to sediment in flatfish	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Δ		
2. Screen isolates of bacteria and viruses from diseased Alaskan fish for pathogenicity for laboratory challenge experiments	—	—	—	Δ													
3. Laboratory challenge of oil-exposed and control marine fish to microbial pathogens	—	—	—	—	—	—	—	—	—	—	—	Δ					
4. Use in vitro tests of immunity to compare the disease resistance of oil-exposed and control fish							—	—	—	—	—	Δ					

MILESTONE CHART

RU #: 73 PI: Malins

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
MORPHOLOGY															
1. Lens abnormalities												Δ			
2. Ultrastructural changes after oiled-sediment exposures											Δ				
3. Ultrastructural changes in eggs and larval fish												Δ			

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SUPPLEMENTARY PROPOSAL TO RU 73; FY 78

Addendum to: Morphological alterations of aquatic organisms after exposure to petroleum hydrocarbons

BACKGROUND

The background section in the RU 73 proposal for FY 78 on morphology applies to this addendum, also. However, three additional studies are proposed which include collaboration with Drs. Jack Anderson, Battelle-Northwest, Sequim, Washington (RU 454); Jeannette Whipple, NMFS, Tiburon, California (RU 389); and Albert Sparks, NWAFC, Seattle, Washington; and a project on liver changes that is a continuation of work from studies conducted during FY 77 in RU 73.

The three studies proposed and background information concerning them include:

(1) The collaborative work generates from observations by Dr. Anderson that the little neck clam, Prototheca staminea, a filter feeder, accumulates petroleum hydrocarbons from water contaminated with petroleum. However, histological changes have not been investigated previously. In addition, Dr. Anderson has noted an increase in viscous material on the cuticle of the marine amphipod, Nanonyx laticoxae after petroleum exposure. In conjunction with Dr. Sparks, we propose to do an histological examination of effects of oil exposure on P. staminea and N. laticoxae and to perform ultrastructural examinations if significant histological aberrations are encountered.

(2) Previous studies have indicated that a number of potentially deleterious changes occur in the liver tissue of rainbow trout exposed to moderately high doses of Prudhoe Bay crude oil (PBCO) in the diet (Hawkes 1977). The vascular tissue in the liver became fibrotic after 3-8 mo exposure to PBCO. These cirrhotic changes could be a response to

inflammation or indicate early neoplasia (Popp and Thomas 1975). As part of this addendum we propose to continue periodic examination of trout exposed to either 1,000 ppm PBCO added to food or to 10 ppm oil on food for up to two years in order to follow long-term changes and to assess the effects of lower dosages.

(3) Reproductive success of organisms after exposure to petroleum is important in evaluating potential deleterious effects from such exposure. Dr. Whipple has proposed a series of experiments for FY 78 (RU 389) which include examination of the gonadal tissue of a mollusc, Prototheca staminea, a crustacean, Cancer magister or Crangon spp., and a teleost, Parophrys vetulus, after exposure to monoaromatic petroleum fractions. Gonadal tissues will be prepared at Tiburon for light and electron microscopy and again, when appropriate, as judged from histology, preliminary ultrastructure studies will be performed.

OBJECTIVES

(1) In collaboration with Drs. Anderson and Sparks, we propose to provide histological and ultrastructural information on the amphipod, N. laticoxae, and the mollusc, P. staminea, after exposure to low levels (10 ppb) of petroleum in a flowing saltwater system.

(2) To assess the degree of liver cirrhosis caused by petroleum in the diet of rainbow trout and to continue sampling for potential neoplasia in fibrotic livers.

(3) To provide ultrastructural information on the selected marine invertebrates and fishes exposed to petroleum as a part of the OCSEAP research by Whipple et al. at the NMFS laboratory at Tiburon.

GENERAL STRATEGY AND METHODS (where applicable)

(1) Little neck clams and amphipods will be exposed to 10 ppb petroleum in in a flowing marine system at Battelle-Northwest at Sequim, Washington (See RU 454). Samples will be taken by Drs. Anderson, Sparks, and Hawkes and appropriately prepared and analyzed (Battelle Columbis) for uptake of petroleum, histology, and, where indicated, ultrastructure analysis.

(2) Liver fibrosis will be assessed in rainbow trout exposed to 1,000 ppm or 10 ppm crude oil added to food. Two analytical methods will be used: (a) Energy dispersive analysis of sulfur as an indicator of connective tissue distribution will be compared between control and experimental fish and (b) morphological change in both the vascular tissue of the liver and the hepatocytes will be followed for evidance of neoplasia.

(3) After an initial training session, samples of gonads from a mollusc, crustacean, and teleost species exposed to a monoaromatic hydrocarbon mixture will be obtained by personnel at Tiburon laboratory of NMFS (See RU 389) for both histology and electron microscopy. If the histological preparations provide evidence of tissue effects, comparable specimens that have been embedded for electron microscopy will be shipped to Seattle for processing.

DELIVERABLE PRODUCTS

Narrative reports including graphs and micrographs from light and electron microscopes.

INFORMATION FROM OTHER INVESTIGATORS

Data concerning the precise exposure times and levels from Drs. Anderson and Whipple.

OUTLOOK

Data collected from the Anderson and Whipple collaborations would provide additional information on structural changes in invertebrate and certain vertebrate tissues which will either indicate "no effect" or areas of tissue damage which will form the basis of possible future research. The other proposed study will provide more in depth information on liver structure changes after petroleum exposure which may with longer exposure time result in serious liver pathology, namely, cirrhosis and possibly neoplasia.

The cost is not expected to fluctuate appreciably from FY 78; in FY's 79 or 80, if similar studies are continued ($26.5 K). No additional major equipment is anticipated and no major changes in logistics.

MILESTONE CHART

RU #: 73 PI: Malins

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
Liver fibrosis studies											Δ				
Sampling at Sequim - WSF exposed clams and amphipods											Δ				
Sampling at Tiburon - gonadal tissue of petroleum exposed clams, crabs, flounder											Δ				

Title: Ecosystem Dynamics, eastern Bering Sea, RU-77

Institutional Proposal ID Number: R7120810

Principal Investigators: T. Laevastu and F. Favorite

Total Cost: $50,000 OCSEAP

Institution: NOAA
National Marine Fisheries Service
Northwest and Alaska Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98112

Date: June 1977

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C. Technical Proposal:

I. Title: Dynamical Numerical Marine Ecosystem model for the eastern Bering Sea (including Bristol Bay and St. George Basin).

Research Unit Number: OCSEAP Research Unit No. 77

Contract Number: R7120810

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

II. Principal Investigators: T. Laevastu and F. Favorite

III. Cost of Proposal for FY 78:

Total: $50,000

Distribution of Effort by Lease Area:

50% Bristol Bay

50% St. George Basin

IV. Background:

The first year studies under this OCSEAP contract demonstrated the manner and feasibility of programming a total dynamic marine ecosystem model. An 8-component submodel of selected marine mammals and birds and some of their principal food groups, such as pollock, herring, and macroplankton, was completed during the first year contract. This work showed quantitatively the intricate interactions of 8 components within the total marine ecosystem (through trophodynamics, interspecies competition ~~composition~~, and interventions by man) and demonstrated that it was possible to design and program a complex ecosystem simulation model that includes most of the quantitative as well as qualitative (descriptive) knowledge of the abundance and behavior (dynamics) of marine biological resources thus, essentially, reducing available descriptive knowledge into quantitative "dynamic" form.

The 8-component submodel was expanded in FY 1977 to include 25 biological components and this submodel is in the process of being tuned. Comparisons of results of both submodels will be made prior to the end of FY 1977 and a report submitted.

The composition of marine ecosystem and processes within it are extensive and complex. The available knowledge on these components is voluminous and growing rapidly. Thus, in order to make the available data and knowledge reviewable, it is necessary to automate handling of data and to reduce the empirical knowledge into numerical models.

Because it is not possible to study empirically all the distributions, interactions and other processes in a marine ecosystem, it is necessary to simulate the interactions on large computers and to study the processes by means of numerical techniques. The feasibility and great utility of this approach has been demonstrated within past work on OCSEAP RU-77, in the framework of which a relatively complete ecosystem model has been programmed. This program has provided one of the chief means of answering quantitatively a majority of questions concerning the effects of offshore oil developments on the ecosystem, as well as becoming a management decision tool for the conservation and protection of marine resources.

It is intended to update the model with the latest information from OCSEAP studies, and to apply model results to offshore oil development questions and decisions. It should be realized that this model is based largely on all pertinent previous data and subject matter, and especially on pertinent data provided by other empirical OCSEAP studies; thereby, constituting a synthesis of these studies.

V. Objectives:

The general objectives and purposes of the numerical ecosystem model fall within three categories:

A. Investigative and consolidative, including quantitative biological resource evaluation.

1. Synthesis of information, including quantification of descriptive data, including summary of exploratory and baseline studies.

2. Simulation of the ecosystem and its essential interactions, including interactions between the ecosystem components and the physical-chemical environment.

3. Determination of the effects of environment and interspecies interactions and natural fluctuations.

B. General management guidance and effects of exploitation.

1. Magnitude of the biological resources and their past and expected future fluctuations (including results from A-1 and A-3).

2. Determination of fishing intensity variations (including spatial and temporal distribution of fishing) on the resources, including the effects of proposed regulations.

3. Determination of research priorities.

C. Oil exploration/exploitation effects on marine ecosystem.

1. Determination of the effects of oil "developments" on the ecosystem as compared to natural fluctuations, including the determination of Contaminant Baselines - OCSEAP Tasks A and E.

2. Quantitative determination, in space and time, of the ecosystem components susceptible to petroleum "developments" - OCSEAP Task E.

3. Quantitative determination, by means of numerical simulation of the effects of contaminants and other possible detrimental effects of petroleum "developments" on the ecosystem and its components - OCSEAP Task F.

The initial submodels developed in FY 76 and 77 have demonstrated the utility and the feasibility of achieving the above general objectives. Detailed plans for FY 78 (and 79) are listed in the following sections.

VI. General Strategy and Approach:

It is proposed to complete the model as conceived at this time in FY 78 and to commence production runs (i.e., to answer any detailed questions falling within the objectives). The strategy and approach in FY 78 is:

a. Update the input data base with all available new data.

b. Program in space and time variable food composition as function of food availability, and investigate the extent and effects of "natural starvation".

c. Separate dominant fish groups into juveniles and adults, and introduce size-dependent feeding.

d. Provide zooming subroutines for detailed investigation of small-scale effects of oil development in Bristol Bay and in St. George Basin.

e. Complete model optimization and documentation (at this stage the model is considered operational).

f. Determine qualitatively and quantitatively the effects of environmental conditions and intervention by man on the trophodynamics and interspecies competition.

g. Determine quantitatively the effects of drastic environmental changes (e.g., the extent of ice cover) versus increase in mortality and/or avoidance behavior as might be caused by an oil spill.

VII. Sampling Methods: N/A

VIII. Analytical Methods:

The methods used in the submodel development have been described in several reports submitted to OCSEAP. A detailed description of the methods and the model is in preparation and will be submitted by 30 September 1977.

In essence, all the advanced experiences and approaches of large-scale modeling in synoptic meteorology and oceanography will have been applied. The study also makes use of applicable, earlier tested population dynamics and ecosystem modeling approaches, but goes much further in incoporating most of the pertinent knowledge, which has been converted (by present investigators) into numerical form.

The model is four-dimensional (three space dimensions and time). Computations are made in weekly to monthly time steps (shorter time steps in zoomed areas). It is fully dynamic, both in respect to motions and migrations as well as in interspecies interactions (e.g., in trophodynamic effects). The computation techniques include not only iterative solving of simultaneous equations with many unknowns and in space and time variables and dependent variable coefficients, but also extensive bookkeeping operations, which make the program so extensive that only the largest available computers can be used. There are numerous outputs, both routine and special, in digital printout and graphical form.

IX. Anticipated Problems:

Due to the size of the program, the local available computers (e.g., CDC 6400) are inadequate. We intend to use ERDA CDC 7600 computer in Berkeley, California for future model runs.

Great volumes of printouts and graphical material can be produced with the model, but it is not feasible to reproduce all these in reports. We intend to archive essential outputs in NWAFC in Seattle for eventual future references and use.

X. Deliverable Products:

A. Digital Data

Card decks of data and program.

B. Narrative Reports and

C. Visual Data

Description of the model and its use (see milestone chart for schedule).
Yearly reports on essential results.
Special reports on specific questions studied including specific numerical printouts and graphics.
Card decks on data and program.

D. Other Data - N/A

E. Data Submission Schedule - N/A

XI. Information Required from Other Investigators:

The pertinent information produced by other investigators is extracted from quarterly and annual reports submitted to OCSEAP.

XII. Quality Assurance Plan:

Besides normal model debugging and tuning procedures, output verifications with available information (data and knowledge) has been made an integral part of the work within this project.

XIII. Special Sample and Voucher Specimen Achival Plan: N/A

XIV. Logistic Requirements: N/A

XV. Management Plan:

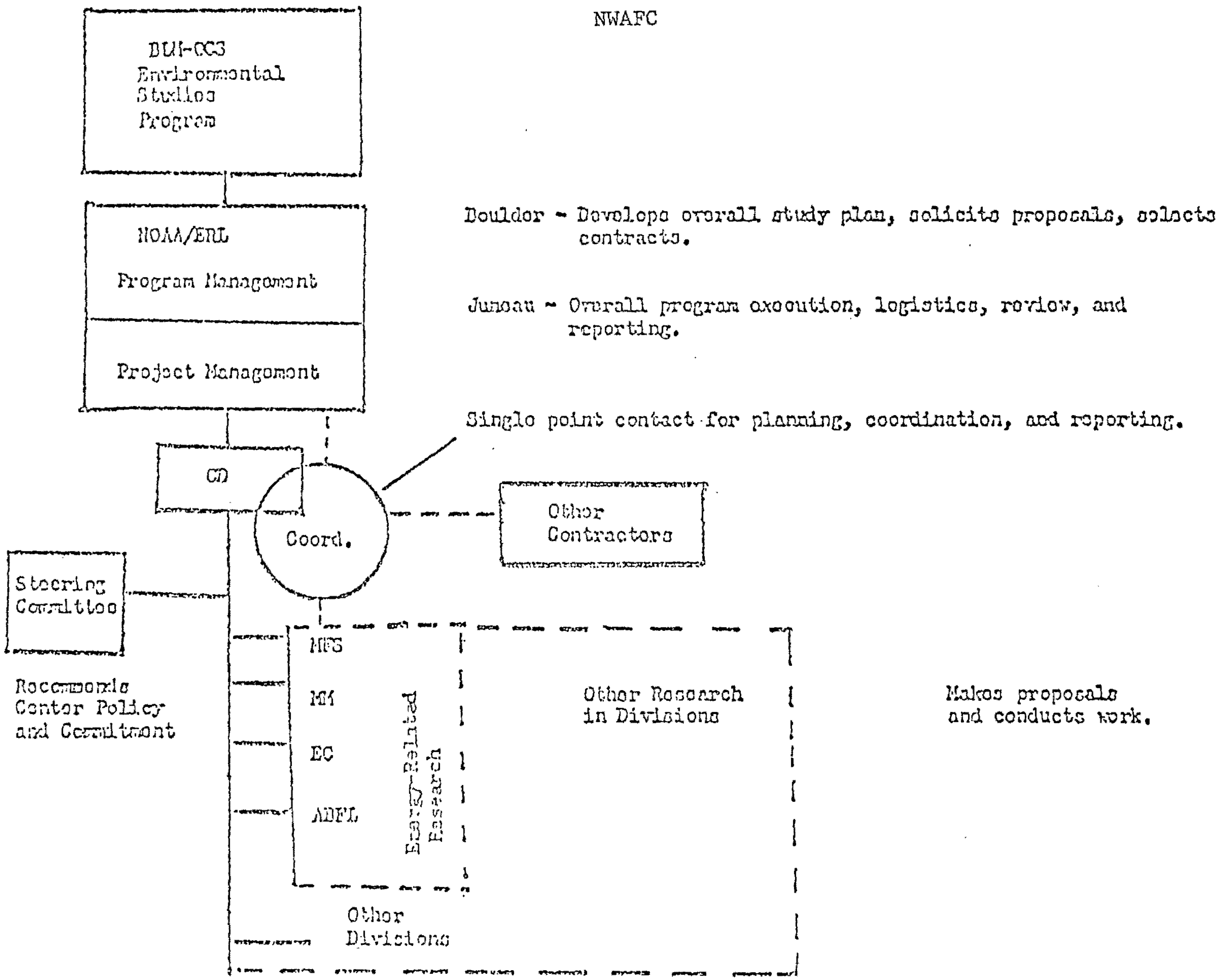
Management of OCSEAP Research - NMFS/NWAFC agrees to be responsible for conducting studies described in the Technical Proposal Forms. Changes in the scope of work may be initiated by either party and will be implemented after mutual agreement has been reached and this agreement has been confirmed in writing by the NMFS/NWAFC and the OCSEAP Program/Project Office. Such agreements will be accompanied by revised work statements where considered necessary by the Program Office and will reflect changes in schedules and/or funding, as appropriate.

The NMFS/NWAFC has designated G. Tanonaka to coordinate all energy related research activities with the OCSEAP Program/Project Office. In addition, the NMFS/NWAFC will designate principal investigators who will be responsible to the NWAFC for the implementation and conduct of assumed tasks.

The principal investigators may be freely contacted regarding clarification and technical aspects of the research program but any negotiation which involves change in commitments of NWAFC personnel or other resources must be made with the Coordinator for Energy Related Research (see OCSEAP Research Organization - NWAFC) attached.

OCSEP RESEARCH ORGANIZATION

NWAFC



XVI. Outlook:

It is anticipated that the extensive model will be fully programmed, tested and verified in FY 78. The majority of the production runs and multiple use of the model are planned for FY 79:

—Complete the description of the final operational model, including its use manual.

—Determination of the effects of fishing (present and projected intensity) on the (future) quantitative changes in the ecosystem in the eastern Bering Sea.

—Quantitative comparison (using the model) of environment caused, fishing caused, and possible oil development caused changes in the ecosystem.

—Answering of any other pertinent questions arising in connection with oil development and falling within the model objectives.

XVII. Other Provisions/Obligations

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

PROJECT RU #77 DATE

PRINCIPAL INVESTIGATORS T. Laevastu and F. Favorite

MAJOR MILESTONES/ ACTIVITIES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Update the input data base with all available new data			Δ												
Programme in space and time variable food composition				Δ											
Investigate the effects of starvation						Δ									
Programme subroutine for separation of dominant fish groups into juveniles and adults					Δ										
Programme size-dependent feeding					Δ										
Programme zooming subroutines for detailed investigation of small-scale effects of oil development in Bristol Bay and in St. George Basin								Δ							
Model optimization and documentation										Δ			Δ		
Commencement of production runs:															
1. Determination of the effects of environment and man on the trophodynamics & interspecies competition												Δ			
2. Determination of the drastic environmental changes-effects versus increase of mortality and/or avoidance behavior as might be caused by oil spill													Δ		
3. Answering (with model use) other questions pertaining to the offshore oil/gas development															

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Title: Littoral Studies: Gulf of Alaska and Bering Sea
OCSEAP Research Unit 78 (Formerly 78/79).

Principal Investigators:
Theodore R. Merrell, Jr.
Charles O'Clair (tentative)

Period of Work: October 1, 1977 to September 30, 1978.

Institution and Department:
Auke Bay Laboratory, Northwest Fisheries Center
Environmental Impact Programs Section

Required Signatures:

Principal Investig~~ators~~

Name ______________________ Date 6/22/77

Name ______________________ Date ______________

Address: NOAA, National Marine Fisheries Service
Auke Bay Laboratory
P. O. Box 155
Auke Bay, Alaska 99821

Telephone Number: 789-7231

Required Organization Approval

Name ______________________ Date 6/30/77

Address: Northwest and Alaska Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98122

Telephone Number: 442-4760

Organization Financial Officer

Name ______________________ Date ______________

Address:

Telephone Number:

Technical Proposal

I. Title, Research Unit Number, Dates of Contract.

Littoral Studies Gulf of Alaska and Bering Sea.
OCSEAP Research Unit 78 (Formerly 78/79).
October 1, 1977 through September 30, 1978.

II. Principal Investigator

Theodore R. Merrell, Jr.
Charles O'Clair (Tentative)

III. Cost of Proposal

$75,000

IV. Background

During the 1974-76 field season approximately 2,000 quantitative littoral samples were collected in an area extending from Yakutat in the eastern Gulf of Alaska to King Island in the northern Bering Sea. Many of the samples remain to be sorted. Much of the already sorted data need to be summarized, combined with qualitative observations, worked up into graphical output and turned into reports which describe the different basins. Recent meetings with OCSEAP (JPO) personnel have indicated that highest priority should be given to the production of these summary reports prior to leasing activities in the various basins. The reports may also be used as a basis for choosing areas and formulating research plans for other scientific efforts.

Previous guidance from OCSEAP had also indicated that emphasis should be placed on continuing and expanding intensive studies to determine the seasonal changes and trophic relationships of the dominant littoral biota, and to interpret and apply the survey reconnaissance data to littoral ecosystems likely to be affected by OCS oil development. Unfortunately, the funding guidance for FY 78 is not sufficient to allow us to continue this phase of our work. Because we feel this research is of great importance, however, we are including a supplemental section with this proposal outlining the work we feel should be done and the additional costs above the funding guidance of $155 K.

V. Objectives

Throughout this project there have been two major objectives: to determine the distribution of the major habitats (sandy, muddy, rocky, etc) along the coastline, and to determine the densities and distribution of biotic populations within these habitat types.

With the publication of the Alaskan intertidal atlas in the summer of 1977, the first goal will have been realized. Accomplishment of the second objective has been partially realized with the data workups contained in several quarterly reports and in the report on the Kodiak Basin. It will be the primary objective of this project to complete these aspects of our work and to provide data summaries and interpretations on all of the basins where we made reconnaissance or baseline-level surveys.

VI. General Strategy and Approach

All of the field work for the aerial survey and habitat reconnaissance phase has been completed. Sorting of remaining samples by U of A IMS will continue in FY 78. In the meantime, computer analysis of presently sorted samples will continue and new data will be processed as it becomes available from the IMS IMS Sorting Center. Statistical and graphical interpretations of the species associations within and between major habitat types is ongoing and will be completed in FY 78. Our approach toward the dissemination of these data will be to prepare reports summarizing our observations and major conclusions for all of the lease basins.

VII. Sampling Methods: Not Applicable

VIII. Analytical Methods: Not Applicable

IX. Anticipated Problems

1. Computer delays will continue to be a problem. Our shared usage of the Forest Service system, which utilizes the INFONET network in Los Angeles, is becoming more difficult due to increased Forest Service usage. Turn-around time is still slow and the system is expensive to use. Neither of the proposed alternatives to the INFONET system (University of Alaska system or installation of a computer at Auke Bay Laboratory) appear to be viable substitutes for FY 78.

2. In the past we have had to expend considerable effort to make sure that the Sorting Center was adhering to contractual schedules and processing samples on a timely basis. Recently the OCSEAP (JPO) has assumed responsibility for the assignment of sorting priorities. Unless a strong effort is expended by OCSEAP on our behalf, considerable delays in receipt of sorted material are likely to occur.

3. If intensive studies begun in FY 77 are cancelled staff morale will deteriorate. This aspect of our research has been eagerly anticipated as a significant and relavent means of contributing to evaluating of OCS potential oil impacts, to a much greater degree than the previous reconnaissance surveys.

X. Deliverable Products

A. Digital Data

1. List of Parameters

Record Type 1	Vessel name/cruise number Cruise dates Senior scientist/investigator/institution
Record Type 2	Geographic position Date/time Surface water temperature Salinity Beach exposure direction Substrata type Habitat description
Record Type 3	Catalog/photograph numbers Gear type Transect number/direction and meter number 07 Sample/zone/arrow number Quadrat size/elevation/slope Substrata and surface topography types Collection time Sediment volume
Record Type 4	NODC taxonomic code/subspecies Sex Sample condition Percent coverage Count of species Wet and dry weights Lengths (when appropriate)

Note: These are the major parameters measured. Occasional other fields (such as Secchi Disc Depth) may be filled but data were not collected on a routine basis.

2. List of Digital Products--See Table 1.

B. Narrative Reports

We will produce several basin reports summarizing the results of our reconnaissance surveys. The narrative parts of these reports will include site descriptions, summaries of the zonation and associations between dominant species and a discussion of major conclusions concerning relationships between sites and basins. The report on the Kodiak Basin is essentially complete and will form the basis for later reports on the Eastern Gulf, St. George Basin, Bristol Bay, and Norton Sound.

C. Visual Data

For areas in which quantitative samples were collected we will produce the following visual outputs:

1. A species list for each site.
2. A listing of species numbers and weights contained in each sample (Table 2).
3. A summary table for each dominant species showing its density at all sites by tidal elevation. (Table 3)
4. A summary table for each site showing the densities of dominant species with tidal elevation. (Table 4)
5. A summary figure showing the distribution of dominant species along each transect line.

D. Other non-digital data--Not Applicable.

E. Data submission schedule (see attached data products schedule).

XI. Information Required from Other Investigators--Not Applicable.

XII. Quality Assurance Plans

Intertidal samples are sorted and coded at the Sorting Center in Fairbanks. Voucher collections are maintained in order to verify identifications.

Table 1. 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	Tapes		030	Yes	9/74-10/74 (EGOA)	1/76
"	"		"	"	4/75/75 (EGOA)	12/76
"	"		"	"	5/75 (WGOA)	7/77
"	"		"	"	7/75 (Bering)	9/77
"	"		"	"	7/75 (WGOA)	9/77
"	"		"	"	8/75 (Bering)	10/77
"	"		"	"	9/75 (EGOA)	90 days after Receipt of Remaining Sorted Samples
"	"		"	"	5/76 (WGOS)	10/77
"	"		"	"	6/76 (Bering)	90 days after Receipt of Remaining Sorted Samples
"	"		"	"	8/76 (Norton Sound)	90 days after Receipt of Remaining Sorted Samples

BIOTIC DENSITIES OF INTERTIDAL ORGANISMS FROM THE WESTERN GULF OF ALASKA
5/20 TO 5/30 1975

STATION NBR: 14 SUD ISLAND DATE: 5/23/75
LATITUDE: 58 54 30 N LONGITUDE: 152 12 40 W
STATION INVESTIGATED FOR 4.3 HOURS BEGINNING AT 13:45 IN TIME ZONE: +10
CATALOG NBR: AB750481 ZONE/TRANSECT: D SUBSTRATE: BEDROCK
PHOTOGRAPH NBR: 7502030091 METER NBR: SURFACE TOPOGRAPHY: IRREGULAR
SAMPLING TIME: 2:10 ARROW NBR: D16 GEAR: ARROW
ELEVATION: 2.68 METERS QUADRAT SIZE: .062 SQUARE METERS SEDIMENT VOLUME: 0. LITERS

SPECIES IDENTIFICATION	SEX	CONDITION	COVRG	COUNT	WET WEIGHT (GRAMS)	DRY WEIGHT (GRAMS)
CHLOROPHYTA						
MONOSTROMA FUSCUM	ND				.003	0.
PHAEOPHYTA						
	ND	FRAG			.234	0.
ALARIA SP	ND	FRAG		351	0.	0.
FUCUS DISTICHUS	ND	FRTL		5	164.200	35.450
FUCUS DISTICHUS	ND	STRL		27	95.682	21.310
FUCUS DISTICHUS	ND	STRL			219.214	30.512
RHODOPHYTA						
RHODOPHYTA	ND	FRAG			.401	0.
ENDOCLADIA MURICATA	ND				5.457	.982
GIGARTINA PAPILLATA	ND				72.600	10.890
IRIDAEA CORNUCOPIAE	ND				72.348	8.333
HALOSACCION GLANDIFORME	ND				1.453	.116
RHODYMENIA PALMATA	ND				.064	0.
RHYNCHOCOELA						
EMPLECTONEMA GRACILE	ND			1	.105	0.
ANNELIDA						
TYPOSYLLIS A ADAMANTEA	ND			12	.603	0.
FABRICIA CRENICOLLIS	ND			64	.108	0.
FABRICIA CRENICOLLIS	ND			1	.001	0.
ENCHYTRAEIDAE	ND			128	.162	0.
MOLLUSCA						
MYTILUS EDULIS	ND			855	9.344	4.154
	ND			192	.249	0.
COLLISELLA PELTA	ND			3	.415	0.
LITTORINA SITKANA	ND			136	1.128	.631
LITTORINA SITKANA	ND			22	5.511	3.235
SIPHONARIA THERSITES	ND			4	.538	0.
CRUSTACEA						
BALANUS GLANDULA	ND			96	44.300	24.792
EGG MASS	ND					

Table 3 . Means, number of observations, and standard deviations of the grams/sq. meter of *Fucus* sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		989.81 5 1395.72	989.81 5 1395.72				
7.99 ft. to 6.00 ft.	974.57 4 1457.98	2515.78 4 2142.10	1745.17 8 1885.80	3792.00 2 1787.57		1593.28 4 1622.13	
5.99 ft. to 4.00 ft.	4716.26 2 6649.82	523.43 8 575.09	1362.00 10 2880.26	1726.25 2 243.03	349.49 1 0.	206.10 5 436.00	
3.99 ft. to 2.00 ft.	314.22 3 514.92	80.96 5 165.40	168.43 8 325.52	1800.65 3 3118.82	1.48 4 2.96	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	22.88 1 0.	.76 7 2.01	648.80 4 1297.60	793.23 22 2265.23
-0.01 ft. to -2.00 ft.	3.85 2 5.44		3.85 2 5.44	11.78 4 20.10		0. 1 0.	0. 4 0.
	1098.55 13 2646.08	816.85 24 1325.48	915.83 37 1864.12	1375.70 12 2010.10	30.06 12 100.62	588.17 17 1114.53	671.19 26 2096.53

Table . Average densities (g./sq.m.) of selected organisms estimated along transect lines at Sud Island in August 1975. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
6	4	925.27	974.57	.00	2.53	.00	.00	.00	11.26
4	2	.26	4716.26	.00	.00	.00	.00	.00	.00
2	3	5.35	314.22	6.11	7.19	.00	.00	.00	.00
0	2	.50	.00	.50	3.31	.00	2.39	.00	1.86
-2	2	.00	3.85	.00	.00	.00	.00	.00	.00
10	1	1718.40	.00	.00	.00	.00	.00	.00	.00
8	5	44.84	989.81	.00	.00	.00	.00	7.39	.00
6	4	581.95	2515.78	.16	4.90	.04	10.76	282.23	138.26
4	8	17.74	523.43	.01	3.41	2.14	186.19	20.03	.01
2	5	.32	80.96	.00	12.27	13.91	6.43	.60	.12
0	1	.00	.00	.00	.00	.00	.00	3.68	1.24

Elev.	No. of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
6	4	10.48	.00	.00	24.32	.00	.00	.00	.00
4	2	.00	.00	.00	.00	.00	.00	.00	.00
2	3	996.75	.00	.00	9.31	.00	.00	.00	.00
0	2	1712.92	.00	35.53	1090.09	.00	.00	3168.40	.00
-2	2	28.28	.00	.00	.00	26.74	.00	720.00	.00
10	1	.00	.00	.00	.00	.00	.00	.00	.00
8	5	.00	.00	37.72	.00	.00	.00	.00	.00
6	4	.14	.84	365.88	.00	.00	.00	.00	.00
4	8	891.51	.00	130.80	.00	.00	.00	.00	.00
2	5	1948.44	.00	1296.44	71.36	119.04	.00	460.83	.00
0	1	.00	.00	.00	258.58	.00	.00	.00	9097.07

Troublesome groups are sent to experts for identification. All sorted samples are stored in order that questionable data from any sample can be checked after scrutiny in Juneau.

When the sorting forms are received in Juneau the completeness of each form is checked and each sample is identified and compared with field records in order that all samples are accounted for. Data from the sorting forms are then transferred to computer punch cards which are verified by conventional methods. The data are then computer printed in an organized form in tables and figures which allow rapid scanning to pick up obvious errors. A multiple-phase update program is available to make corrections as they occur.

XIII. Voucher Collections

Voucher specimens are maintained at the U.A. Sorting Center in Fairbanks. Two sets of voucher specimens are presently being prepared; one to be deposited in the museum collection at ABL, and one to be maintained at the Sorting Center in Fairbanks. Representative specimens of all species encountered in this study are included in the voucher collection.

XIV. Logistics Requirements

Unless the intensive phase of the littoral research is funded we shall not have any logistics requirements. A discussion of logistics required for that phase of the program is contained in a subsequent section.

XV. Management Plan (See Milestone Chart)

Overall project planning will be coordinated by Merrell who will also be responsible for personnel administration and allocation of laboratory staff and facilities. Production of reports summarizing the results of the reconnaissance survey will be coordinated by Gnagy and MacKinnon. Quality control and manipulation of data will be handled by Gharrett. Grimm will provide, in conjunction with the Biometrics staff, computer analysis of data.

If the intensive phase of the program is also funded, O'Clair will become the Principal Investigator and will be responsible for planning and scheduling field research and overseeing the scientific quality of the reports.

XVI. Outlook

The workup of the reconnaissance survey should be completed in FY 78. The remaining research effort would then focus entirely on reinitiating and continuing the intensive studies. These studies would provide narrative reports on the primary productivity, community structure, species composition, and trophic relationships of littoral sites in the Hinchinbrook Entrance and Kodiak areas. Milestones would include an annual summary of research indicating seasonal patterns and major new information gained on the dominant processes.

The cost of this project would be approximately $200k annually. No major equipment would be needed. Sites would be located in Hinchinbrook Entrance where a small vessel (60') might be needed to berth scientists, and in the Kodiak area where a field camp with helicopter transportation would be most advantageous. Helicopter support would not be required if the study site is accessible by a road system.

XVII. 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. Where biota are concerned, all species and higher categories will be represented by the voucher specimens that will be preserved, labelled, and 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."

Littoral Studies (supplement: Intensive Studies)

IV. Background

Previous guidance from OCSEAP had indicated that emphasis should be placed on continuing intensive studies to determine the seasonal changes and trophic relationships of the dominant littoral biota. In April 1976, we traveled by charter helicopter to two lighthouses, now automated but previously operated by resident Coast Guard personnel. This was a reconnaissance trip for site selection and to begin working on methods for the intensive studies. The two sites, at Cape Hinchinbrook on Hinchinbrook Island, and at Cape St. Elias on Kayak Island, were judged unsuitable for intensive studies because they would be difficult to reach at all times of the year and because they did not provide diverse habitat types.

In April 1977 we traveled to Kodiak Island where we looked at several sites in the vicinity of Chiniak Bay. We selected a possible study site at Isthmus Pt. in Kalsin Bay. However, this site has a history of oil spills and may not be suitable for a long-term study site (see quarterly report, June 1977).

In May 1977, we traveled to Hinchinbrook Entrance to select a study site within the NEGOA lease area. We selected a site in the area of Nuchek and Constantine Harbor which provides a great variety of habitats and which is accessible at all times of the year (see quarterly report, June 1977).

V. Objectives

In the next phase of our study we propose to narrow our geographic range to one or two study sites and to increase our spatial and temporal range at those sites so that we will be able to look at several microhabitats within the study sites at least three, and preferably four, times a year. Initially we will determine what plants and animals live at each site and then select a few of these to examine in detail to determine their role and the interrelationships that make up the trophic dynamics of the system. In the case of macrophytes, for instance, we will look for seasonal patterns of presence or absence, reproductive state, abundance, the interrelationships among algae and with the fauna, and the contribution they make to the productivity of the system.

VI. General Strategy and Approach

1. Determine community structure and species composition by transect line-quadrat enumeration and collection. Record data on species type, number, size, sex, reproductive state, and behavior.

2. Compile trophic relationships of primary producers, benthic macroinvertebrates, and pelagic invertebrates and vertebrates from observation, experimental manipulation, gut sample analysis, and the literature.

3. Conduct surveys during high tide using SCUBA to observe behavior and interrelationships of intertidal predator and prey species.

4. Observe and collect subtidal quadrats of macrophytes using SCUBA to determine distribution, percent coverage, biomass, reproductive state, and growth.

5. Measure water quality at each site on both flood and ebb tides. Parameters proposed for measurement will include nitrates, phosphates, organic C, petroleum and natural hydrocarbons, CO_2, O_2, pH, salinity and temperature.

6. Determine water circulation patterns within bays or lagoons with drift cards on a flood tide. These data will provide information for understanding the patterns of water exchange between these confined bays and the larger water bodies with which they connect.

Data from the categories listed above will be integrated into a comprehensive analysis of the littoral ecosystem at each site. Sampled every 3 months, 1 year of research will provide information on the seasonality of many of the plants, animals and processes at each site. This may allow us to narrow the scope of our study and intensify our efforts on the more important or critical aspects as we learn what they are and how they are likely to relate to OCS oil impacts on marine resources.

Data collected over several years will go beyond seasonality into the interrelationships of the various subdivisions of the ecosystem, specifically birds, fishes, shellfish, marine mammals and plankton. The studies will be closely coordinated with related research on these groups by other OCSEAP projects. Implementation of this study will transform our program from its previous survey mode to a holistic mode, addressing an understanding of the intimate interrelationship of the shore and nearshore environment and their relevance to BLM needs and to traditional NMFS goals and activities.

Data products will include a comprehensive report of our studies at each site as well as formal publications.

LOGISTICS REQUIREMENTS

INSTITUTION Auke Bay Laboratory PRINCIPAL INVESTIGATOR Theodore R. Merrell, Jr.

A. SHIP SUPPORT For Intensive Study Phase

1. Sampling areas: Hinchinbrook Entrance. Boat will need to remain in Constantine Harbor (Port Etches, Hinchinbrook Island) for 7 days. Geographical Position: 60° 21'N, 146° 38'W.

2. Vessel will be used as a support facility while shore parties and diving teams investigate the community structure of Constantine Harbor and Nuchek Reef.

3. Optimum time is during low tide periods. One trip per season (4 times per year) is anticipated.

4. Eight days, including transit time from and to Cordova are required.

5. Our investigation should probably be the principal one due to tidal constraints.

6. We shall need two small skiffs.

7. Approximately 1000 pounds.

8. No.

9. Only required chemical is formalin for preserving marine specimens.

10. No preference. However, a small charter boat (50'-75') would be most economical and would be able to navigate the entrance to Constantine Harbor.

11. Charter cost based on previous usage is approximately $750/day.

12. Six persons. To be named. No foreign nationals.

MILESTONE CHART

RU #: 78　　PI: T. R. Merrell, Jr.

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
Submission of 8/75 Data to NODC	Δ														
Submission of 5/76 Data to NODC	Δ														
Quarterly Report with Emphasis on EGOA			Δ												
Annual Report with Emphasis on St. George Basin						Δ									
Quarterly Report with Emphasis on Bristol Bay									Δ						
Submission of 9/75 Data to NODC									Δ						
Quarterly Report with Emphasis on Norton Sound												Δ			
Submission of 6/76 Data to NODC												Δ			

Δ Planned Completion Date　　▲ Actual Completion Date

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest & Alaska Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98112

SEP 13 1977

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

Dear Herb:

We were dismayed to receive your letter of August 30 informing us of a crippling reduction to $75K for RU 78, "Littoral Studies: Alaska and Bering Sea". With reluctance, we agree to the changes required in your letter, including elimination of field studies. But to make certain that you do not expect more than we can deliver, at this inadequate funding level, following are listed the "Deliverable Products" which we will provide:

We will submit completion reports covering previous reconnaissance surveys, one each for the eastern Gulf of Alaska, Norton Sound, and the Bristol Bay-St. George Basin. These three reports will be submitted according to the schedule in our original proposal, provided that we receive the data on our samples from the University of Alaska Sorting Center on schedule. Responsibility for requiring the Sorting Center to meet their schedule commitments rests with the Juneau Project Office. The reports will follow the same general format as the Kodiak report, now being processed by the Juneau GSA printshop, but will be shorter and more concise. The reports will include site descriptions, descriptions of the distribution and relative abundance patterns of dominant organisms at each site, and species lists showing the distribution of species among sites. In our analysis of community attributes among sites, we will restrict our use of computer analyses to those which are of direct value to the interpretation of the data. Visual data products such as those shown in Tables 2, 3 and 4 of our original proposal, have not proved especially useful to interpretation of our data and will not be presented.

Computer data will be submitted to NODC on the schedule in our original proposal. To save on expensive computer disc storage time, minor corrections in NODC tapes will not be made after September 30, 1977.

As a result, the tapes will lack complete identification of some species of the following groups: Porifera, Polychaeta, Bryozoa, Harpacticoida, and Ascidiacea.

In our view, your decision to eliminate funding for field studies of nearshore biological communities is a mistake which will drastically diminish the value of previously collected survey data. These field studies are an important component of the OCSEAP Program Development Plan (Tasks E-8 and E-9 littoral communities) and their elimination will result in a serious gap in information required to assess and predict potential impact of oil development on living marine resources on the Alaska Continental Shelf.

Sincerely,

Dayton L. Alverson

Dayton L. Alverson
Center Director

cc: Smoker
O'Clair
Merrell
Rietze

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

RFx41-78-599

Mr. Theodore R. Merrell, Jr. and
Dr. Steven Zimmerman
NOAA, National Marine Fisheries Service
NWAFC, Auke Bay Laboratory
Post Office Box 155
Auke Bay, Alaska 99821

Reference: (1) OCSEAP FY 78 Proposal Solicitation Letter dated 5/23/77
(2) NWAFC Auke Bay Lab Proposal for OCSEAP Research Unit 78, FY 78, dated 6/22/77
(3) NWAFC/ABL-OCSEAP Meeting of 7/25/77

Gentlemen:

Required Proposal Revisions for FY 78

Your FY 78 renewal proposal, entitled "Littoral Studies: Gulf of Alaska and Bering Sea," has been reviewed by the Juneau Project Office and discussed at a subsequent meeting (References 2 and 3). On July 29, after our discussions on revisions to your original proposal, OCSEAP was informed by the Bureau of Land Management of a substantial budget reduction for FY 78. This reduction in budget required a severe revision of overall program content, which affected the guidance given you during our meeting. The following additional revisions are required before your work statement can be sent to our Contracting Office for funding:

1. The guidance funding level of $150,000.00 should be reduced to $75,000.00, all of which should be used for the synthesis of existing data. No field work will be performed. The revised funding level must not be exceeded.

2. FY 78 efforts should consist entirely of the completion of intertidal data submissions and the production of final reports on the results of reconnaissance surveys conducted during the period 1975-77. This will involve the final analysis, interpretation and reporting of intertidal and subtidal data collected in the eastern Gulf of Alaska, St. George Basin, Bristol Bay, and Norton Sound. Separate reports should be produced following the milestone chart shown in your original proposal (Reference 2). We have contracted with the Institute of Marine Science at the University of Alaska to complete sorting of remaining intertidal samples. Sorting will proceed at a minimum rate of 25 samples per month, while sorting priorities will parallel the schedule for report production shown in your milestone chart.

3. With respect to personnel, the Project Office feels that it is desirable to have continued involvement by Dr. Zimmerman in the production of the final reports. The loss of his expertise and familiarity with the existing data would markedly impact on the final reports, either through diminution of information content or through delays incurred by other investigators having to familiarize themselves with the data before making interpretations. Dr. Zimmerman's involvement through sub-contractual arrangements by the Auke Bay Lab merits consideration.

4. The "Deliverable Products" section of your original proposal is acceptable. However, please include the anticipated ranges of digital data products where applicable.

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 August 31, 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

Reproductive Ecology of Pribilof Island Seabirds

University of California, Irvine Proposal Number RU 083

George L. Hunt, Jr.

University of California, Irvine

Department of Ecology and Evolutionary Biology

1 July 1977

Signatures

George L Hunt by P.R.A.
George L. Hunt, Jr.
Associate Professor

Peter A. Atsatt
Peter A. Atsatt
Acting Chair

Howard A. Schneiderman
Howard A. Schneiderman
Dean

C. Technical Proposal

I. Reproductive Ecology of Pribilof Island Seabirds

Research Unit: 083

Proposed Notes of Contract: 1 October 1977 - 30 September 1978

II. Principal Investigator: George L. Hunt, Jr.

III. Cost of Proposal:

Total $80,922

Distribution of Effort by lease Area: St. George Basin

IV. Background:

In order to assess the impact of oil exploration, extraction and transport on seabirds of a given area, it is necessary to know; 1) the number of birds in the area, 2) their activity patterns (where they go and what they do there eg. nest, roost, forage), 3) the timing of their activities, 4) the foods on which they depend 5) the vulnerability of these food items to oil, and 6) the probability that oil related activities or spilled oil will impinge on the bird populations in question. Since natural population exhibit daily and seasonal rhythms of activity and year to year fluctuations, studies should encompass a sufficient period of time to establish the normal limits of these fluctuations and the factors that may cause extraordinary perturbations of the system.

In the St. George Basin the University of Wisconsin team under the direction of Dr. J. Hickey obtained estimates of population sizes for marine birds nesting in the Pribilof Islands and U.S. Fish and Wildlife Service studies have provided estimates of the sizes of colonies of seabirds in other areas contiguous with the St. George Basin. While all of these estimates could be further refined to provide hard data for baseline comparisons, the present level of knowledge certainly allows us to know the areas supporting the major concentration of nesting seabirds. The Pribilof Islands clearly support one of the largest concentrations of marine birds in Alaska, if not the world.

Our efforts have and will be directed toward delineating the reproductive and foraging ecology of the seabirds of the Pribilof Islands. These efforts are colony based and have a modest pelagic component conducted near the islands during the breeding season to determine major foraging areas used. Our studies are complemented by the work of the U.S. Fish and Wildlife Service and Mr. G. Devoky on food habits and at sea distribution over a wider area and in periods of the year when we are not in the field. Our work will eventually also integrate the results of various fish and zooplankton studies that should allow us to relate at sea distributions of foraging seabirds to the distributions of their primary food resources. There efforts should culminate in the ability to model the Bering Sea Marine Ecosystem and relate the marine birds to other components of the system. To this end, a first step will be integration of our Pribilof Island data into a model developed by Dr. John Weins of the Oregon State University. Continuation of studies on Pribilof Island seabirds is required in order to establish normal ranges of variation in timing, reproductive success, food habits and foraging areas used.

V. Objectives:

The objectives of the proposed research are to:

1. Determine the phenology of the seabirds nesting on the Pribilof Islands in so far as timing of egg laying, chick hatching and fledging are concerned.

2. Determine clutch size, hatching success, fledging success and reproductive output for Fulmar, Red-faced Cormorant, Black-legged Kittiwake, Red-legged Kittiwake, Common Murre and Thick-billed Murre. These species are more accessible for study than others on the islands and the Kittiwakes and Murres account for the major portion

of the biomass present. If time and opportunity permit data on other species such as Horned Puffin and least Auklets will also be gathered.

3. Determine growth rates of chicks and food used for all species for which data can be obtained.
4. Determine the distribution of foraging birds in the vicinity of the islands.

The Bering Sea is home to some of the greatest concentrations and the greatest diversity of seabirds in the world. Baseline studies of these populations are necessary in order to identify areas of particularly great sensitivity from which oil should be excluded, to identify areas in which special priority should be given to the clean-up of spilled oil, and to provide evidence as to the effects of spilled oil on avian populations.

Timing of breeding, number of eggs laid, hatching and fledging success and growth rates are all indicators of the health of seabird populations. Knowledge of when and why the normal normal stresses in the reproductive cycle occur will facilitate predictions of the possible effects of oil spills and disturbance on these systems. Nesting seabirds are particularly vulnerable to spilled oil, as they are tied to restricted areas by their need to incubate eggs or feed developing young. Young birds, newly departed from their nests, may also be unusually vulnerable to oil on the sea because of incomplete development of flying ability and inexperience in foraging. Thus it is important to document reproductive phenology.

Data on the foods and foraging areas used by seabirds will be collected in order to determine in which ocean areas oil spills will be particularly damaging to Pribilof Island populations. Knowledge of the food chains upon which the seabirds are dependent is also necessary to establish both the role seabirds play in the marine ecosystem and the potential vulnerability of seabirds should certain other marine species be damaged by oil.

VI. General strategy and approach:

The overall strategy of the research is to gather detailed, in-depth data over a sufficiently long time-base so statistically valid comparisons can be made between this area and the other areas on a contemporary basis and between this area now and later, after oil development is under way. Parameters of reproductive success and growth rates of chicks are sensitive indicators of environmental quality and population health and they are more easily and accurately measured than total population size. For these reasons, we are pursuing a detailed, thorough study of the Pribilof Islands colonies to provide a benchmark for future comparisons.

Oil-related activity that may have a major impact on the birds includes, but is not limited to, exploration, especially by aircraft in the vicinity of colonies, drilling and production and transport. Critical features, the impacts of which need to be monitored, are disturbance of nesting birds, oiling at sea and reduction in the availability of food resources. The proposed research contributes to a baseline on reproduction and foraging ecology against which the effects of these impacts can be measured.

The research is designed to provide a broad comparative baseline. To this end, studies will be conducted on both St. Paul and St. George Islands. The relative species composition on these two islands differs as apparently do the phenologies and reproductive success of some species. Species chosen to study are those with the greatest numbers present on the islands, as well as those for which large amounts of data can be gathered efficiently. Less effort is being put into those species that are difficult to work with, thus yielding little data for the effort expended and that can be studied more readily in other areas.

VII. Sampling Methods:

1. Rationale

Several variables which influence reproductive success and growth rates impinge on any natural study. These variables include: 1) year to year changes in the ecosystem, 2) variations in the exposure of different nest sites, and 3) variations in the age and experience of nesting individuals being studied.

Variable 1, year to year variations can only be understood by a multiple year study; one year's efforts represent but a single data point for understanding the input of this variable. The possible distortions that variables 2 and 3 might cause to a baseline study can be minimized within a single year's study by choosing a sufficiently large number of subsampling areas and by following the success of an adequate number of nest in each area. The number of separate sites to be chosen will depend on the dispersal of nests and on local conditions but at a minimum will include 5 sites on St. Paul and 3 sites on St. George. The number of nests to be studied in each area will be at least 15-20, if possible, so that individual variations and chance events will not unduly distort the results obtained.

2. Reproductive Success

Seabirds breeding on St. Paul Island either nest on cliff ledges or raise their young in holes and crevices in the cliffs or below ground among the rocks of boulder beaches. For those species which breed in the open (Fulmars, Red-faced Cormorant, Black-legged and Red-legged Kittiwakes, Common and Thick-billed Murres), data on reproductive success can be obtained relatively easily by observation of many nests at a time from locations at the top or bottom of the cliffs. Accurate data on the hole-nesting species (Tufted and Horned Puffins, and Crested, Least and Parakeet Auklets) must be obtained by looking into each hole individually.

The basic techniques for obtaining data on the reproductive success of the six ledge-nesting species, and the Horned Puffin and the Parakeet Auklet if time permits,will be to locate nests, number them individually, and count the eggs or chicks contained in those nests usually every three to seven days, either until chicks fledge and leave the nest, or until total egg or chick loss occurres. Inaccessible nests will be reidentified each visit using black-and-white photographs.

Part of the egg and chick counts for Red-faced Cormorant, Black-legged and Red-legged kittiwakes and Thick-billed and Common Murres on both islands and for all Horned Puffin and Parakeet Auklet nests that we are able to study will be obtained by using a ladder at the bottom of the cliffs to reach into nests and nesting holes. This method, while causing some disturbance, allows more accur-te assessement of timing of laying and of mortality than visual observations above, as it is often hard to count eggs or tell when eggs are first laid or hatch under birds that sit very tightly. These nests will be identified by numbers painted on the cliffs.

In 1976 on St. Paul we used two methods to assess Murre reproductive success, to see whether or not our studies the previous year, envolving scaring birds from ledges, had had unanticipated effects. At several sites the scaring methods employed in 1975 were used, and at other sites the observer did not scare the birds, but sat quietly for an hour or so at each visit watching to see by the birds' behavior whether they were incubating eggs, brooding young, or were not breeding. In 1976 the use of black-and-white photographs of each ledge made the task of assigning an individual number to each egg or young far easier. The scaring techniques did depress reproduction. In 1978 we will rely primarily on long, quiet observation to determine "nest" contents for Murres, although birds on one or two ledges on each island will be scared off in order to obtain better data on phenology.

On St. George in 1976 there were no small Common Murre ledges easily observable from the cliff tops. At the Staraya Artil study site a small ledge was reachable by ladder, and reproductive success was assessed by climbing up to the site, which disturbed the adults and caused them to fly off. Thick-billed Murres were studied in the same fashion. Disturbance at this site did not have the severe effects on hatching success as was found on St. Paul in 1976. We expect to continue ladder checks at this site in 1978, but also to use purely observational methods at other sites to facilitate comparisons with St. Paul birds.

3. Growth Rates

Growth rates of young seabirds have been shown in past studies to be strongly correlated with fledging success (Hunt, 1972; Hunt and Hunt, 1975, 1976).

Data on growth rates of the chicks of five species (Red-faced Cormorant, Black-legged and Red-legged Kittiwakes, Common and Thick-billed Murre) will be obtained by weighing chicks periodically, usually at least twice a week. Chicks will be individually marked with numbered plastic leg bands or fingerling fish tags, placed in cloth bags and weighed with Pesola spring scales (300g to 5kg capacity, depending on the species and the size of the chick). The weight of the bag and of any food regurgitated by the chick will be subtracted from the total weight to obtain the weight of the chick.

In all of the above species with the exception of the Murres the typical growth pattern is a period of rapid and steady weight gain followed by either a plateau or a slight decline in weight prior to fledging. In these cases the growth rate for the straight-line portion of the growth curve will be calculated by the formula:

$$\frac{\text{weight}_2 - \text{weight}_1}{\text{day}_2 - \text{day}_1}$$

where the gain in weight between the first weighing and the peak weight is divided by the number of intervening days, yielding an average number of grams gained per day.

Murre chicks hatch at 65-70 grams and gain weight for 10-15 days. Many of them will reach a plateau or begin to lose weight when their contour feathers begin to grow in. Then there is a second period of weight gain, sometimes followed by a slight drop in weight just before the chick goes to sea. This pattern is not always consistent, however; some chicks may not lose weight at all during the period of contour feather growth. We have used and will continue to use for comparative purposes the number of grams per day that a chick gains during the first growing phase.

An important parameter for chick survival is its weight when it leaves the cliffs to go to sea. It is presumed that a heavy chick will be more likely to survive than one which is light and has little fat reserves. Our data for both species of Murres in 1976 show a positive correlation between the number of grams gained per day until the first peak of growth and the last weight obtained before the chick leaves the island. When possible we will obtain peak or fledging weights of young.

4. Food Sampling

Information on foods will be obtained in three ways: 1) adult birds will be shot with a 16 gauge shot gun and their stomachs will be removed and opened, 2) chick regurgitations will be collected, 3) adult Least Auklets will be captured in mist nets, and their regurgitations collected.

Early in the season, before chicks hatch, about 5 adults each of Black-legged Kittiwakes and Red-Leg Kittiwakes, Common Murres, Thick-billed Murres, and Red-faced Cormorants will be collected weekly. Alcohol will be injected into their stomachs upon shooting and stomachs will be removed, preserved in 80% ETOH and shipped to the laboratory in Irvine for analysis.

As the field season progresses and chicks begin hatching, we will be able to obtain food samples from Red-faced Cormorant, Black-legged Kittiwake and Red-legged Kittiwake chicks. Chicks often regurgitate while being weighed, and during August and September samples from these species will be obtained primarily by this method of collection, rather than by shooting. We will continue to shoot Puffins, Murres, Crested and Parakeet Auklets during this time, when they are observed carrying food, but samples from Least Auklets will be collected by mist-netting adults returning with food for their chicks. A bird containing food in its gular pouch will regurgitate as soon as it hits the net.

Food samples will be preserved in plastic Whirl-pak bags in 80% ethanol, and labeled as to sample number, species, island and date collected.

Food items used by birds will be identified as well as is possible, depending upon their state of digestion. The results will be catalogued by bird species on a % volume and % occurence basis. For the purposes of the annual report, foods taken by a bird species over the entire season will be treated together. As additional years of data accumulate it will become possible to analyze separately foods given to young and those consumed by adults prior to the chick stage.

5. Distribution of Foraging Seabirds:

We propose that three sets of radial transects be made during the 1978 breeding season: 5 days each, May 8 - 12 $\pm$ 8 days, August 10 - 14 $\pm$ 5 days and September 13 - 17 $\pm$ 8 days. This schedule will allow censusing as the birds are seting up nest sites, at the peak of Murre chick-feeding activity and as the birds are dispersing with newly fledged young, respectively. Ship tracks will cover those proposed for 1977 subject to revision pending 1977 results, plus filling in areas where data are lacking.

Each cruise will be manned by three bird observers; one to take a hard copy record and two to make observations in shifts or simultaneously if bird densities were high. This system proved most successful on our recond Moana Wave cruise in 1976 and will be used on the 1977 cruises.

Observations will be made as continuously as possible from dawn to dusk, depending upon weather and sea-state. Segments (transects) will be begun every 10-15 minutes and at the commencement of each segment location and environmental data will be recorded.

Counts of birds will be made out to 300 meters from the ship, grouping birds into three 100 meter zones. Observations will be recorded from directly ahead to 90^{o} off one side of the ship, the side being chosen for maximum visibility. Note will be taken of flock composition, numbers, activity (e.g. on water, flying, foraging), and if flying, flight direction. This method of counting may result in overestimates of density of flying birds (because the count for an entire segment is not instantaneous, birds continually fly in and are added to the count), but it will be consistant with previous censuses and will give good relative abundance information as well as data on flight directions.

During all transects, care will be taken to ensure that observations are of a natural situation and not of a situation influenced by the ship's presence in the water. Garbage and refuse will be dumped only at the completion of the observations and a radar watch will be kept for foreign and domestic fishing vessels within the radar range (50 nautical miles). Effort was made not to count circling or following birds more than once.

VIII. Analytical Methods

No elaborate analytical methods are used in this research. Data on phenology, reproductive success, growth rates and food habits are compiled by straight-forward methods as outlined above. Differences between sub-colonies, islands or years will be tested using appropriate parametric and non-parametric statistics.

IX. Anticipated Problems:

Based on our first two years of experience and the beginning of the third field season, we anticipate no major problems with the field work.

Problems may develop if housing costs are again increased by National Marine Fisheries after the conclusion of contract negotiations or if wash and storage space on St. Paul cease to be available to us. There is little we can do about these potential problems until such time as they arise.

Our biggest potential problem is data management for A.D.P. Within our research group we have neither the man-power nor the expertise to effectively transform our data from field data forms to punch cards as tapes. Two options appear to be open to us. One is to go to a commercial firm with our data and pay to have it punched and verified and subsequently checked by us. Judging by the experience of Mike Crane's staff, outside punching firms are likely to produce files rife with errors. A second alternative, tentatively verbally agreed to by Mike Crane and the Juneau Project office is to have Mike Crane's office punch our data and for us to then proof his efforts. I feel that this will be more efficient and cost effective for the project. Punching without verification in California of 26,000 lines (estimated of $6.15/line by Mike Crane) would cost approximately $39000. With verification and corrections costs would probably more than double. As a more drastic solution, I would favor cutting way back or dropping most colony data from the A.D.P. files, and instead rely on summaries or narrative reports and the tables and charts therein. At sea transects could also be reported in summary form. Most if not all of the data relevant to O.C.S.E.A.P. could still be retained and the data processing could be cut by 20 or 30 fold.

X Deliverable Products:

A Digital Date

Parameters that will be collected and submitted:

Bird colony Q35:

Record Type A	Station number
	Latitude
	Longitude
	Start date/time
	End date/time
Record Type B	Sample date/time
	wind direction
	wind speed
	sea state
	weather code
	visibility
Record Type G	Sample date/time
	Toxonomic code
	Egg number
	Endoparasites
	Ectoparasites
	Egg mortality
	Chick number
	Chick weight before sampling
	Chick weight after sampling
	Food sample number
	Chick mortality
	Band number

Record Type H	Station number	
	Sample data/time	
	Taxonomic code	
	Sex	
	Age class	
	Food present	
	Food sample number	
	Endoparasites	
	Ectoparasites	
	Gonad-size	
	Whole body weight	
	Fat classification	
Record Type J	Station number	
	Sample date/time	
	Taxonomic code	
	Food sample number	
	Material code	
	Food sample Taxonomic code	
	Food quantity	
	Weight of food sample (wet)	
	Displacement volume	
	Representative length	

Record Type F Station number

Sample date/time

Taxonomic code

Station type

Number of eggs

Number of chicks

Egg mortality

Chick mortality

Total number of incubators

Total number of adults

Total number of nests

Egg mortality cause

Chick mortality cause

Ship Census 033:

Record Type 1 Station number

Start latitude

Start longitude

Start date/time

End latitude

End longitude

Elapsed time

Time zone

Speed made good

Course made good

Platform type

Sampling technique

	Ship activity
	Photo taken
	Width of transect
	Angle of view
	Observing condition
	Distance made good
Record Type 2	Station number
	Bottom depth
	Surface temperature
	Surface salenity
	Dry bulb temp.
	Wind direction
	Wind speed
	Swell height
	Weather code
	Visibility
	Distance to nearest shoreline
Record Type 5	Station number
	Time
	Taxonomic code
	Species group
	Age class group
	Color phase
	Number of individuals
	Counting method

Reliability

Distance measurement type

Platform to birds distance

Direction of flight

Association type

Multispecies link

Number of species participating

Behavior code

Special works

Food source association

Taxonomic code for food species

Debris code

Oil code

Distance from nearest breeding colony

Habital code

2. List of Digital Products

It is our plan to submit punching compatible field data sheets and code forms to Mike Crane's office throughout the field season. At the termination of the field season we will proof his listings of cards punched and prepare data documentation forms. In this manner it is expected that most data gathered in FY 77 will be punched in FY 77 rather than in FY 78 as originally planned and that FY 78 data will be punched primarily in FY 78. Because of field committments on this project through the end of September 1978, we will still require additional funding in FY 79 to complete submission of FY 78 data as has been the case in the past. See Table 1 for details.

TABLE 1

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)	Collecting Period (Month/Year to Month/Year)	Submission (Month/Year)
Ship board survey	Cards	7,500	033	In part	May 77 - Sept 77	January 78
Bird Colony	Cards	17,000	035	In part	May 77 - Sept 77	January 78
Ship board survey	Cards	12,000	033	In part	May 78 - Sept 78	January 79
Bird Colony	Cards	17,000	035	In part	May 78 - Sept 78	January 79

B. Narrative Reports:

At present I do not anticipate generating any special reports other than the standard quarterly and annual reports. If the opportunity is available we would be interested in synthesizing reproductive data for Kittiwakes for all Alaskan colonies studied, thereby expanding in the pilot synthesis attempted last year. This could again be submitted as an appendix to the 1 April 1978 annual report.

The narrative report will contain information on reproductive ecology, phenology, foraging areas, and food habits. Life history data on selected species will included when appropriate.

C. Visual Data:

We do not expect to produce visual data other than those contained in the quarterly and annual reports. Visual data to be included in the 1 April 1978 annual report includes but will not be limited to:

1. A map showing locations of subcolonies selected for study (Fig. 1)
2. Charts showing seasonal changes in the use of colonies for selected species (Fig. 2)
3. A chart showing the overall use of the Pribilof Islands by birds (Fig. 3)
4. Flight directions to and from major foraging areas for selected species (Fig. 4)
5. Tables showing hatching success, fledging success for each major species (Table 2)
6. Tables comparing hatching success, fledging success, and growth rates for each major species on the two islands and for the three years of the study (Table 3)

7. A table giving foods habits of each major species (Table 4) If data are adequate food habits will be broken down by adult vs. chick and for male and female.

8. Figures showing sightings of each of the major species or species groups at sea on foraging areas. (Fig. 5) and on water (Fig. 6)

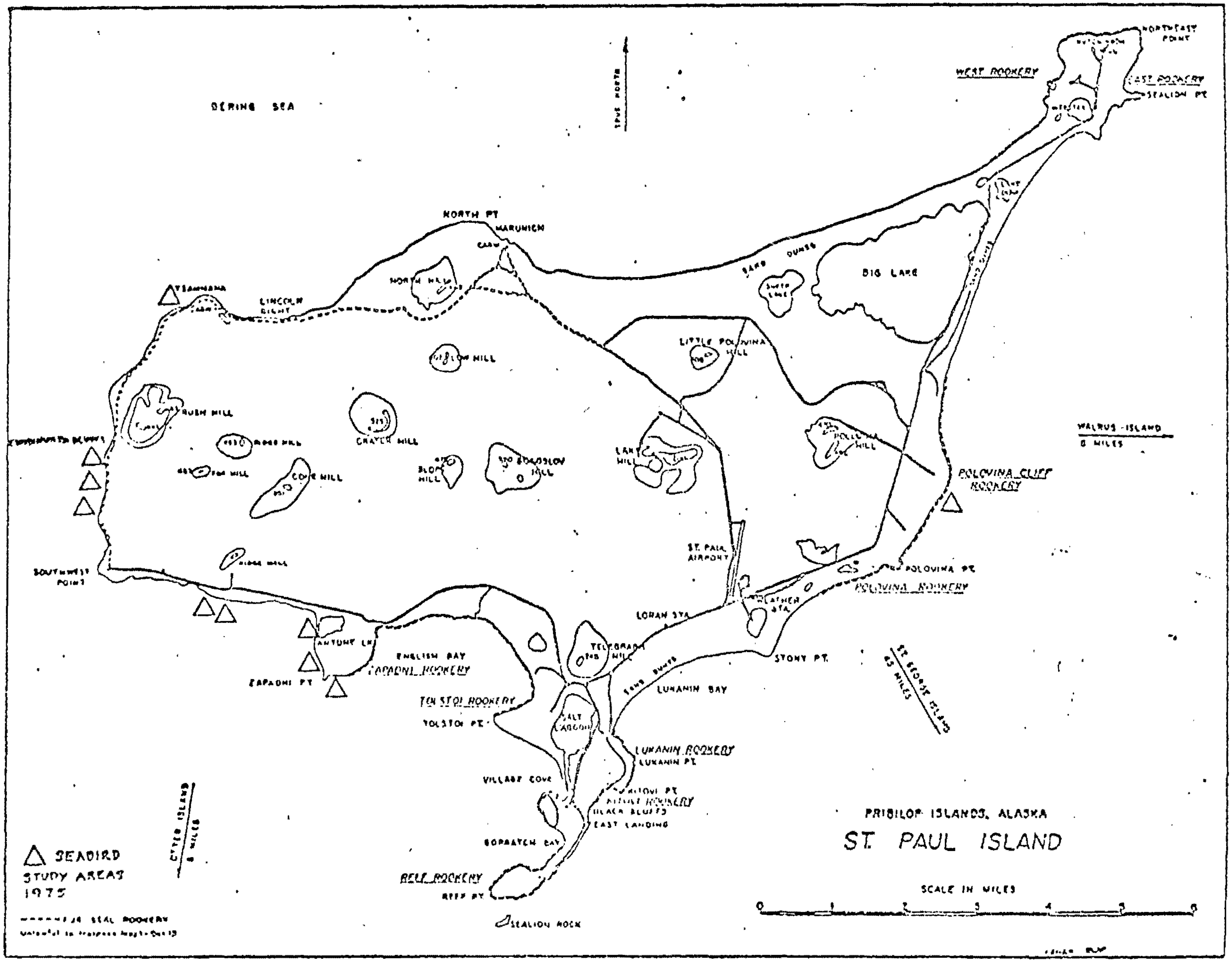


Fig.1. 1975 study sites, St. Paul Is.

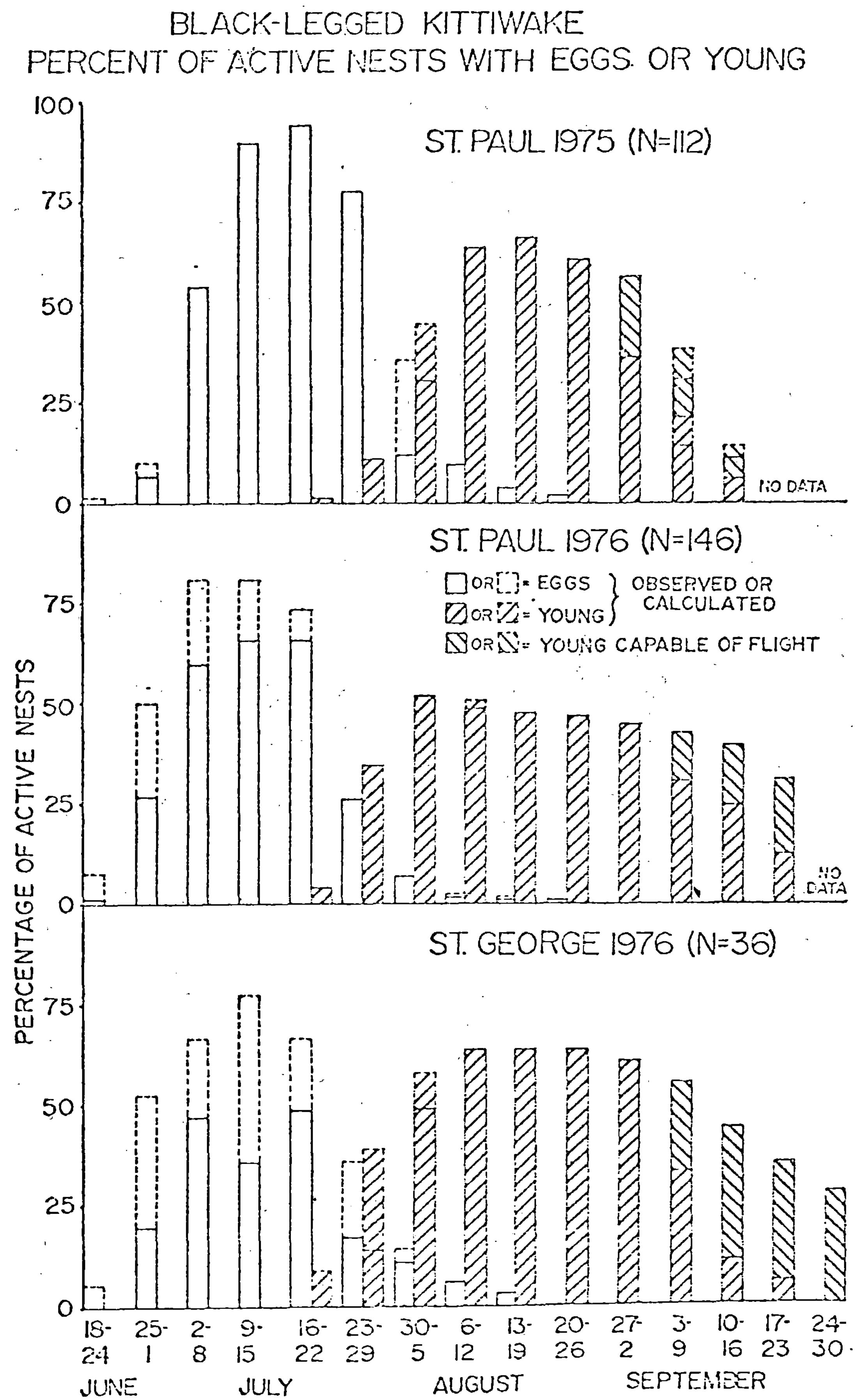
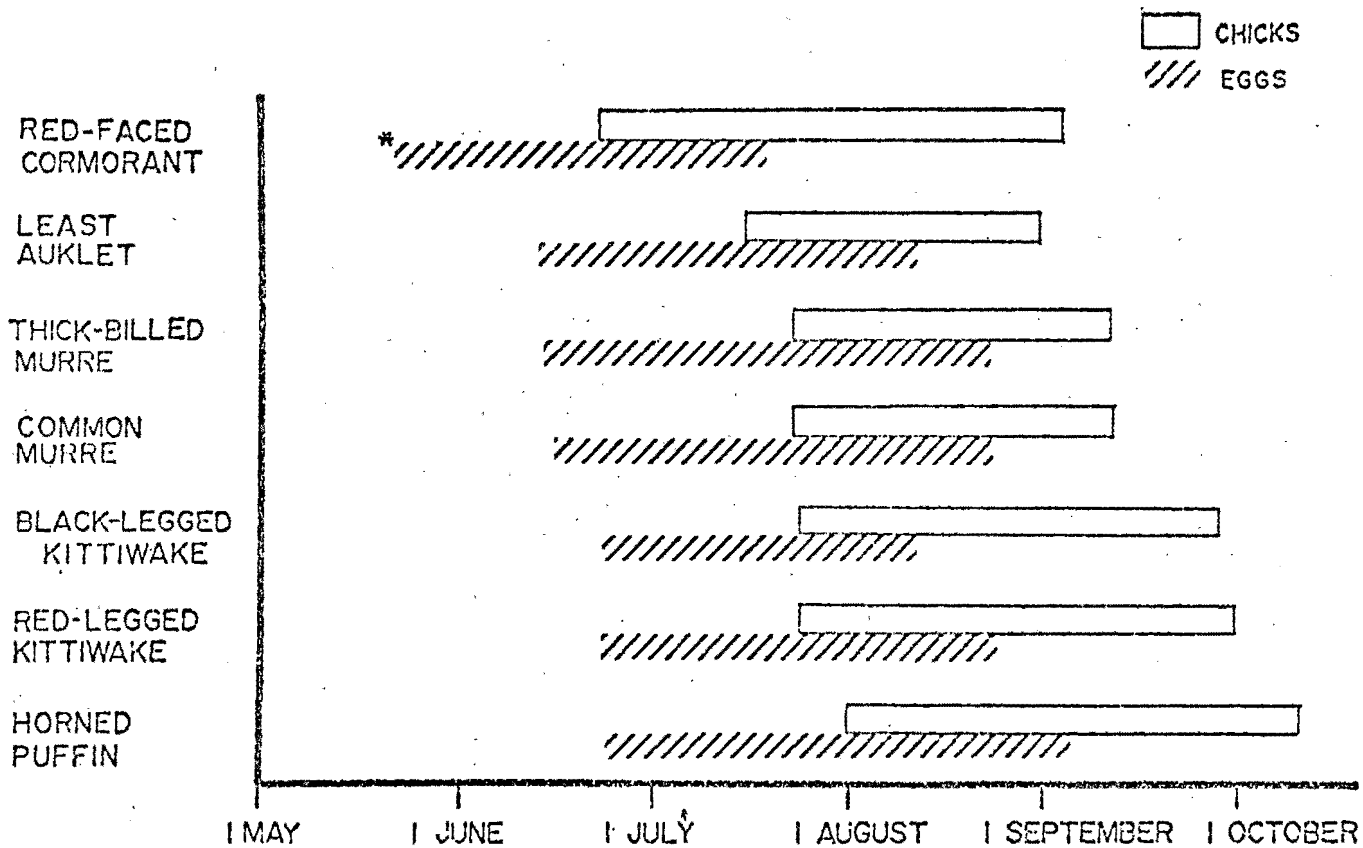


Fig. 2. Timing of breeding of Black-legged Kittiwakes 1975-1976

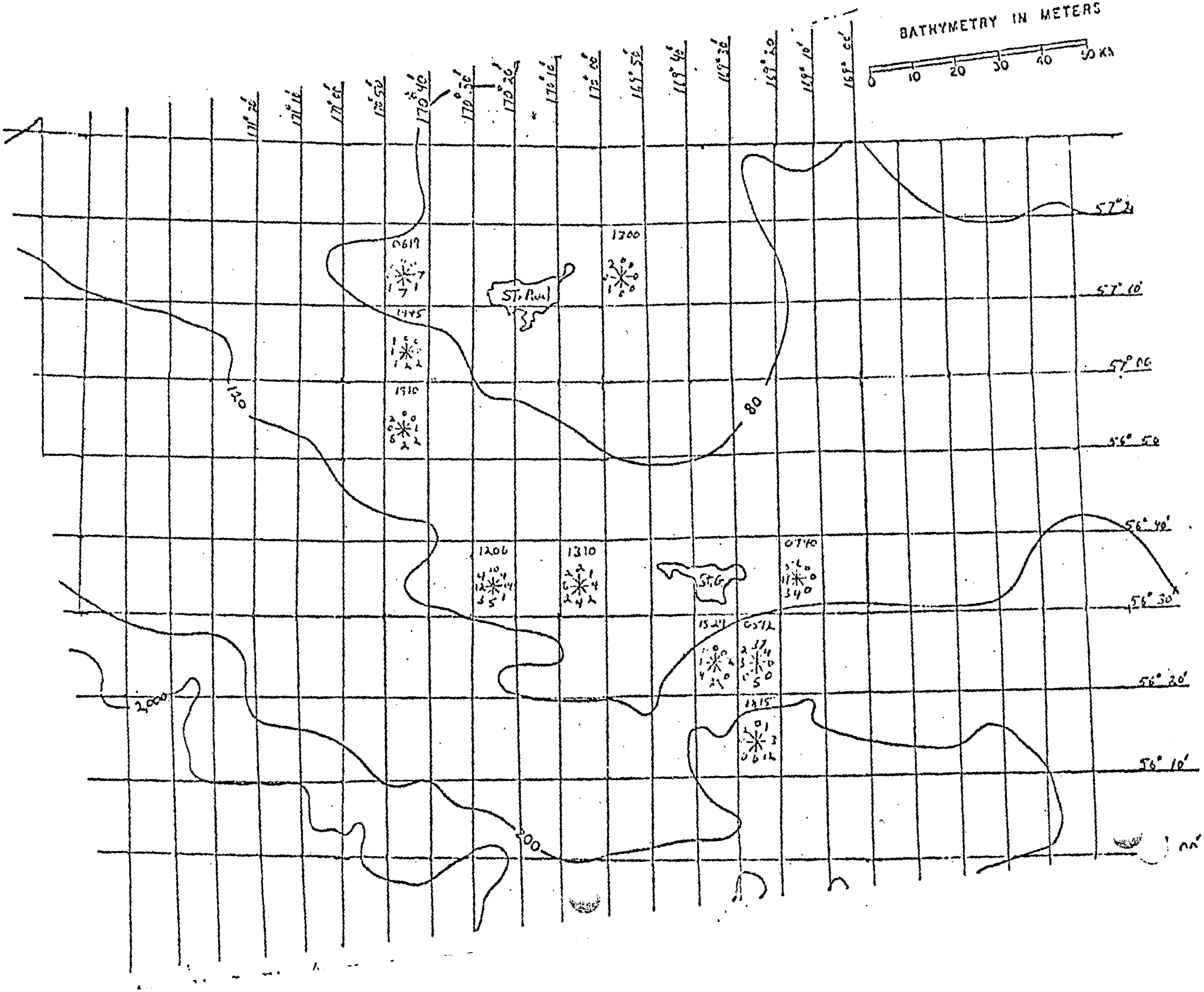
PRESENCE OF EGGS AND CHICKS IN NESTS OF SEVEN SPECIES OF SEABIRDS ON ST. PAUL ISLAND, 1975 & 1976



*Extrapolated from hatching dates.

Incubation period = 1 month

Fig. 3 . Timing of breeding of ven species of seabirds, St. Paul Is. 1975-1976


BATHYMETRY IN METERS
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170° 40'
170° 30'
170° 20'
170° 10'
57° 20'
57° 10'
57° 00'
56° 50'
56° 40'
56° 30'
56° 20'
56° 10'
St. Paul
St. G.
120
80
200
2000
0619
1700
1445
1310
1206
1310
0740
1815

TABLE 2

REPRODUCTIVE SUCCESS

BLACK-LEGGED KITTIWAKES - ST. PAUL ISLAND 1976

	Tsammana North	Tsammana South	Rush Gap	Gun Emplacement	Ridge Wall	Total
# nests	69	20	18	13	35	155
# incubated nests	55	18	14	9	26	122
# nests with known clutch size	55	12	11	7	9	94
average clutch size	1.45	1.50	1.64	1.26	1.33	1.46
chicks hatched/ egg laid	.50-.55	.72-.83	.50-.83	.44-.55	.67-.92	.54-.66
chicks fledged/ chicks hatched	.59-.65	.60-.69	.69-1.00	.40-.50	.55-.75	.58-.70
chicks seen/ incubated nest	.73	1.00	.79	.77	.65	.76
chicks fledged/ incubated nest	.47	.61	.71	.33	.58	.53
chicks fledged/ egg laid (known clutch)	.33	.33	.50	.22	.58	.36
chicks fledged/ nest built	.38	.55	.56	.23	.43	.42

TABLE 3

REPRODUCTIVE BIOLOGY

BLACK-LEGGED KITTIWAKE - PRIBILOF ISLANDS 1975-1976

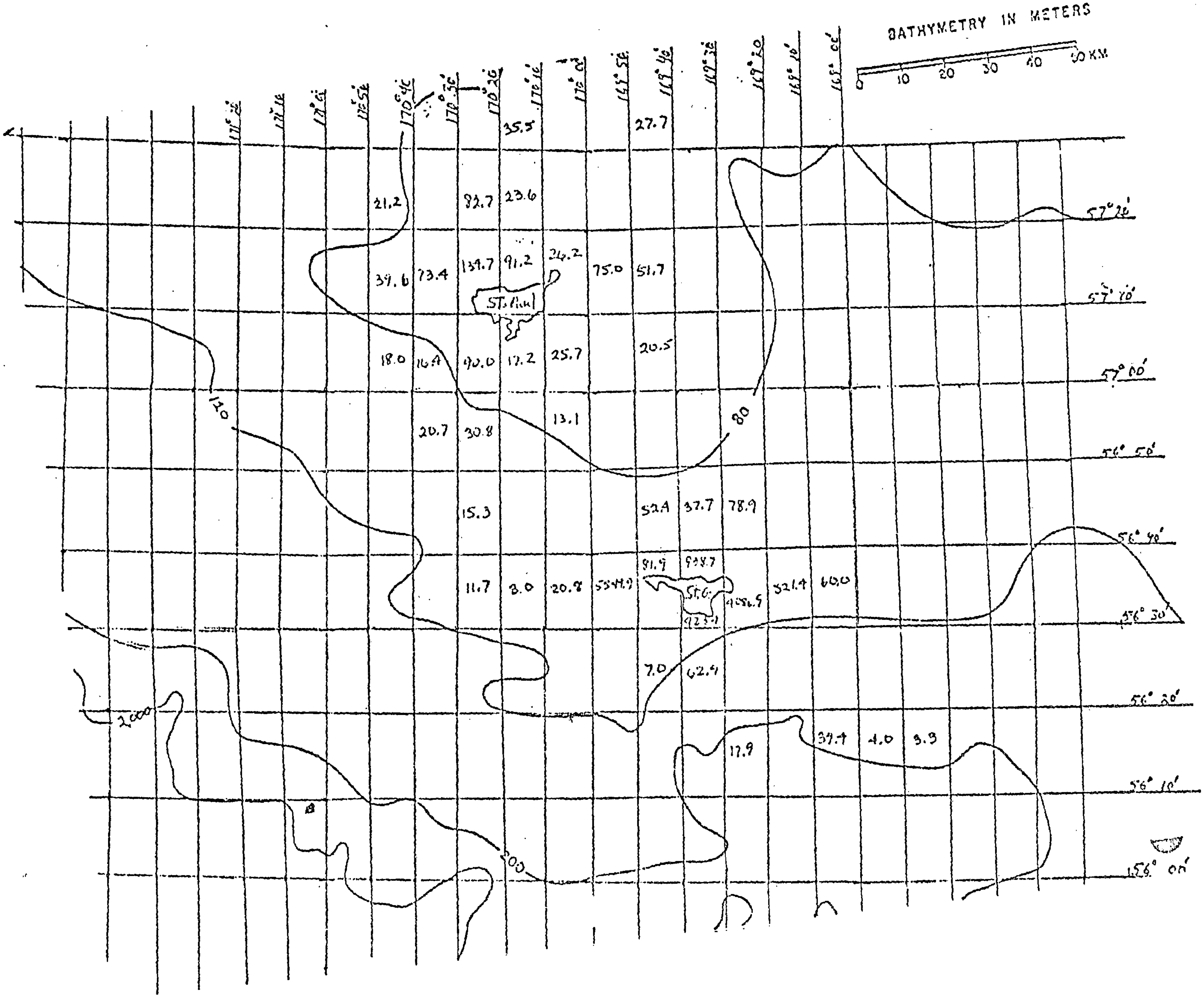
	St. Paul 1975	St. Paul 1976	St. George 1976
Total nests studied	185	155	36
# nests known clutch size	87	94	22
average clutch size	1.44	1.46	1.36
chicks hatched/ egg laid	0.57-0.67	0.54-0.66	0.67-0.80
chicks fledged/ chicks hatched	0.57-0.68	0.58-0.70	0.71-0.85
chicks fledged/ egg laid	0.38	0.36	0.57
chicks fledged/ nest with eggs	0.54	0.53	0.75
chicks fledged/ total nests	0.44	0.42	0.58
average growth rate (g/day gained)	17.9 ± 3.4	12.8 ± 4.9	11.5 + 2.6
# chicks with growth data	34	33	24

TABLE 4 FOODS USED BY RED-FACED CORMORANTS

ST. PAUL ISLAND 1975 - 1976

	% Samples* 1975	% Samples* 1976	1977	% Volume 1975	% Volume 1976	1977
Sample size	38	65		1803ml	1783ml	
Food Types						
Marine worm	2.6	0.0		0.1	0.0	
Mollusca (not squid)	7.9	7.7		trace	trace	
Isopoda	0.0	3.1		0.0	0.1	
Amphipoda	36.8	33.8		4.2	2.2	
Gammaridea	34.2	27.7		3.9	0.4	
Hyperiida	2.6	3.1		0.2	0.1	
Parathemisto libellula	2.6	1.5		0.2	0.1	
Euphausiacea	2.6	0.0		trace	0.0	
Decapoda	65.8	53.8		12.8	13.5	
Shrimp	52.6	34.6		8.5	7.1	
Lebbeus polaris	--	27.7		--	6.4	
Lebbeus groenlandica	--	9.2		--	0.3	
Argis crassa	--	7.7		--	0.4	
Crab	52.6	35.4		3.7	3.7	
Dematuras mandtii	--	18.5		--	1.3	
Haplogaster spp.	--	6.2		--	1.4	
All Fish	92.1	95.4		66.5	83.2	
Ronquil Jordanii	--	1.5		--	0.4	
Myoxocephalus	--	1.5		--	0.9	

* % of Samples in which food types occurred


BATHYMETRY IN METERS
0 10 20 30 40 50 KM
57° 20'
57° 10'
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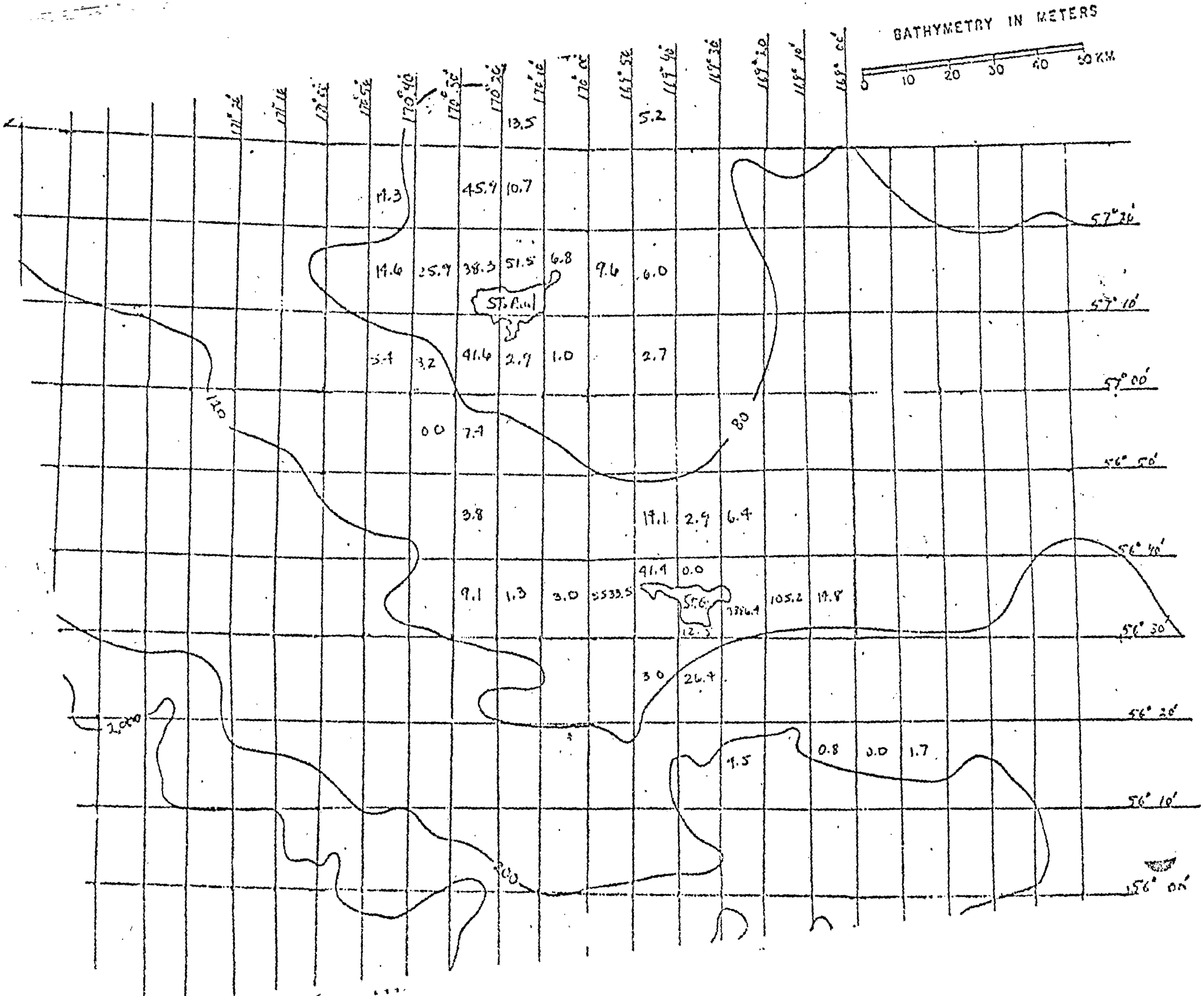
56° 50'
56° 40'
56° 30'
56° 20'
56° 10'
56° 00'
St. Paul
St. G.
120
80
200
2000
35.5
27.7
21.2
82.7
23.6
39.6
73.4
139.7
91.2
26.2
75.0
51.7
18.0
16.4
90.0
17.2
25.7
20.5
20.7
30.8
13.1
15.3
52.4
37.7
78.9
11.7
3.0
20.8
7.0
62.4
17.9
37.4
4.0
3.3


BATHYMETRY IN METERS
0 10 20 30 40 50 KM
171° 20'
171° 10'
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169° 00'
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57° 10'
57° 00'
56° 50'
56° 40'
56° 30'
56° 20'
56° 10'
56° 00'
St. Paul
St. G.
120
80
200

D. Other Non-Digital Data:

At present we do not anticipate submitting other non-digital data.

E. See Data Products Schedule (Table 1).

XI. Information Required from Other Investigators

No data will be required of other investigators to complete the proposed work. However, it will be important to obtain data on the distribution and abundance of major food species used by Pribilof Island seabirds. Also, we would be interested in data on Kittiwake reproductive ecology so that we could synthesize information for this species throughout Alaska. Such a synthesis would put into perspective the data obtained from each separate colony or lease area.

XII. Quality Assurance Plans

Since we do not use instruments (other than binoculars and a camera) in our work there is no need for instrument calibration. Colony techniques are standardized and involves straight-forward writing. Intercalibration of at-sea surveys is almost impossible, as the greatest source of variation is observer skill and fatigue and next probably is observation conditions. The best intercalibration would be to put all OCSEAP observers on the same ship at the same time and compare results. Since that is not feasable, data will have to be treated as approximate, which is also reasonable in light of the mobility of the birds in question.

XIII. Special Sample and Voucher Specimen Archival Plans:

No special specimen archival plans are anticipated. We have inquired about archiving bird specimen and food samples collected during the project and have been informed by the Juneau Project Office that there is no interest in keeping these specimens. Most bird skins and skeletons have been given to museums; stomach contents are still being held.

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 California, Irvine PRINCIPAL INVESTIGATOR George L. Hunt, Jr.

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 attached sheet (Fig. 7) and Table 5

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. Direct visual observations of birds will be made continuously. At the start of each 10 minute segment we will require a position fix, sea surface salinity and temperature, depth from surface to bottom and true wind speed and direction.

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.) Times of cruises are keyed to the reproductive cycle of the birds. The first leg should be 8-12 May $\pm$ 8 days, the second 10-14 August $\pm$ 5 days and the third 13-17 September $\pm$ 8 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.) 5 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? Mine should be the Principal Investigation during the 5 day legs.
   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 will use all day light hours available, weather permitting. This will range between 12 and 14 hours.

6. What equipment and personnel would you expect the ship to provide? We will need a Deck Tech to help take the weather and oceanographic data while bird observations are in progress. The ship should be instrumented to give continuous readout on water depth, sea surface temperature and salinity and wind speed and direction.

7. What is the approximate weight and volume of equipment you will bring?
   25 lb, 3 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. 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 Not applicable

12. How many people must you have on board for each leg? Include a list of participants, specifically identifying any who are foreign nationals. 3-4 persons, as yet unnamed

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)

St. Paul Is.	1 May - 31 May	3 persons/day	total person/days - 93
St. Paul Is.	1 June - 31 July	2 persons/day	total person/days - 122
St. Paul Is.	1 August - 31 August	3 person/day	total person/days - 93
St. Paul Is.	1 Sept. - 30 Sept.	2 person/day	total person/days - 60
St. George Is.	1 June - 30 Sept.	1 person/day	total person/days - 122
			Total Person Days 490

2. Do you recommend a particular source for this support? If "yes" please name the source and the reason for your recommendation. Yes. Quarters have been available through National Marine Fisheries Service during the summers of 1975, 1976 and 1977. We have been assured they will be available in 1978. Food is both shipped from Seattle and purchased on the Islands.

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

We estimate person/day costs at $15/day/person on St. Paul and $15.00/day/person on St. George

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?

We estimate the cost of food on the Islands at $7/day/person.
The cost of housing on St. Paul will average $8.42/day/person
The cost of housing on St. George will average $8.20/day/person
Housing rates are fixed by National Marine Fisheries Service.

Fig. 7

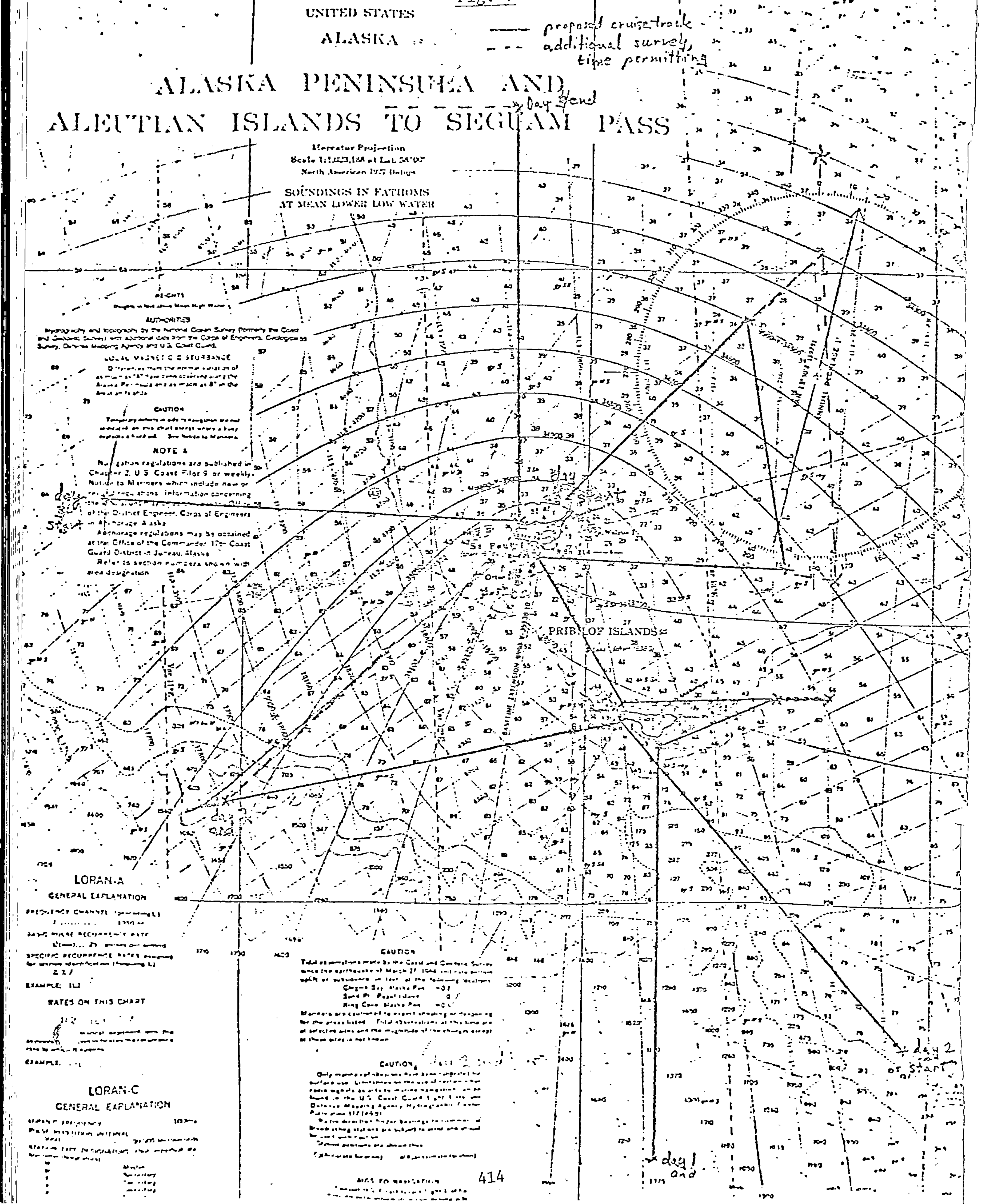
UNITED STATES
ALASKA
proposed cruise track
additional survey, time permitting
ALASKA PENINSULA AND ALEUTIAN ISLANDS TO SEGUAM PASS
Mercator Projection
North American 1927 Datum
SOUNDINGS IN FATHOMS
AT MEAN LOWER LOW WATER
AUTHORITIES
CAUTION
NOTE A
PRIBILOF ISLANDS
St Paul
BASELINE EXTENSION
LORAN-A
GENERAL EXPLANATION
RATES ON THIS CHART
CAUTION
LORAN-C
GENERAL EXPLANATION
day 2 end
day 1 end

TABLE 5

Turning Points for Proposed 1978 Cruise Tracks

day	Turning Point	Location		
day 1	1 start	57° 7'N	170° 17'W	at St. Paul
	2	56° 38'N	169° 38'W	Dalnoi Pt.
	3	56° 39'N	168° 30'W	East of St. George
	4	56° 30'N	169° 35'W	So. side of St. George
	5 end	55° 10'N	169° 35'W	80 miles So. of St. George
day 2	1 start	55° 32'N	168° 10'W	80 miles SE St. George
	2	56° 35'N	169° 47'W	So. side Dalnoi Pt.
	3 end	55° 30'N	171° 00'W	80 miles SW St. George
day 3	1 start	50° 35'N	169° 47'W	So. side Dalnoi Pt.
	2	56° 19'N	172° 05'W	80 miles WSW of St. George
	3 end	57° 7'N	170° 17'W	at St. Paul
day 4	1 start	57° 17'N	172° 48'W	80 miles W. of St. Paul
	2	57° 13'N	170° 25'W	NW. Pt. St. Paul Is.
	3 end	58° 30'N	170° 25'W	80 miles N of St. Paul
day 5	1 start	57° 12'N	170° 07'W	No. of N.E. Point, St. Paul
	2	57° 51'N	169° 06'W	50 miles NE of St. Paul
	3	57° 10'N	168° 51'W	50 miles E of St. Paul
	4 end	57° 07'N	170° 17'W	at St. Paul

XV. Management Plan:

The project will be managed in essentially the same way it has been in past years. Barbara Mayer who presently has a year and a half experience on the project will supervise the 1977 data work-up and will be in charge of food analysis and planning for the 1978 field season. She will not, however, be going into the field for the 1978 field season.

Two of our other three present island staff will help Ms. Mayer in the work-up of the 1977 data and the preparation for the 1978 field season. One of these individuals will be in charge of the St. George effort, the other in charge of St. Paul. The second staff member on St. Paul in 1978 will either be one of our present field staff or a newly recruited individual. Thus for the 1978 field season we will have one person on St. George and two people on St. Paul.

The Principal Investigator will have overall responsibility for scientific guidance, program management and will participate in the writing of the 1977 annual report. He will participate in field work during the month of August 1978.

During the 1977 field season our entire effort will be directed toward gathering data. Upon return from the field in October 1977 we will simultaneously analyse the data and proof the punched data sent to us by Mike Crane's office. Similarly in 1978 from May through October we will gather data with all hands in the field. After we return from the field in October, we will analyse data and proof the punched data as it is sent back by Mike Crane.

XVI. Outlook:

1 and 2) Continued baseline research on the Pribilof Islands is important for two reasons. First, the Pribilof Islands support one of the largest concentrations of seabirds in Alaska, if not the world, and the major part of the birds are alcids, a family of birds notoriously vulnerable to disturbance and spilled oil. If there is to be any development of oil extraction in the St. George Basin, apparently an important foraging area for Pribilof Island Murres, Red-legged Kittiwakes and Fulmars, or if there is to be significant tanker or support vessel traffic (related to more northern lease areas) in the vicinity of the Pribilofs, then it will be essential to be able to monitor the effect of these activities on Pribilof seabirds.

Secondly, our studies on the Pribilofs, now in their third year, represent one of the largest running and most detailed baseline studies of Alaska seabirds. The length and thoroughness of this study provides an almost unique opportunity to develop a hard data base, showing normal variability, and providing a base against which other shorter-term or less intense studies may be compared. For this reason, as well as because the Pribilofs are such an important seabird nesting area, I feel that the present level of studies, given the amount of variation we have seen to date, should be carried out through the summer of 1979, that is for five field seasons.

After the first five years of baseline study are complete, I feel that effort could be somewhat reduced and that thereafter, until oil related activities ceased, a monitoring effort, coupled with special studies designed to fill data gaps in modeling efforts would be an appropriate level of effort.

The objective of the first plateau - completion of the baseline, would be to determine a first approximation of the range of natural variation in 1) timing of breeding, 2) reproductive success, 3) growth rates of young and 4) types of foods used by the seabirds of the Pribilof Islands. A fifth objective would be to determine the major foraging areas that support these vast numbers of birds during their nesting season. With the present level of research effort these first level objectives should be accomplished by the end of the 1979 field season.

Data products for the first major plateau would be range, mean and standard deviation from phenology, reproductive success and growth rates for Red-faced Cormorant, Black-legged and Red-legged Kittiwake and Common and Thick-billed Murres for both St. Paul and St. George Islands. Food habit information would be presented by year, and data for all years would be combined and then examined for differences in foods used by adults and fed to chicks, and whether males and females used different types of food. Data on foraging areas will be expressed as the mean and range of densities of birds encountered in 10' x 10' sections of latitude and longitude. When appropriate, flight lines between the islands and foraging grounds will be delineated, and birds seen on the water foraging will be separated from those recorded as in flight.

As part of the final years of intensive baseline study, two short term projects should be integrated into the program. The first would be a study of the metabolic demands of growing chicks and adult birds. This information, generalizable throughout Alaska, will be useful for modeling by fixing food demands and by determining the sensitivity of young birds to exposure or short-term deprivation of food, as might occur with either disturbance or an oil spill.

The second project would involve one or two intensive one to two week cruises combining bird observations with plankton and fish sampling.

The objective of such cruises would be to establish the degree to which bird foraging distribution reflects the distribution of critical food resources. Such an integrated program will most profitably be carried out once we have analysed the major portion of our data on food habits and foraging areas. With these data in hand, an integrated cruise could be planned for maximum efficiency in the use of ship time.

The second level of study should continue as long as oil related activity occurs in the vicinity of the Pribilofs, or for as long as the Pribilofs prove a useful base of comparison for work alone in other areas. For this monitoring phase it will be appropriate to have either one person on each island or perhaps two people on only one island. During this phase effort should be concentrated on obtaining data from modest samples of 3-5 species, Black-legged Kittiwake, Red-legged Kittiwake and Thick-billed Murre, with data being taken on Red-faced Cormorant and Common Murres as time allows. In the monitoring phase, effort should be directed toward determining phenology, reproductive success and growth rates. Food habits date should be taken as a means of checking general trends in relation to ecosystem modeling efforts.

Of high priority in the minitoring phase will be the development of long-term research on the dynamics of major populations. Virtually nothing is known of natural rates of mortality, age at first breeding, the size of the floating non-breeding populations or site tenacity for most Alaskan seabirds. Knowledge of these parameters is essential if the effects of an oil spill are to be predicted. To this end, studies of individually marked birds and color banding of large numbers of young should be emphasized.

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."

Hunt, G. L. and M. W. Hunt. 1976. Abnormal pairing in Western Gulls. Bull. Pacific Seabird Group. 3(1): 27 (abstract).

Eppley, Z, D. Schwartz, S. Anthony and G. Hunt. 1976. The breeding biology of the Xantus' Murrelet. Bull. Pacific Seabird Group. 3(1): 29 (abstract).

2. Publications

Hunt, G. L. 1964. Tyrannus melancholicus using a partially domed nest. Auk 81: 434-435.

Hunt, G. L. and W. J. Smith. 1964. The swallowing of fish by young Herring Gulls (Larus argentatus). Ibis 106: 457-461.

Wilson, E. O. and G. L. Hunt. 1966. Habitat selection by the queens of two field-dwelling species of ants. Ecol. 47: 485-487.

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Hunt, G. L. 1972. Influence of food distribution and human disturbance on the reproductive success of Herring Gulls. Ecology 53: 1051-1061.

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Hunt, M. W. and G. L. Hunt. 1974. A preliminary report on dispersal of young Western Gulls from Santa Barbara Island. Western Bird Bander 49(3): 8-9.

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Hunt, G. L. 1975. Opening statement for SCAS/BLM workshop on design of baseline studies for the outer continental shelf, southern California marine vertebrates: Birds, in Lavenberg, R. J. and S. A. Earle, eds. Proceedings: Recommendations for baseline research in southern California relative to offshore resource development. Special publication, Southern California Academy of Sciences. p 113-117.

Hunt, G. L. and K. Briggs. 1975. Administrative Final Report to U. S. Fish and Wildlife Service: Aerial surveys of marine birds: Northeastern Gulf of Alaska. 151 pp.

Hunt, G. L. and S. McLoon. 1975. Activity patterns of gull chicks in relation to feeding by parents: Their potential significance for density-dependent mortality. Auk 92: 523-527.

Hunt, G. L. and M. W. Hunt. 1976. Exploitation of fluctuating food resources by Western Gulls. Auk, 92: 301-307.

Hunt, G. L. and M. W. Hunt. 1976. Gull chick survival: The significance of growth rates, timing of breeding and territory size. Ecology, 57: 62-75.

Hunt, G. L. Low preferred foraging temperatures and nocturnal foraging in a desert harvester ant. In Press, American Naturalist.

Sexton, C. and G. L. Hunt. An annotated checklist of the birds of Orange County, California. In Press, Systematic Biology, Research Series, University of California, Irvine.

3. Manuscripts in Preparation

Hunt, G. L., S. Causey, S. McLoon and M. Hunt. Foods of Glaucous-winged Gulls - are specialists more successful foragers?

Hunt, G. L. and M. W. Hunt. Colony size and nest spacing in Western Gulls in the Gulf of California. Submitted.

Hunt, G. L. and M. C. Thompson. Black-legged Kittiwake nesting on snow bank. Submitted.

Hunt, G. L. M. W. Hunt, and R. W. Risebrough. Evidence for female-female pairing and extra-pair courtship among Western Gulls. In Manuscript.

Hunt, G. L. In prep. Feeding behavior and foods of three species of gulls in Maine.

Causey, S. and G. L. Hunt. In prep. Colony structure and exposure to predators in two species of Cormorants, *Phalacocorax auritus* and *P. pelagicus*.

Hunt, G. L. and S. McLoon. Food size selection by Black-oystercatchers during the breeding season.

MILESTONE CHART

RU #: 083 PI: George L. Hunt , Jr.

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
Analysis of 1977 Reproductive Success	—	—	△															
Analysis of 1977 Growth rates	—	—	△															
Analysis of 1977 Food Samples	—	—	—	—	△													
Analysis of 1977 at Sea Surveys	—	—	—	△														
Submission of Data to OCSEAP format to NOAA	—	—	—	—	△													
Final report 1977 field Season	—	—	—	—	—	△												
3 Staff to St. Paul Island and St. George Is. for 1978 Field Season								△	—	—	—	△						
Collection of data on reproductive success growth, food and phenology								△	—	—	—	△						
Collection of data on shipboard surveys								△			△	△						
Analysis of reproductive success, growth & phenology													—	△				
Analysis of shipboard data													—	—	△			
Submission of reproductive success, growth, phenology and shipboard data.													—	—	—	△		
Analysis of foods data													—	—	—	—	—	△
Submission of foods data																		△
Submission of Annual (Final) report																		△

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

RFx41-83-829

Date: SEP 28 1977

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

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

Subj: OCSEAP Research Unit 83.

Reference: (1) FY 78 proposal, R.U. 83, dated 1 July 1977
(2) G. Hunt ltr. of 2 August 1977
(3) G. Hunt ltr. of 6 September 1977

Required FY 78 Contract Revisions, R.U. 83

George Hunt's contract must be modified to include the provision of internal data management. This will entail modification of text and supplementary funding, as outlined below.

1. An additional $20,954 will be required, bringing the total cost to $95,933.

2. Cost Proposal categories CPF-1, CPF-2 and CPF-5 should be modified to reflect the additional salary, benefits, travel, and supplies and expenses shown in the enclosed letter (ref 3).

Enclosure

cc:
L. Jarvela
Files

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

DEPARTMENT OF ECOLOGY AND
EVOLUTIONARY BIOLOGY
SCHOOL OF BIOLOGICAL SCIENCES

IRVINE, CALIFORNIA 92717

6 September 1977

Dr. Herbert Bruce
NOAA-OCSEAP
Juneau Project Office
Post Office Box 1808
Juneau, Alaska

Dear Dr. Bruce:

This request for revised funding is in response to my meeting with Francesca Cava, Laurie Jarvela and Mike Crane in which it was decided that we should take care of all of our data coding, card punching and data management at U.C. Irvine rather than relying on Mike Crane's office as I had originally planned in my contract proposal. At this meeting it was suggested that it would be most cost-effective to hire a full-time person to manage our data on a year-around basis, and that this person should accompany us to the Pribilofs to aid with data management and preparation in the field. In addition, based on the amount of data we have generated it was agreed that I should request an additional $5,000 for card punching services.

Thus, the additional costs that should be added to our contract* are as follows:

Personnel - Lab Assistant I, full time 1 Oct. '77 - 30 Sept. '78*	$9,015
Fringe Benefits	1,803
Travel - 1 round trip, Irvine, CA - St. Paul Is., AL	
including 3 person days in Anchorage	950
60 days per diem @ $15/day	900
Supplies and Expenses - computer card punching	5,000
	$17,668
Overhead @ 18.6%MTDC	3,286
Total increase	20,954
Previously requested amount	74,979
Revised total amount requested	$95,933

Thank you for considering this request.

Sincerely,

George L. Hunt, Jr.
George L. Hunt, Jr.
Associate Professor

GH:bb

Approval:

Peter R. Atsatt
Peter R. Atsatt
Acting Chairman

Howard A. Schneiderman
Dean, Biological Sciences

Walter Selufsky
Contracts & Grants

UNIVERSITY OF CALIFORNIA, IRVINE

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DEPARTMENT OF ECOLOGY AND
EVOLUTIONARY BIOLOGY
SCHOOL OF BIOLOGICAL SCIENCES

IRVINE, CALIFORNIA 92717

2 August 1977

Dr. Herbert Bruce
NOAA - OCSEAP
Juneau Project Office
Post Box 1808
Juneau, Alaska 99801

RE: Continuation of 03-5-022-72

Dear Dr. Bruce:

I am herewith submitting the revision to my FY 1978 Proposal for studies of the Reproductive Ecology of Pribilof Island Seabirds (RU 83) as requested by Laurie Jarvela.

1. The total amount of funding requested is $74,979 * not $80,922. The higher figure represented the anticipated cost had the University of California indirect cost rates been adjusted as expected. Since the negotiations for the cost increase were not completed at the time the proposal was submitted the amount requested was adjusted to reflect the original level.

2. The question of Data Management is recognized as still subject to negotiation. If Mike Crane's office is not going to provide punching services, it is understood that NOAA will provide additional funds, in an amount to be negotiated, to cover the cost of punching the data for A.D.P.

3. We will use NOAA taxonomic codes revised as of March 1977 for the submission of our data.

4. A representative selection of voucher specimens of food items obtained from bird stomachs will be retained at the University of California, Irvine and will be available for archiving by N.O.A.A.

5. Although the details of N.O.A.A. needs remains to be negotiated, we will provide the anticipated ranges of selected digital data parameters to N.O.A.A. to facilitate computer quality control of data entries.

6. We will provide N.O.A.A. with photographic records of all study sites.

* Per detailed budget - U.C.I. 3656

Dr. Herbert Bruce
NOAA - OCSEAP
Juneau Project Office
2 August 1977
Page: 2

7. Bobbie Mayer Assistant Specialist I and the two unnamed laboratory Assistants II will be employed on a full time basis throughout the year. George Hunt, Principal Investigator will be employed full time for one summer month and 1/3 time for January - March 1978. Additionally he will devote approximately 1/3 of his time October - December 1977 and March - June 78 to this project on a without salary basis.

8. In section 18.6 after the word "submitted" add "to the project office".

I hope that the above covers all points of concern.

Sincerely,

George L. Hunt Jr.

George L. Hunt, Jr.
Associate Professor

GLH:jm

cc: Project Office

Approved Peter R Atsatt
Peter Atsatt, Chair

Approved H C Schneider
Dean, Biological Sciences

Approved
Contract and Grants
CONTRACTS & GRANTS

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

TO:	Outer Continental Shelf Environmental Assessment Program National Oceanic & Atmospheric Administration
TYPE OF SUPPORT REQUESTED:	Contract
TITLE OF PROPOSED RESEARCH:	The Interaction of Oil with Sea Ice Research Unit: 87
PRINCIPAL INVESTIGATOR:	Seelye Martin, Research Associate Professor Department of Oceanography University of Washington Seattle, Washington 98195 Telephone: (206) 543-6438
AMOUNT REQUESTED:	$50,081
DESIRED CONTRACT PERIOD:	1 October 1977 - 30 September 1978
UNIVERSITY OFFICE TO BE CONTACTED REGARDING CONTRACT NEGOTIATION:	Office of Grant and Contract Services 1 Administration Building, AD-24 Telephone: (206) 543-4043
DATE:	28 June 1977

Seelye Martin

Principal Investigator

OFFICIAL AUTHORIZED TO GIVE
UNIVERSITY APPROVAL

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

Francis A. Richards
Associate Chairman for Research
Department of Oceanography

Robert G. Fleagle, Chairman
Department of Atmospheric Sciences

Joe S. Creager, Associate Dean
College of Arts and Sciences

REF: P77-48

TECHNICAL PROPOSAL

I. Title: The Interaction of Oil with Sea Ice Research Unit Number: 87

II. Principal Investigator: Seelye Martin

III. Cost of Proposal

Total: $50,081

Distribution of Effort by Lease Area:

Beaufort:	25%
Chukchi:	25%
Norton Sound:	50%

IV. Background

During the past two years, we have done research for the OCSEAP program in two areas:

(i) laboratory studies on the spread of oil in a field of ice floes;

(ii) field studies in the Beaufort Sea on the properties of sea ice such as crystal structure, drainage channels, and void spaces which are related to oil absorption.

The laboratory studies are written up in a report submitted to the OCSEAP program on 30 September 1976 by Martin, Kauffman, and Welander; the field results are summarized in our annual report of 30 March 1977.

In our research, we determine for different kinds of ice such as grease ice, pancake ice, ice floes, rafted ice, and pressure ridges, the likelihood that oil spilled in and under such ice will be distributed both within and on the ice surface. Therefore our work is immediately applicable to the research of Burns and Shapiro, and that of Braham, on sea ice as a habitat for marine mammals and the sea ice migration routes for mammals. Our research also helps to determine the small scale features of the larger scale patterns observed from satellites.

In the present proposal, we plan to do field work in the Chukchi Sea-Norton Sound lease areas. Specifically, we plan to investigate the properties of the ice shear zone along the Alaskan Chukchi coast, and the properties of the large areas of grease ice formation in Norton and Kotzebue Sound. We also propose to continue our laboratory work on the interaction of oil with different kinds of ice; in particular, we will attempt to model the Beaufort Sea problem of oil and multi-year ice. This work will continue to be of value to the existing OCSEAP research efforts on marine mammals and sea ice; and by providing insight into the small-scale diffusion and flow of oil in the sea ice, will also interact with the new program planned by OCSEAP on the numerical simulation of oil spill trajectories in sea ice.

V. Objectives: The objectives of this research project which are relevant to the environmental assessment of the Alaskan Continental Shelf are as follows.

1. To determine on a small scale how the different kinds of sea ice in the ice-covered OCS lease areas around Alaska will entrain and release oil.

2. To relate these small scale studies to the large scale problem of of how an actual oil spill will diffuse within the moving pack ice of the Alaskan waters.

The results of this study will be used in predictive models of the movement and diffusion of oil spills within the sea ice of the lease areas and should help to show the impact of potential spills on critical biological areas.

VI. General Strategy and Approach:

Our proposal consists of two parts: a field experiment and a laboratory study. In the field experiment, we propose to survey the ice properties in certain critical areas of the Chukchi Sea and Norton Sound; in the laboratory, we will examine the interaction of oil with sea ice as occurs in multi-year ice, heavy wind-driven grease ice, and wind wave-driven rafted ice.

In detail, our program consists of the following work:

1. The laboratory program. We plan studies on how oil interacts with multi-year ice; heavy, wind-driven grease ice; and an active, wind and wave driven field of rafted ice floes. In each case, we will follow the oil behavior as the ice grows, and then as the ice warms up.

a) Oil in multi-year ice. An unanswered question about oil pollution and sea ice is whether oil spilled under multi-year ice will rise to the ice surface during the arctic summer. From our previous field work and the work of others, we know that multi-year ice consists of a layer of practically fresh water ice at the surface, with a gradual transition with depth to salty, columnar first year ice.

If oil is released beneath this ice, we suspect by analogy with first year ice that some of the oil will be entrained beneath the ice. Then in the spring and summer when the ice warms, brine channels will open up in the columnar ice, so that the oil will rise up inside the multi-year ice at least to that height at which the fresh water ice begins.

At this point, several things may occur. First, there may exist natural channels or elongated air bubbles in the fresh ice through which oil will rise to the surface. Second, the oil may collect at the top of the salt water ice below the fresh water ice, then absorb radiation through the translucent layer of fresh ice. The increase in energy caused by the radiation absorption may cause the ice either to crack or to melt, thus allowing the oil to rise to the surface. Third, the multi-year ice will melt and ablate at its surface, and the melting may extend down to the oil, thus releasing it. Fourth, the oil may remain trapped throughout the summer season.

In an attempt to see which of the above mechanisms are important, we will simulate multi-year ice in our laboratory, then release oil beneath it. We will create this ice by growing young ice in our cold room, then warming it so that it desalinates and partially melts, and then refreezing it so that new growth occurs beneath the old ice. We will next release oil beneath this ice, re-warm it, and simulate with lights, solar radiation on the ice. The results of this experiment should show on a small scale how oil and multi-year ice interact, and will aid in planning of a follow-up field experiment.

b) Oil in grease ice. Recent satellite surveys done for the OCSEAP program by Shapiro and Burns show large areas of heavy grease ice forming on the north sides of both Norton and Kotzebue Sounds during their observational months of March and April. Because both these areas are potential lease sites, we propose some laboratory experiments to look at the specific behavior of oil in grease ice.

Our previous work on grease and pancake ice shows that the presence of grease ice beneath the pancake ice did not hinder the rise of the oil to the surface. Recently however, we have rebuilt our apparatus so that we can generate waves with much larger amplitudes; and because of the importance of grease ice, we plan to grow thick layers of grease ice under strong wind and wave conditions to simulate its growth in the Arctic. We will then release oil beneath this ice to look at the following:

i. How the grease ice changes the lateral spreading of oil on the surface;

ii. How the oil is distributed in depth in the ice; in other words, does it spread on the surface completely independently of the grease ice, or is there some entrainment with depth in the ice;

iii. How the oil freezes into the grease ice with time; and how it responds when the ice is melted.

This laboratory study also will complement our proposed field study.

c) Oil in wind-driven rafted ice. Because of the importance of rafting as an ice growth mechanism in the Bering Sea, as shown by the results of the BESEX experiment, and its presumed importance in the Chukchi Sea, we also plan to use the wave tank to generate an active rafting ice floe situation. This will also simulate the natural behavior in the Norton-Kotzebue Sound case described above, where now instead of pure grease ice, we have the formation of small floes which raft because of the wind stress.

In the experiment, we will generate an active rafting situation, release oil under it, then follow its behavior with time. This experiment should help in the understanding of how oil is entrained or brought to the surface in an active rafting ice zone, such as exists downwind in Norton and Kotzebue Sound.

2. The field experiment. The field experiment involves three separate traverses during March 1978. The first will be run out of Nome on a line between Nome and the Yukon River Delta; the second will be run out of Cape Lisburne at 305°T for a distance of 60 nautical miles; and the third will be run out of Cape Lisburne across Point Hope into Kotzebue Sound.

Because the ice conditions will be changing rapidly in the areas of study, we will not simply try to occupy stations, rather we will also attempt to map from low-level flights the changing characteristics of the ice. Also, once on the surface, besides taking single cores from the ice, we will also document ice features which previous experience shows to be important in the capture and transport of oil.

a) These features include the following:

i. The nature of the rims on ice floes. Our laboratory experiments show on a small scale that the rims are built up from water and grease ice pumped up over the floe edge to freeze; further, that oil can be pumped in the same way. Evidence from the field that rims are built up by pumping will suggest that oil spilled in this ice would also be pumped onto the surface. Therefore, in the field, we will seek out several floes and survey them to determine how the rims formed.

ii. Rafted ponds. At the Buzzards Bay spill on 28 January 1977, which occurred in an active rafting and ridging ice field; about 30% of the spilled oil collected in ponds with depths up to 0.2 m on the ice surface. Briefly, these ponds formed by the ice floes rafting one on top of each other, with sea water ponds forming at the join between the floes. Oil released under this ice flowed up into these ponds replacing the denser sea water. In the Beaufort Sea, we have observed similar ponds, but we never mapped their structural details. Therefore, during the proposed field traverse, we will also try with our SIPRE corer or auger to map the above-and underwater structure of several of these ponds.

iii. Rafted ice. The results on the BESEX experiment showed in the central Bering sea that wind-driven rafting caused much of the thickness increase of sea ice. Because of the importance of rafting to both numerical models and oil entrainment, we also plan to attempt to estimate the extent of rafting along the traverse lines.

b) The specific traverse lines from which we will make the observations described above are shown on the charts in the section 'Other Information.' These traverses, which we next discuss, consist of one line out of Nome, and two out of Cape Lisburne.

i. The Nome traverse. The first chart shows the line running from Nome down to the Yukon delta. Satellite photographs show, because of the strong northeast winds, that this is an active region of ice growth and transport. In this traverse, we plan to sample stations at intervals of approximately 10 nautical miles, where we will take ice cores and if feasible do the other measurements described above. We will also pull one core at the entrance to the Yukon Delta, to see the effect of the river runoff on the sea ice. If a large area of grease ice forms adjacent to shore, we will photograph it from low level flights, and determine its properties. We will also attempt, by landing on the nearest solid ice downwind of the grease ice, to get bucket samples of the grease ice so that we can estimate its porosity.

Finally, if it is feasible, and a large area of grease ice forms offshore, we would like to arrange a one day boat charter in an attempt to get grease ice samples from the active growth regions.

ii. The Cape Lisburne shear zone traverse. From their analysis of satellite data, Shapiro and Burns document the large scale properties of the shear zone adjacent to the Alaskan Chukchi coast. Because of its importance as a shipping and marine mammal migration route, as well as overlying a potential lease area, the nature of the ice behavior in this zone is important to OCSEAP.

We therefore propose to investigate the small scale sea ice properties across this zone by running a traverse shown on the second chart out of Cape Lisburne at 305^{o}T for a distance of 50 - 70 nautical miles, depending on the ice conditions. In the zone, we will land at intervals of approximately 10 nautical miles and both take cores and sample the other ice properties described above. If time permits, we will attempt to re-occupy the stations a few days later, in order to document possible changes. The purpose of traverse will be to document the kinds of small scale ice growth and deformation in the shear zone which are relevant to oil pollution.

iii. <u>The Cape Lisburne Kotzebue traverse</u>. The third chart shows the flight line for this experiment; satellite photographs show that the water along the shore line east of Point Hope in Kotzebue Sound is an especially good site for grease ice growth. Therefore, if a storm occurs while we are at Cape Lisburne, we will survey from low level flights on successive days the way in which the grease ice forms in Kotzebue Sounds, and the transition to pancake ice and ice floes. We will also land downwind of the grease ice and sample the ice properties. The observations made on this traverse line will serve as an intermediate step in the relating of our laboratory experiments to the satellite photographs of grease ice.

VII. Sampling Methods:

At the different stations shown on the charts in 'Other Information', we will land on the ice and determine the ice properties in the following way. First, we will pull a core with a SIPRE corer, measure its temperature profile with thermistors, then cut up half of the core into horizontal sections for determination of the salinity profile. We will also both sketch and photograph the vertical crystal structure of the core and look for evidence of rafting. On ice floes, we also plan to check surface salinity, examine the way in which the rims around the floes are built up, and look at the structure of ponds formed by rafted ice. Finally, we plan low-level aerial photographic mapping of regions of grease ice.

VIII. Analytical Methods: N/A

IX. Anticipated Problems

We expect no additional major difficulties outside of those inherently associated with field work in the Arctic.

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. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year
sea ice properties	narrative report	40 pages	N/A	N/A	March 1978 - April 1978	August 1978
laboratory study on oil and ice	narrative report	40 days	N/A	N/A	October 1977 - September 1978	September 1

X. Deliverable products:

A. Digital Data: none

B. Narrative Reports:

1. Laboratory results. An account of our laboratory experiments on oil and sea ice will be submitted as a report which will include descriptive photographs and tables.

2. Field results. The results of our field traverses will also be submitted as a report which will include photographs, tables of ice salinities and temperatures, and descriptive material.

C. Visual Data: All visual data will be submitted in our narrative reports.

D. Other Non-Digital Data: none.

E. Data Submission Schedule:

1. Laboratory: our laboratory report will be submitted by 30 September 1978.

2. Field: Collection of field data will begin in March 1978 and end in April 1978. Our data report will be submitted in August 1978 (see attached Data Products Schedule).

XI. Information Required from Other Investigators: None.

XII. Quality Assurance Plans:

Our salinometer used in the determination of the ice core salinity profiles will be calibrated against standard salt water solutions.

Our thermistor array used to determine the temperature profiles of the ice cores will be calibrated both in $0^{o}C$ ice baths and against mercury thermometers in the field.

XIII. Special Sample and Voucher Specium Archival Plans: N/A

XIV. Logistic requirements; see attached forms.

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.

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.

   One day small boat cruise out of Nome following grease ice formation. (optional)

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.

   We will take near-shore 'bucket' samples of grease ice.

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.)

   March 1977, cruise should follow grease ice formation by 1-2 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.)

   1 day

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 estimte of sampling time on station and sample processing time between stations.

   6 daylight hours.

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

   1 boat driver plus navigational aids.

7. What is the approximate weight and volume of equipment you will bring?

   3 cubic feet, 100 lbs.

8. Will your data or equipment require special handling? Yes If yes, please describe:

   We need a boat with easy access to the sea surface.

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.

    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?

    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.

    2; S. Martin, P. Kauffman.

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)

   See charts in 'Other Information'.

2. Describe types of observations to be made.

   We will land at different sites; take ice cores and analyze site topography.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

   optimum: 7 - 30 March; maximum; 1 March - 15 April.

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

   14 days at 1 - 1.5 hours/day

   Total flight hours? 20 hours

5. How many people are required on board for each flight (exclusive of the pilot)?

   three

6. What are the weights and dimensions of equipment or supplies to be transported?

   1 sled, 140 lbs, 4' x 1' x 2.5'
   1 power head, 50 lbs, 1.5' x 1.5' x 1.5'
   3 auger flights, 40 lbs, 3' long by 0.75' diameter
   2 instrument cases, 70 lbs each, 2' x 2' x 1'

7. What type of helicopter do you recommend for your operations and why?

   Bell 205 with long range tanks. Our equipment will not fit into a Bell 206.

8. Do you recommend a particular source for the helicopter? If "yes" please name the source and the reason for your recommendation.

   NOAA, based on previous experience.

9. What is the per hour charter cost of the helicopter?

   N/A

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

   Nome, Cape Lisburne

11. Will special navigation and communications be required?

   Global or other on-board navigation system.

   Note: Our research plan requires that a member of our party occupy that co-pilot's seat for a least part of each traverse; both to help choose the landing sites and to take aerial photographs of the ice field.

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) 7 - 14 March; Nome; 3 men at 21 man days.

b) 14 - 28 March; Cape Lisburne; 3 men at 42 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?

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

XV. Management Plan:

The principal investigator will direct and/or participate in all phases of the work. Much of the photographic and instrumentation work will be done by Peter Kauffman.

By:	15 February 1978	Finish preparations for field experiment
	30 April 1978	Complete field traverse
	30 August 1978	Submit field report
	30 September 1978	Submit laboratory report and analysis of field traverse.

XVI. Outlook beyond FY78:

With regard to future work on oil pollution and sea ice, first, we should do a winter ice survey along the ice front of the Bering Sea. This work, which relates to the Bristol Bay and Saint George Basin lease areas, might best be done from an icebreaker working out of either a helicopter or a small boat. Second, we should plan a specific ship traverse of the grease ice in Norton Sound combined with an aerial photographic or SLAR overflight. The purpose would be to look at variations of grease ice porosity with fetch. The decision to go ahead with this experiment should await the results of the laboratory experiments proposed herein, which should show whether the interaction of grease ice and oil is important. Third, we will need a summer ice survey on the drainage properties of multi-year ice.

With regard to future laboratory experiments, because they are inexpensive and repeatable, we will probably want to continue with them; however, I do not want to speculate on future experiments until I have done some of the work proposed here.

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 24-28) 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.

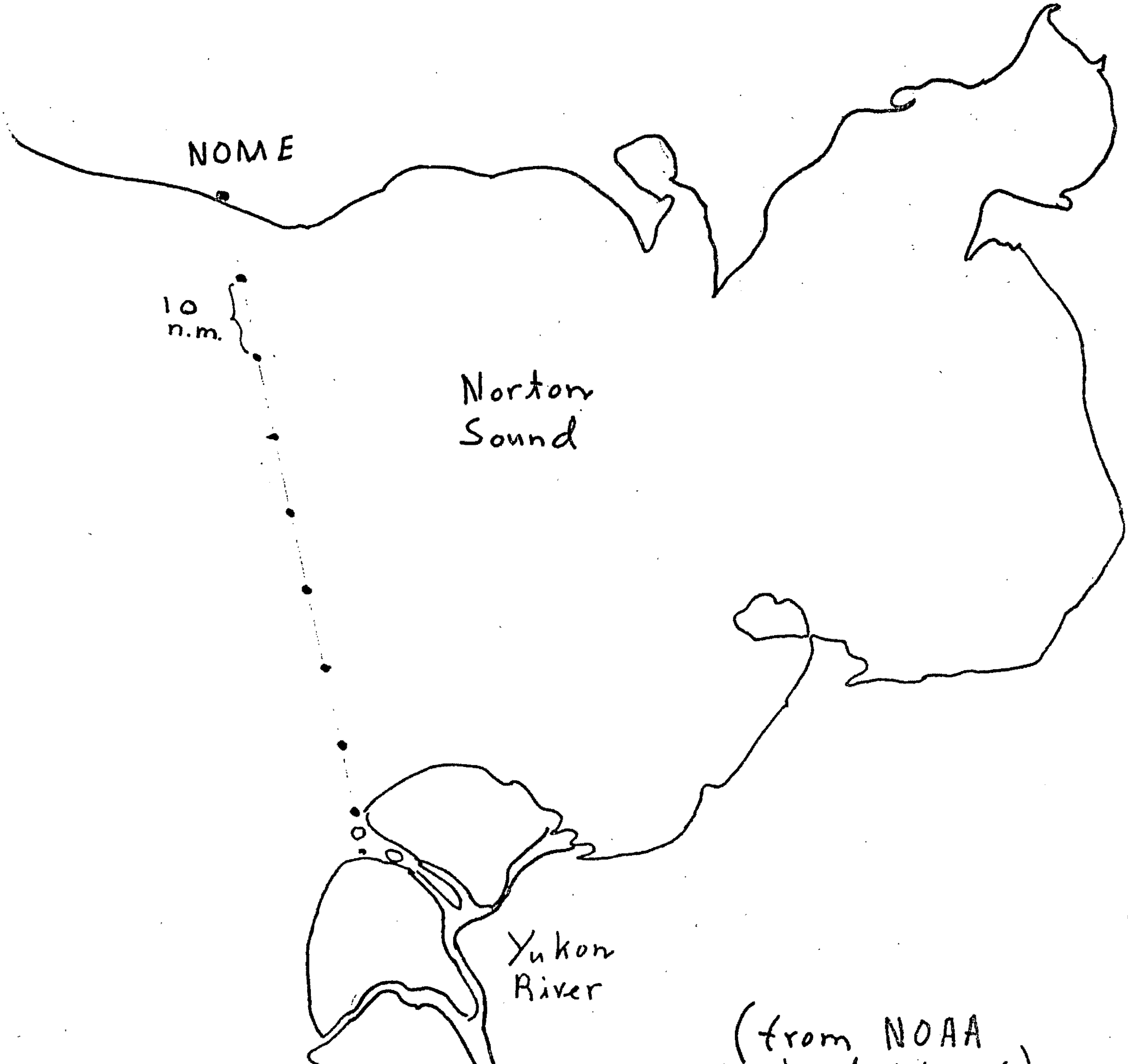
10. All publications and presentations of material developed under OCSEAP funds will acknowledge BLM/OCSEAP sponsorship.

RU #: 87 PI: Seelye Martin

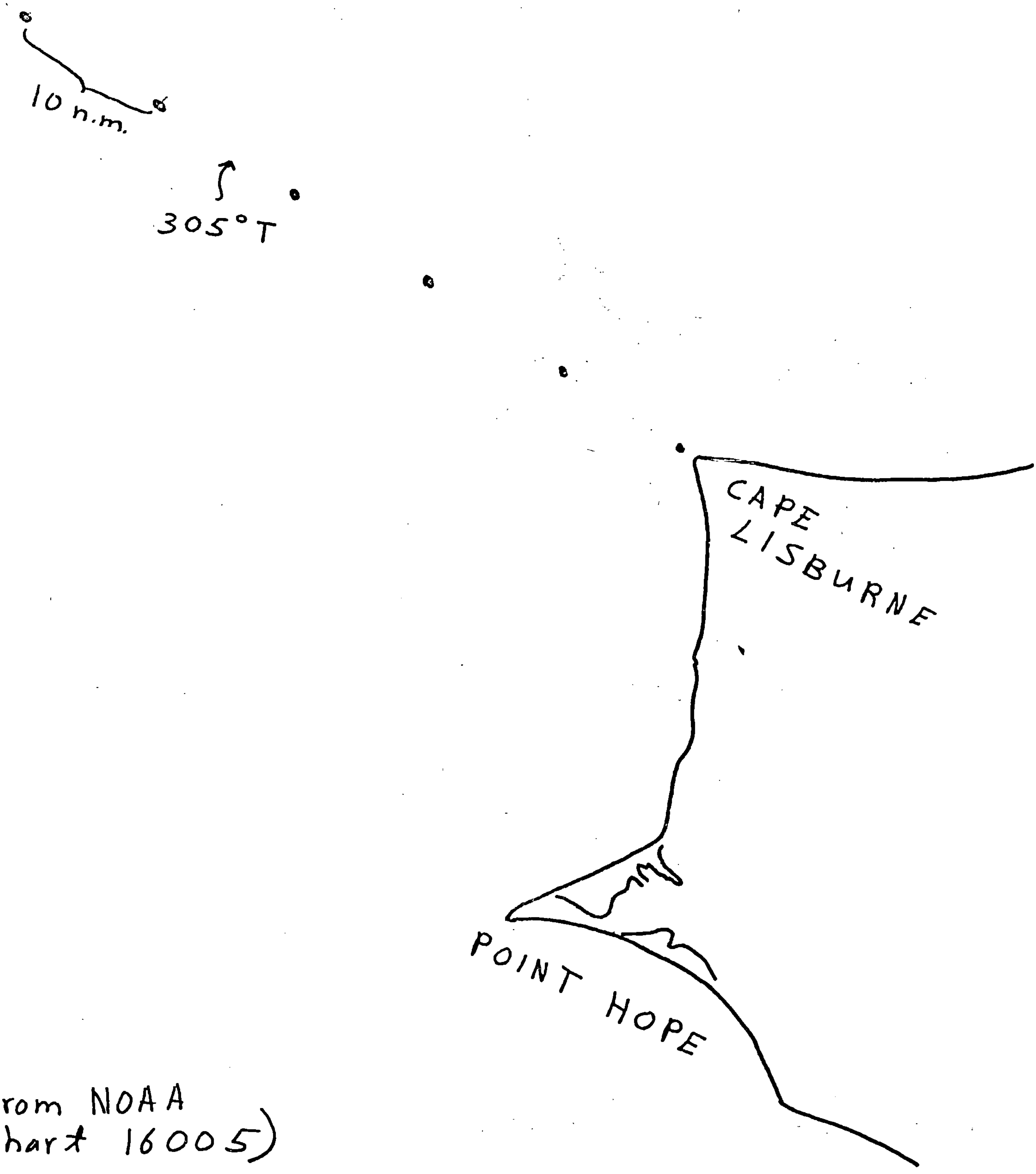
Major Milestones: Reporting, data management and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES	1977 O	N	D	1978 J	F	M	A	M	J	J	A	S	O	N	D
Complete field traverse						X	X								
Submit field report											X				
Complete laboratory work	X											X			
Submit laboratory report												X			
			X						X			X			
						X									

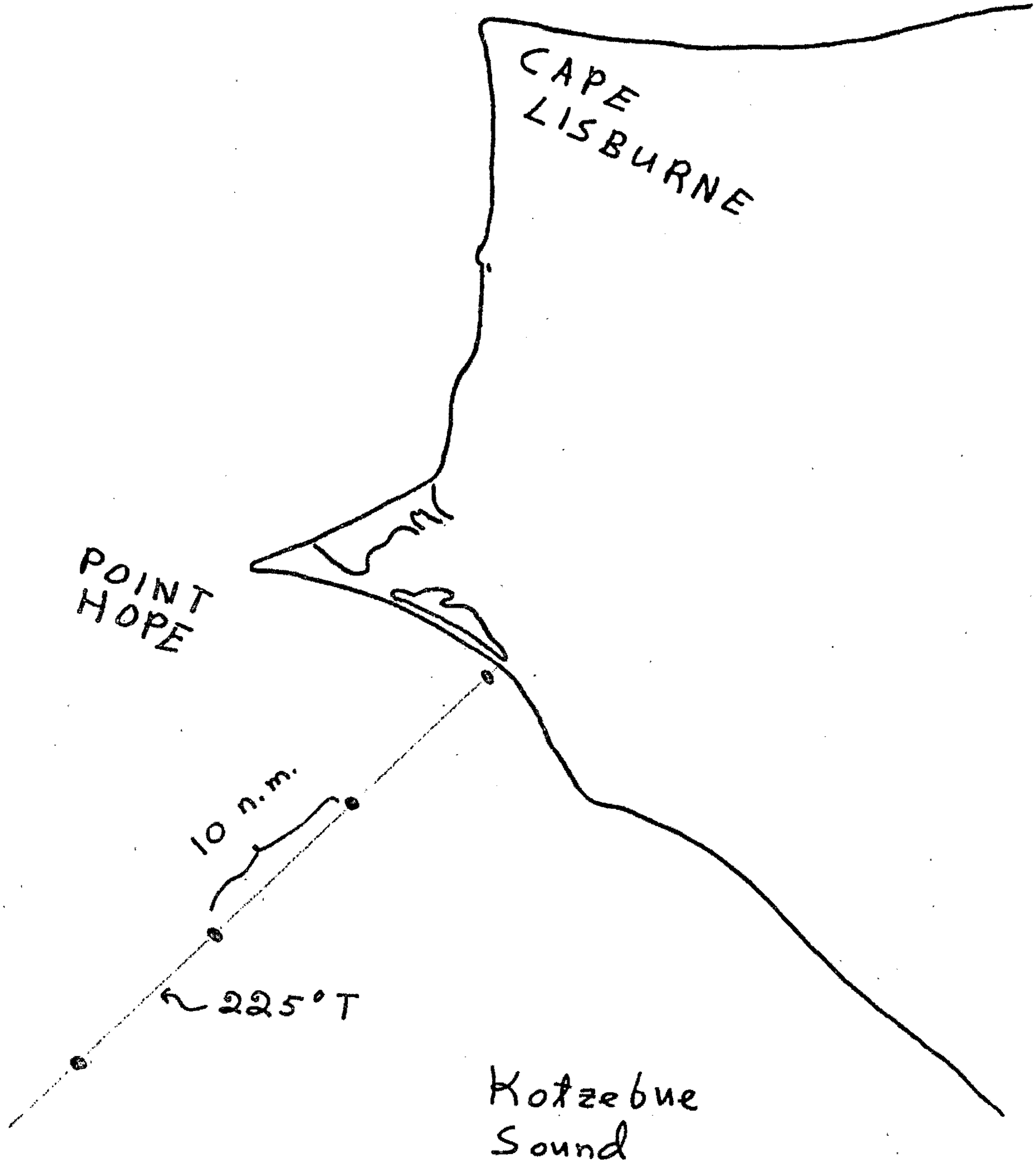
1. Nome traverse



2. Shear Zone Traverse



(from NOAA chart 16005)



(from NOAA chart 16005)

1. COVER PAGE

30 June 1977

Title and Research Unit
DYNAMICS OF NEAR-SHORE SEA ICE
(OCSEAP Research Unit #88)

Principal Investigators
W. F. Weeks and A. Kovacs

Institution
U. S. Army Cold Regions Research and Engineering Laboratory
Hanover, NH 03755

Period of Work
1 October 1977 - 30 September 1978

Signatures

W. F. Weeks and A. Kovacs

W. F. WEEKS ext. 261 (Principal Investigators) A. KOVACS ext. 211

D. R. Freitag

D. R. FREITAG (ext. 200)
(Technical Director)

for F. FERRARO (ext 315)
(Comptroller)

CRREL Telephone (603) 643-3200
AUTOVON: 684-3400
FTS: 834-7585,6,7

TECHNICAL PROPOSAL

I. Title

Dynamics of Near-Shore Sea Ice
OCSEAP Research Unit #88
1 October 1977 - 30 September 1978

II. Principal Investigators

W. F. Weeks and A. Kovacs

III. Cost of Proposal

Total $173,376
Distribution of Effort by Lease Area Beaufort Sea 55%, Chukchi Sea 40%, Norton Sound 5%.

IV. Background

There are four main thrusts to the present proposal. These are concerned with the study of ice movement in the vicinity of Narwhal Island (Prudhoe Bay), the study of ice movement through the Bering Strait, the analysis of remote sensing data on sea ice from the Chukchi and Beaufort Seas, and the effect of large scale crystal orientation in fast ice on its properties and the use of these orientations to determine current directions. All this work is a direct extension of our previous field studies and is largely devoted to the analysis of data that we have already collected as part of the Arctic OCSEAP.

V. Objectives

The objectives of the different sections of this proposal are as follows:

A. Narwhal Island Ice Movement Studies: We plan to complete a thorough analysis of the Narwhal Island ice movement data which were collected during the 1975-76 and 1976-77 winter field seasons and combine these data with an analysis of satellite imagery to gain historical insight into ice motions both offshore and onshore from the barrier islands north of Prudhoe Bay. We also plan to spend short periods of time in the field along the coast of the Beaufort Sea (2 weeks in the fall of 1977 and 2 weeks in the spring of 1978) taking measurements that will allow us to determine the net movement of the fast ice over the winter and the locations and geometry of large coastal ice pile-ups. These data have direct bearing on offshore design and on hazard assessment for proposed oil and gas operations offshore along the coast of the Beaufort Sea.

B. Bering Strait Imaging Radar Studies: In this part of our program, we plan to continue to operate the X-band ice radar system at Tin City during the 1977-78 ice season. We also plan to make minor changes in the system to improve its reliability and its ease of operation. In addition, we will continue the analysis of ice drift radar data and attempt to model these observations by using a finite difference model for ice motion and deformation through a restricted channel. The above research is an essential part of the information needed to develop an adequate scenario for a major oil spill in either the Beaufort or Chukchi Seas. The motion of the oil once it rises to the sea surface will be almost completely controlled by the motion of the ice. At first the oil will move westward following the general movement of the ice in the southern portion of the Pacific Gyral. Even this drift is, during part of the year, dependent on the ice in the Chukchi Sea moving "out of the way" largely by moving south through the Bering Straits into the Bering Sea. Once the oil has moved into the Chukchi Sea, it can take three different trajectories: 1) move south into the Bering Sea during an ice breakout (note that the general flow of water through the Bering Straits is south to north opposed to the direction of the breakouts), 2) move north becoming incorporated in the Pacific Gyral (this would retain the oil in the Arctic Ocean for a period of at least 7 to 10 years and perhaps many times this value), 3) move north becoming incorporated in the Trans-Polar Drift Stream in which case the oil would ultimately be deposited within two years off the east coast of Greenland. Each of these routes has its particular geophysical, biological and political problems. Of immediate interest is, of course, the movement of the oil through the Bering Strait in that this would release the oil along the ice-edge in the Bering Sea, an area of extremely high biological productivity. The radar information that will be collected at the Bering Strait should serve as the first step in the development and verification of suitable models for forecasting ice (and oil) motion in this general region.]

C. Analysis of Remote Sensing Data: In this program, we plan to complete the analysis of the existing laser profilometry and the SLAR imagery that we obtained on flights made during the 1975-76 and 1976-77 ice seasons. The results of the laser studies will provide valuable quantitative information on both temporal and spatial variations in the amount of deformed ice present along the coasts of the Chukchi and Beaufort Seas. The SLAR studies will supplement these observations by allowing measurements to be made on the areal percentage of deformed ice, the general geometry of the deformation patterns, and the size distribution of multiyear ice floes. [This study will add to our quantitative data base characterizing the nature of the ice along the coasts of the Beaufort and Chukchi Seas. As such, it will contribute to both the hazard assessment and offshore design aspects of leasing and development.]

VI. General Strategy and Approach

A. Narwhal Island Ice Movement Studies: This program is largely concerned with the analysis of ice movement data that we have already collected. The proposed field observations make use of the fact that we have found that by short periods of surveying and by surface measurements of the displacements of identifiable ice features (cracks, ice roads, etc.) we can obtain a rather detailed picture of the nature of the net motion within the fast ice during an ice season. Most of this work will be focused on the region north of Prudhoe Bay inasmuch as it is an area of prime interest for offshore development.

B. Bering Strait Imaging Radar Studies: This site was selected because the Bering Strait is the bottleneck through which ice must pas on its way between the Bering and Chukchi Seas. Another obvious advantage of the site is the fact that the radar unit can be housed within the ray-dome of the Tin City AC and W Site on tope of Cape Mountain. Analysis of the resulting imagery is time-consuming but straight-forward and follows procedures developed by Tabata and Shaprio. The theoretical aspects of the study build upon previous attempts to model ice flow through both the Bering Strait and the Strait of Belle Isle by Sodhi and the main Arctic Ocean by Hibler.

C. Analysis of Remote Sensing Data: This is purely a program concerned with the analysis of existing data. Techniques for analyzing laser data of sea ice have largely been worked out at CRREL and are readily available to us. We also have extensive experience working with SLAR imagery.

D. Summary of Existing Knowledge (see separate attachment)

VII. Sampling Methods

A. Narwhal Island Ice Movement Studies: The considerations governing the data acquisition rate and the spacing of our transponders were given in our prior contract proposal and will not be repeated here. In the study of the net movement of the ice over the winter, we will take observations "near" to islands or to grounded ice features so that we can determine absolute movements. We also will collect information on the relative movement of one ice feature with another. These observations can be made anywhere we can find suitably displaced ice features. Our general target area for this study will be between the Stockton and the Midway Islands.

B. Bering Strait Imaging Radar Studies: We photograph the radar screen once every 2½ minutes. This is adequate to define quite rapid ice movements without requiring a vast amount of film. In deciding which radar return to track, we are guided by the strength and uniqueness of the target. Also, it is wise not to pick targets that are clustered in only one segment of the sampled area.

C. Analysis of Remote Sensing Data: The laser sampling lines were spaced down the coast so that three representative replicate tracks could be made into both the Beaufort and the Chukchi Seas. The starting points of these tracks were Barter Island, Cross Island, Lonely, Barrow, Wainwright, and Point Lay. The length of the flight lines was 200 km which gives adequate transverse coverage of the continental shelf. The SLAR imagery was primarily obtained using a continuous track along the coast with short transects normal to the coast starting from prominent locations such as Lonely and Cross Island. In the analysis, it is planned to use all the data except in areas where there is excess overlap.

VIII. Analytical Methods

Not applicable.

IX. Anticipated Problems

We foresee no major problems in carrying out this proposed program.

X. Deliverable Products

The main output from this program will be a series of CRREL reports focused on the different special aspects of the program outlined earlier. Each of these reports will contain maps, graphs, photographs, data tabulations, etc. as required to best develop the specific aspect of the research that is under discussion. Ultimately, the time-lapse photography of the radar screen will be archived in the OCS data bank. However, this will not be done until all the studies using it are complete at CRREL.

XI. Information Required from Other Investigators

We will require all available observations on ocean currents that have been collected during the winter in the vicinity of our crystal orientation observations. We have had no trouble obtaining this type of information for the Beaufort Sea and we expect no difficulties in obtaining similar data, if available, for the Chukchi Sea and for Kotzebue Sound.

XII. Quality Assurance Plans

Inasmuch as the new field work that will be undertaken primarily uses routine surveying and crystallographic techniques, this section is not particularly applicable to our proposed program.

XIII. Archival Plans

Not applicable.

XIV. Logistics Requirements

Of the four different sub-programs that will be carried out under this research unit, only two will require logistics support. These are:

1. Narwhal Island Ice Movement Studies, and
2. Large-Scale Crystal Orientation.

Inasmuch as their requirements are quite different, the logistics of each will be discussed separately.

1. <u>Narwhal Island Ice Movement Studies</u>

Point of Contact - A. Kovacs

A. Ship Support
   1-12. N/A

B. Aircraft Support - Fixed Wing
   1. Location of flights
      Reconnaissance flights along the edge of the fast ice and over the barrier islands in the Beaufort Sea for the purpose of locating large ice pile-ups as well as characteristic ice features that can be used in studies of net ice motion.

   2. Types of observations
      Visual and photographic (hand camera)

   3. Time of flights
      During a two-week period covering the last week in October and the first week in November 1977

   4. Days of flight operations
      3 days, approximately 8 hours of flight time.

   5. Relation to other investigations
      No strong interactions.

   6. Special equipment.
      None.

   7. Weights, etc.
      Carry-on equipment will weigh approximately 100 lbs. No power is required.

   8. Type of aircraft
      Ski-equipped Cessna 180.

   9. Source of aircraft
      NARL

   10. Cost
      Approximately $85 per flight hour

   11. Number of people on board (excluding pilot)
      Two

   12. Staging area for flights
      Barrow and Deadhorse.

C. Aircraft Support - Helicopter

1. Location of flights
   To visit large ice pile-ups identified during the Cessna 180 reconnaissance flights and also to visit several of the barrier islands so that net ice movement markers can be installed.

2. Types of observations
   Standard surveying type observations using a theodolite, a laser ranger, a level, and a tape.

3. Time of flights
   During two each two-week periods covering the last week in October and the first week in November 1977 and the last two weeks in May 1978.

4. Days of flight operations
   During each of the two periods, a helicopter will be required for 10 flight hours distributed over a 14-day period.

5. Number of people on board.
   Two.

6. Weights and dimensions of equipment
   Two hundred lbs., 5x2x2 feet.

7. Type of helicopter
   205 or 206

8. Source
   NOAA with ERA back-up (NOAA does not operate a 206)

9. Charter cost
   For the ERA back-up helicopter, approximately $500/flight hour (206) or $1000/flight hour (205).

10. Staging area
   Deadhorse

11. Special features
   An inertial navigation system will be required to locate and to relocate the study sites.

D. Quarters and Subsistence Support

1. Quarters and subsistence requirements
   a. Location - Deadhorse
   b. Time - 24 October-7 November 1977 and 15 May-1 June 1978
   c. Staff - 2 persons, approximately 64 man/days

D. 2. Source of support

Mukluk (Crowley) at Deadhorse. This organization has space to handle the OCS operation and they would like the business. We have received excellent support from them in the past. The support we received last year from V and E was poor.

3. Cost

Costs would have to be negotiated.

E. Special Logistics Problems

None.

XV. Management Plan

Weeks and Kovacs are experienced investigators who will personally be involved with all phases of the proposed work. General administrative control of the project will be handled by Dr. George D. Ashton, Chief Snow and Ice Branch, CRREL, who is well acquainted with the subject area of the proposed studies. The milestone chart is as follows:

Major Milestones	Date
1. Tune-up and check radar at Tin City	30 October 1977
2. Complete fall ice movement measurements from Deadhorse	7 November 1977
3. Complete first crystal orientation paper	15 December 1977
4. Complete final Narwhal Island Ice Movement paper	15 February 1978
5. Complete crystal orientation field observations	1 May 1978
6. Complete spring ice movement studies from Deadhorse	30 May 1978
7. Complete remote sensing studies	15 July 1978
8. Complete first paper on Bering Strait radar study	15 September 1978

XVI Outlook

The work proposed here will largely complete our studies in the vicinity of Narwhal Island. We may propose some small additional work on ice movements and pile-ups (≃$75K) and on crystal orientation and ice properties. We would probably like to operate the Bering Strait radar unit for one final year. We also plan to become involved in other types of OCS research programs.

XVII The standard statements numbered 1, 2, 4, 5, 6, 7, 8, 9 and 10 (see instructions for preparing renewal proposals to OCSEAP/NOAA) are applicable to the proposed program and will be binding under the contract.

30 June 1977

A. COVER

TASK D: Included in RU 88 - FY 78 Renewal

Title and Research Unit

ICE CONDITIONS OF THE BEAUFORT AND CHUKCHI SEAS: A SUMMARY OF EXISTING KNOWLEDGE AS RELATED TO OFFSHORE DEVELOPMENT. (OCSEAP RESEARCH UNIT # (NEW))

Principal Investigator

W. F. Weeks

Institution

U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, N.H. 03755.

Period of Work

1 October 1977 - 30 September 1978

Signatures

W F Weeks

W. F. WEEKS (ext. 261)
(Principal Investigator)

D. R. Freitag, (Ext 200)
(Technical Director)

Frank J. Ferraro

F. Ferraro (ext 315)
(Comptroller)

B. QUALIFICATIONS OF THE PRINCIPAL INVESTIGATOR AND HIS INSTITUTION

Principal Investigator

W.F. Weeks - 22 years field and laboratory experience on studies related to the geophysics of sea ice; author of 120 papers with special emphasis on structure of sea ice, crystal growth, ice mechanics, ice drift and deformation, and remote sensing; President International Glaciological Society 1972-75, Polar Research Board 1971-77, Chairman Committee on Glaciology of the National Academy of Science 1971-77.

Institution

USACRREL is the principal laboratory within the U.S. Government that deals with the special geophysical and engineering problems that occur in the world's polar oceans. It has a major library that acquires all the world literature related to this problem area, a large number of cold rooms designed for experimentation on snow and ice, extensive experience in the operation of projects in the high Arctic, and a staff of approximately 90 scientists and engineers who specialize in this type of research.

C. TECHNICAL PROPOSAL

I. Title

Ice Conditions of the Beaufort and Chukchi Seas: A review
OCSEAP Research Unit # (New)
1 October 1977-30 September 1978

II. Principal Investigator

W. F. Weeks

III. Cost of Proposal

Total $31,994.
Distribution of Effort by Lease Area: Beaufort Sea 60%, Chukchi Sea 40%

IV. Background

The arctic OCSEAP is now in its 3rd year. As a result of this program a large amount of information bearing upon specific aspects of the ice conditions in the Beaufort and Chukchi Seas has been and is being collected. In addition to these data, there are large amounts of additional data on similar subjects scattered throughout the older literature. However, one soon discovers that much of the earlier work is published in obscure references only accessioned in speciality libraries and that much of the newer work is only available in contract reports or in the minds and data books of the concerned investigators. There is no thorough, informed summary of the state of knowledge in this area to assist in decision making by non-sea ice specialists and to serve as a guide to both more detailed treatments in the literature and to existing data gaps.

V. Objectives

The objective of the proposed study is to prepare a thorough yet concise summary of the present state of knowledge of the sea ice conditions in the Chukchi and Beaufort Seas as they bear upon the development of the offshore resources in these areas. Particular emphasis will be given to incorporating the most up-to-date information on this subject as collected by the various OCS projects concerned either directly or indirectly with sea ice. Data and theory gaps that affect OCS objectives will be identified.

VI. General Strategy and Approach

Inasmuch as Dr. Weeks specializes in the study of sea ice, he is well acquainted with the scattered literature on the subject. He also has available to him, through use of the CRREL library, the most complete collection of literature on this subject available in the United States. In addition, he plans to review all pertinent OCS documents on the subject and to personally visit and discuss the current status of their research with all the major OCS investigators involved in the study of sea ice. After he finishes with digging through the above, he simply plans to sit down and write a first-draft of the review and then have it examined by selected specialists to point out any gaps in the treatment.

VII. Sampling Methods

First the CRREL bibliography will be surveyed to locate pertinent references on ice conditions relative to offshore development in the Beaufort and Chukchi Seas. Then discussions with active investigators will be used to identify important references that have been missed. Finally a peer review of the manuscript will be used to check the fairness of the treatment and the validity of the conclusions and recommendations.

VIII. Analytical Methods

Not applicable.

IX. Anticipated Problems

There should be no major problems in carrying out this review.

X. Deliverable Products

B. Narrative Reports and C. Visual Data

The final product of this program will be a narrative report containing pertinent maps, graphs, tables and photographs. This report will be published as a CRREL report. However xerox copies of the report will be provided the OCS data bank prior to the actual publication. There will be no visual data beyond that which is included in the final report.

E. Data Submission Schedule

The writing portion of this project will be completed during July-September 1978. Therefore, the xerox copy of the report should be available by November 1978 and the final CRREL publication by June 1979.

XI. Information Required from Other Investigators

Dr. Weeks will require xerox copies of all OCS sea ice studies that have been completed but are not, as yet, available as formal reports. This will be accomplished by informal communication with the pertinent principal investigators and should not present a serious problem.

XII. Quality Assurance Plans

Not applicable.

XIII. Special Archival Plans

Not applicable.

XIV. Logistics Requirements

All travel arrangements will be made and travel costs paid under the cost of the contract. There are no other logistic requirements as this is not a field program.

XV. Management Plan

Dr. Weeks is an experienced investigator who will personally initiate and complete all phases of the project. General administrative control of the project will be handled by Dr. George Ashton, Chief, Snow and Ice Branch, CRREL who is well acquainted with the general subject area of the proposed report. The milestone chart is as follows:

Major Milestones	Date
Complete visits to OCS investigators involved in sea ice research	June 1978
Complete survey of published literature	June 1978
Complete writing of summary report and preparation of the figures	September 1978

XVI. Outlook

This is a "one-shot" project that should essentially be complete by 30 September 1978. The only possible costs that might occur during FY79 would be one months additional salary associated with time required for editing and final report preparation

XVII. The standard statements numbered 1, 2, 4, 8, 9, and 10 (see instructions for preparing renewal proposals to OCSEAP/NOAA) are applicable to the proposed program and will be binding under the contract.

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:	Current Measurements in Possible Dispersal Regions of the Beaufort Sea Research Unit: 91
PRINCIPAL INVESTIGATOR:	Knut Aagaard, Research Associate Professor Department of Oceanography College of Arts & Sciences University of Washington Seattle, Washington 98195 Telephone: area code 206, 543-7978
AMOUNT REQUESTED:	$99,632
DESIRED CONTRACT PERIOD:	1 October 1977 - 31 July 1979
UNIVERSITY OFFICE TO BE CONTACTED REGARDING CONTRACT NEGOTIATION:	Grant and Contract Services 1 Administration Building, AD-24 University of Washington Seattle, Washington 98195 Telephone: area code 206, 543-4043

DATE: 22 June 1977

Knut Aagaard
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: P77-50

Technical Proposal

I. Title: Current Measurements in Possible Dispersal Regions of the Beaufort Sea
Research Unit No.: 91
Present Contract No.: 03-5-022-67, T.O.3
Proposed Dates: 1 October 1977-30 September 1978

II. Principal Investigator: Knut Aagaard

III. Cost:

C. $99,632
D. Beaufort Sea - 100%

IV. Background

Anchored current measurements are an essential and integral component of any modern oceanographic study. Prior to the present OCSEAP work, there had only been one time series current measurement of significant length on the Beaufort shelf. This was from a single instrument moored in water 54 m deep about 70 km ENE of Barrow during 15 days of August 1972. Other current measurements were also from summer and had been made in water shallower than 20 m; the records are of very short duration. During the spring and summer of 1973 we obtained two four-month long current records from the inner part of Barrow Canyon, whence waters enter onto the Beaufort shelf. By piecing together these observations, along with the indirect evidence provided by summer hydrographic measurements, one could arrive at some general ideas about the circulation on the Beaufort Sea shelf, primarily during summer.

Water originating in the Bering Sea and modified in its passage through the Chukchi flows NE through Barrow Canyon at speeds as high as 100 cm sec^{-1}. Subsequently, the majority of this flow probably turns eastward and enters the Beaufort Sea. On the shelf some 70 km ENE of Barrow, the eastward motion has been observed to average 60 cm sec^{-1} during a six-day interval. The eastward flow, concentrated on the outer shelf, can be traced through hydrographic evidence at least as far as Barter Island at 143°W. Measurements have shown that changes in the meridional atmospheric pressure gradient can temporarily reverse the flow in Barrow Canyon, and apparently also on the western Beaufort shelf.

Summer observations have also indicated the likelihood of an intermittent upwelling regime on the eastern part of the shelf. It appears that the upwelling is a response to locally strong easterly winds, and that the water upwelled onto the shelf moves westward.

While tidal effects have been thought to be small, storm surges and related effects may be important in promoting significant changes on short time scales.

Earlier studies have contributed essentially nothing to knowledge of the advective exchange between the shelf and the deep basin.

In the Beaufort Sea we have been involved in the OCSEAP in two ways. One has been execution of a seasonal series of CTD sections across the Beaufort shelf and slope. One general result of this work particularly bears on the present discussion, *viz.* the Beaufort Sea shelf is not neutral with respect to the Arctic Ocean to the north. Rather there are one or more forms of interaction, in which water and the substances it transports are exchanged between the shelf and the offshore regions. A dramatic example appeared in the series of four sections run in the fall of 1976. These indicated an intense subsurface current core sweeping up the slope and onto the shelf, flooding at least one section to the innermost station with dense, saline water.

Our second effort in the Beaufort OCSEA Program has been moored current measurements. The results to date indicate that at least in late winter the currents on the inner shelf are slow, generally less than 5 cm sec^{-1}. Long-term mean currents are extremely small, representing net displacements over a week of only 1-2 km. Two time series from north of Nowhal Island showed these small displacements to have been WSW. Tidal currents do not appear to be much above 1 cm sec^{-1} in winter.

On the outer shelf an entirely different situation prevails. Measurements made at 100 m under the ice from May-September showed the flow to reach over 55 cm sec^{-1}, and even over a three-month period the mean flow was 13 cm sec^{-1} toward the east. Pollutants reaching the outer shelf at sub-surface depths could thus be transported 1000 km eastward in three months. The most remarkable feature observed was the dominance of the motion by low-frequency variations with a typical time scale of ten days. These oscillations represent bursts of speed as high as 50 cm sec^{-1} or more; they are directed eastward and are aligned approximately with the shelf edge. Between the bursts there were shorter periods of westward motion, the maximum observed speed toward the west being 26 cm sec^{-1}. There is some reason to believe that these motions are a response to atmospheric forcing, but we have not yet resolved the matter. Tidal currents are in the neighborhood of 5 cm sec^{-1}, and a diurnal inequality probably prevails at times of high lunar declination.

The implication of these measurements with respect to the transport and dispersal of pollutants on the Beaufort shelf is that the ice-covered inner and outer shelf represent very different advective regimes. Over the former, currents are weak and net displacements are small. However, over the outer shelf there are strong currents and pollutants can be transported very long distances.

The work proposed here for FY 1978 concentrates on this more active current regime and its variability.

V. Objectives

The principal objective is twofold: 1) To obtain two year-long time series of current and temperature over a portion of the shelf which appears to have a very strong and variable flow. Such an area could be expected to be a very effective dispersal region. 2) To obtain two year-long series farther in on the shelf, trying to bridge the outer active region and the inner quiescent (at least in winter) one.

VI. Strategy

We will deploy two moorings, each with two internally recording current meters; the meters have temperature sensors. Experience in the OCSEAP so far indicates mooring recovery through the ice to be both practical and the simplest approach to the measurement problem. We will deploy as soon as ice forms in the fall, probably the second one-half of October, and recover one year later.

VII. Sampling Methods

The moorings will be located at about 200 m and 100 m depth off Lonely. The deeper one will almost certainly be in an active area. The upper current meters will be 65-70 m below the surface, out of the reach of drifting ice, and the lower ones about 15 m above the bottom.

VIII. Analytical Methods

Standard time series analyses will be used.

IX. Problems

At this point no major difficulties are anticipated.

X. Products

A. 1. Current speed and direction, temperature
   2. See attached Data Products Schedule

B. Narrative of the circulation over the Beaufort Sea shelf, including analysis and calculation of vector means and trends over various time scales, examination of unusual or special current events, and normal time series variance analyses.

C. Graphical representations to be included in the reports.

D. None

E. See attached Data Products Schedule.

XI. None

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)
Current meter records	Mag tape	4 meters running on 40 min. cycle for one year, recording 3 parameters = 157,680 records	015	yes	10/77-10/78	3/79

XII. Quality

Instruments will be calibrated at the Bonneville towing facility, at the Northwest Regional Calibration Center in Bellevue, and/or with the University of Washington facilities as required.

XIII. None

XIV. See attached forms.

XV. See attached Milestone Chart.

XVI. Outlook

No further work is anticipated once analysis of these data is completed.

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 in July 1979.

3. 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.

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 in March 1978. This does not apply to report requirements (see par. 2).

6. Within ten 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.

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

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)

The two mooring sites are approximately 35 and 45 nautical miles NNE from Lonely.

2. Describe types of observations to be made.

Deploy and retrieve moored current meters.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

Deployment must be in October 1977 and recovery in October 1978.

4. How many days of helicopter operations are required and how many flight hours per day? Two days are required to deploy and 4-6 days to recover, each of approximately 6 hours flying.
Total flight hours? 36-48 hours, staging not included.

5. How many people are required on board for each flight (exclusive of the pilot)?

4

6. What are the weights and dimensions of equipment or supplies to be transported?

Total weight is about 3600 lbs. each mooring on deployment and recovery. All equipment can be broken down to fit inside a Bell 205 or UH1H.

7. What type of helicopter do you recommend for your operations and why?

Bell 205 or UH1H, based on previous experience. Must have muff heater.

8. Do you recommend a particular source for the helicopter? If "yes" please name the source and the reason for your recommendation.

Charter, e.g. ERA, Evergreen, or NOAA, based on previous experience.

9. What is the per hour charter cost of the helicopter?

N/A

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

Barrow, Lonely

11. Will special navigation and communications be required?

VLF (GLOBAL or ONTRAC) is required.

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)

October 1977 Barrow - 4 men, 56 man days

October 1978 Barrow - 4 men, 56 man days

Back-up accommodations at Lonely (oil camp) should be arranged in case situation (weather, unusual field circumstances) requires.

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

Barrow - NARL - sole source.

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

8. 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.

9. 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 Environmental Assessment Program (OCSEAP) Office."

MILESTONE CHART

RU #: 91 PI: Knut Aagaard

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
Instruments deployed	In												Out					
Processing and data submission																		
Analysis and final report																		
ROSCOP's submitted: a Deployment only; b Data recovery	a												b					

EFFECTS OF PETROLEUM EXPOSURE ON THE BREEDING ECOLOGY OF THE GULF OF ALASKA HERRING GULL GROUP (Larus argentatus x Larus glaucescens).

Research Unit: #96

Principal Investigators: Dr. Frederik B. Bang, M.D.
Mr. Samuel M. Patten, Jr., M.Sc.

Institution and Department: The Johns Hopkins University
School of Hygiene & Public Health
Department of Pathobiology
615 North Wolfe Street
Baltimore, Maryland 21205

Date of Proposal: June 10, 1977.

Signatures:

Principal Investigator(s) Charles H. Southwick

Name For Frederik B. Bang, M.D. Date 7/28/77
Address The Johns Hopkins University, School of Hygiene and Public Health
Telephone Number 301-955-3459

Required Organization Approval Edyth H. Schoenrich

Name Edyth ~~H.~~ Schoenrich, M.D., M.P.H., Assoc. Dean Date 7/28/77
Address The Johns Hopkins University, School of Hygiene and Public Health
Telephone Number 301-955-3348

Organization Financial Officer Vincent P. Centurelli

Name Vincent P. Centurelli, Asst. Dir. of Business Mgmt. Date 7/28/77
Address The Johns Hopkins University, School of Hygiene and Public Health
Telephone Number 301-955-3256

TECHNICAL PROPOSAL

I. Title: EFFECTS OF PETROLEUM EXPOSURE ON THE BREEDING ECOLOGY OF THE GULF OF ALASKA HERRING GULL GROUP (Larus argentatus x Larus glaucescens).

Research Unit Number: RU #96 Contract Number:

Proposed Dates of Contract: 30 September, 1977 - 30 September, 1978.

II. Principal Investigators: Dr. Frederik B. Bang, M.D.
Mr. Samuel M. Patten, Jr.

III. Cost of Proposal:

Total $ 30, 175

Distribution of Effort by Lease Area: NEGOA - 100% effort.

IV. Background:

This research proposal is addressed to the following task: a continuing analysis of the effects of petroleum exposure and offshore oil development on the breeding ecology of the Gulf of Alaska Herring Gull group (Larus argentatus x Larus glaucescens).

The devastating effects of massive oil spills on seabird survival are widely reported, but little is known of the effects of oil on avian reproduction (Grau et al, 1977). Previous studies of oiling of seabird eggs suggests hatchability is markedly reduced (Gross, 1950, Birkhead et al, 1973, Patten & Patten, 1977). Rittinghaus (1956) and Hartung (1963, 1964, 1965) reported marine birds contaminate eggs with oil from the environment and hatching success of eggs thus exposed to petroleum was markedly reduced even after extended periods of incubation. Abbott, Craig and Keith (1964) suggested that oil interferred with normal respiratory exchange through the eggshell, while Szaro and Albers (1976) found hatching success of eider eggs was significantly reduced by micoliters of petroleum exposure, that is, very small quantities. Patten and Patten (1977-RU96) have recently found North Slope Crude Oil 22 times more toxic than equivalent amounts of mineral oil under field conditions. Grau et al (1977) have confirmed in laboratory experiments that small amounts of bunker C oil significantly depresses bird reproduction. Oil exposure has been used in the past to control gull populations along the Eastern Seaboard of the United States and in several Western U. S. wildfowl refuges (Gross, 1950; R. King, pers. comm.). In summary, literature on effects of oil exposure on the reproduction of marine birds is limited. Studies that do exist suggest high toxicity of petroleum to eggs, and marked effects upon reproductive productivity of females. Complete knowledge of the effects of petroleum exposure in various forms is needed to evaluate the full impact of oil pollution in marine bird populations in addition to further knowledge of the annual productivity of those populations.

The research addressed to in this proposal will provide information of the effects of both North Slope Crude Oil and mineral oil on the hatching success, incubation behavior and fledging success of a key seabird species nesting on barrier islands in proximity to Valdez tanker lanes and offshore oil lease areas. The results of this year's study will expand previous knowledge of marine bird annual productivity and results of petroleum exposure on these populations.

V. Objectives:

Field work conducted during FY78 will include further studies on the annual variability in breeding ecology and pathobiology of gulls in conjunction with additional studies on the effects of petroleum exposure on reproductive success of large gulls, supported with other marine bird species (Larus canus, Caladris minutilla, Sterna aleutica). Specifically both field and laboratory work will be designed with the following objectives:

1. Determine seasonal changes in density and distribution.

2. Identify critical habitat.

3. Identify major migration routes.

4. Further identification of large gull breeding localities in the northeastern Gulf of Alaska.

5. Evaluation of the impact of petroleum on the hatching success and chick survival of gulls and other selected species.

6. Describe population dynamics and trophic relationships of Herring and Glaucous-winged Gulls in the study area.

VI. General Strategy and Approach:

We propose to continue our examination of the effects of petroleum exposure on the breeding success of large gulls (Larus argentatus and Larus glaucescens), which are common inshore and marine scavengers nesting in colonies. We will expand our investigation from the largest gull colony in the northeast Gulf of Alaska, Egg Island, located 10 km SE of Point Whitshed and 20 km south of Cordova (60° 23' N, 145° 46' W) to include an analysis on the reproductive productivity of gull colonies located at Dry Bay, 75 km south of Yakutat, (59° 10' N, 138° 35' W), Icy Bay, and Middleton Island. Where key seabird colonies coincide with oil spill impingement areas, such as around Hinchinbrook Entrance, Cape St. Elias, Pt. Riou in Icy Bay, and Yakutat Bay Islands, a prospective tanker terminal site, the significance for further research becomes apparent. Logistically, Yakutat Bay Islands, Icy Bay and Middleton Island are most accessible and contain key seabird species.

Effects of petroleum exposure hinge on transfer to egg surfaces by adults at egg-laying or during incubation. We are planning experiments to test all likely pathways of oil exposure, including transfer of oil to eggs by adults and possible transport by wind or debris from oiled beaches.

Oiling of adults, eggs and chicks will be continued through the 1978 breeding season. The first season of experiments has indicated that surface application of North Slope Crude Oil causes high mortality to gull eggs. Equivalent amounts of mineral oil also reduce hatching success, suggesting both physical and chemical activity. At present we are testing the effect of 10ul, 20ul, 50ul, and 100ul of petroleum applied to the outside of eggs, during various stages of incubation.

Our research to date has indicated that behavior pathologies resulting from petroleum exposure are equally as important in functional effects of petroleum exposure as direct studies of toxicity. Such behavior studies can only be conducted in the field, and form an integral part of continued research.

VII. Sampling methods:

North Slope Crude Oil in continued experiments will be used to test toxic effects on eggs and chicks.

Mineral oil will be used to test gas exchange impairment of eggs and as a control for behavior experiments on chicks.

Egg exposure. Oil will be delivered to eggs in marked nests by application from microliter syringes with repeating dispensers. This method will allow for precise control of tiny amounts of petroleum exposure. Petroleum exposure will be in 5, 10, 20, 50 and 100 microliter doses at three (3) stages of incubation. Five seabird species (Larus argentatus, Larus glaucescens, Larus canus, Sterna aleutica and Calidris minutilla have been selected for investigation. Mineral oil will serve as before as control with dosage in equivalent amounts.

Chick exposure. Effects on chicks may include: a) external thermo-regulatory disturbance; b) internal metabolic disruption; c) impairment of visual recognition patterns by which adults recognize young (Patten & Patten, 1976). We will construct exclosures around portions of gull colonies.

Adults will have access by flight only. Chicks will be enclosed until capable of flight (40-45 days). Chicks will be banded for individual recognition. Oil will be administered to chicks to simulate beach or intertidal exposure. Another chick sample will be oiled on head feathers to evaluate disruption of recognition patterns.

To document reproductive productivity we will ascertain clutch size, reproductive synchrony, egg and chick weights, distance to nearest neighbor, food items, egg and chick mortality, and fledging success.

We will gather supporting information on habitat utilization, plant species, soil samples, and other animals inhabiting area of the breeding colonies.

We will provide maps and charts delineating habitat, feeding areas, and local and seasonal migration routes.

VIII. Analytical methods.

Experimental results will be compared to the standards previously established for "normal" Alaskan gull reproduction (Patten, 1974; Patten & Patten, 1975, 1976, 1977). Egg loss through predation has been the principal factor influencing hatching success and fledging rate in previous studies. Chick mortality has been most often due to adults attacking strange chicks; weather is also a factor influencing chick mortality.

We will include further analyses and interpretation of data collected during FY 76 and FY 77 on gull population ecology.

Data will be provided in the form of Coding Forms to an agency mutually agreed to with the Project Office for the purpose of further processing to ADP format. A specification of data sufficiently precise to allow ADP format design will be provided within 60 days of the start of the contract.

Schedules and approximate quantities of data to be furnished will be provided within 60 days of the start of the contract and will subsequently be up-dated at least quarterly.

Procedures followed in quality control and data acquisition will be documented for approval by the Project Office. Printouts of all data in its final form will be checked for accuracy by the P.I. according to procedures mutually agreed to with the Project Office.

XI. Anticipated Problems:

Our anticipated major difficulties are minimal, and revolve around severe weather conditions disrupting reproductive cycles, and human disturbance in the study areas (egging). We have discussed this aspect

XI. continued.

in our FY 1977 proposal. To date we have not encountered any of the above conditions.

X. Deliverable products:

A. 1. Digital Data submitted to NODC on coding forms for conversion to magnetic tapes in such OCSEAP approved formats as appropriate (File type 035).

2. see attached Data Products Schedule. We will process and format digital data into OCSEAP format. Projected amount of digital data will be approximately 5,000 records.

B. Narrative Reports:

Narrative reports will detail the spatial and temporal distribution and density of herring and glaucous-winged gulls in the northeastern Gulf of Alaska with specific attention to species diversity, fledgling success, food habits, age structure, mortality and survivorship. In addition, the effects of petroleum on the hatching and fledging success of these populations will be documented and evaluated.

C. Visual Data:

Visual data will identify the existing gull colonies in the northeastern Gulf of Alaska. Maps showing migration patterns and seasonal movements of gulls will be provided. Figures, tables and computer generated plots will supplement the narrative report by illustrating the following:

1. Species present at each rookery

2. Estimates of numbers

3. Pathobiological parameters, including antibody levels to selected diseases such as influenza and ornithosis.

4. Reproductive snychrony, clutch size, territory size, nesting habitat, and food habits.

5. Effects of different levels and manner of petroleum exposure on the hatching success of gull eggs.

Photographic material will be provided of nesting and feeding areas important to bird colonies. Photographs depicting methods of petroleum exposure and results will be provided.

D. Other Non-Digital Data not expected.

E. Data Submission Schedule:

Continued analysis of data on magnetic tape will begin October 1, 1977. First data collected fromthis contract will begin April, 1978, at selected colony sites. Data will be submitted by quarter. (See attached Data Products Schedule.)

XI. Information Required from Other Investigators:

No data will be required from other investigators to carry out proposed work.

XII. Quality Assurance Plans:

No calibration required in our study. Quality control will include 100 per cent proof-reading of NODC data printouts. Information transcribed from field books onto coding forms will be 100 per cent proof-read by P. I., prior to submission to NODC.

XIII. Special Sample and Voucher Specimen Archival Plan:

Adult specimens that may be collected will be housed at the National Museum of Natural History, Smithsonian Institution.

XIV. Logistics Requirements: See attached form Logistics Requirements.

XV. Management Plan:

See attached Activity/Milestone/Data Management Chart.

Population Ecology

Location: Dry Bay, Alsek River mouth, Yakutat, Alaska
Icy Bay, 66 miles north of Yakutat
Middleton Island, NEGOA
Bering River, Copper River Delta

Time Span: April through September, 1978.

Activity:	Sample Size
1. Colony survey, determine density and distribution of birds and other species in study area.	4 colony sites
2. Reproductive survey, mark individual nests, measure internest distances, determine clutch size, reproductive synchrony, egg loss, hatching success, chick mortality, and fledging success.	100 nests
3. Banding and color-marking of adults and chicks to determine local and seasonal migratory movements.	2,000 birds
4. Delivery of North Slope Crude oil to eggs, chicks and adults. Delivery of mineral oil as control to eggs, chicks and adults.	100 nests 100 nests
5. Determine toxic and behavioral effects of petroleum exposure.	100 nests
6. Laboratory work on serology and virology.	250 serum samples

Analysis, Data Preparation

Location: The Johns Hopkins Universtiy

Time Span: October through March 1978.

Activity:

1. Continued analysis of data collected during FY76, and FY77.
2. Preparation of figures, tables and computer generated plots. Mapping of local and seasonal population movements and migration patterns.
3. Initial transfer of data to coding forms.
4. Preparation of Quarterly and Annual Reports.
5. Literature Review.

XVI. Outlook:

We recommend a continuation of concentrated investigations of the breeding ecology and wintering ecology of large gulls in the Gulf of Alaska. Analysis of reproductive parameters is necessary to gauge the relative health of these populations prior to oil development and to provide models for future comparison.

1. The nature of final results and data products:

Complete inventory of all major colonies in NEGOA. Establish reproductive indices for these colonies, including density, distribution, and critical habitat.

Determination of precise amounts of petroleum exposure that will significantly depress hatching success and chick survival.

Effects of petroleum exposure on behavior and pathobiology.

Seasonal and migratory movements of gulls. Banding returns to date suggest a southern shift of these populations in winter, perhaps leaving the NEGOA study area entirely, with replacement by more northern and interior populations wintering on the south coast of Alaska. These populations are completely uninvestigated at present and will be subjected to petroleum development effects just as are breeding and summering populations. We propose further investigations of wintering populations of gulls in the NEGOA area during FY79.

We suggest a large-scale banding and color-marking scheme of wintering birds. Investigations will focus on major feeding and resting localities in proximity to areas affected by human development (Cordova, Yakutat). Our studies indicate that gulls increase with human development. We propose a more intensive investigation of pathobiological parameters of these populations since recent evidence indicates that gulls are highly commensal and dependent upon artificial food sources and are potential disease vectors.

2. Cost by fiscal year:

Current funding guidelines are sufficient to implement future investigations.

3. Additional major equipment required:

None projected at this time.

4. Location of future field efforts:

NEGOA

5. Logistics requirements:

Logistics requirements will not be significantly different from FY78.

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."

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)

n/a to US a/c; transportation only from Yakutat to Icy Bay; Dry Bay; Cordova to Middleton Island and return.

2. Describe types of observations to be made.

n/a transportation 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)

n/a

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

Total flight hours? 8 days n/a to US govt a/c; about 4 flight hours/day

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)?

n/a

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?

When required we will charter small aircraft n/a to government a/c

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

available commercial charter in Yakutat and Cordova:Gulf Air Taxi; Chitina Air

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

$80/hr

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

PI and assistant (e.g. 2)

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

Yakutat and Cordova

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) Cordova	May-Sept 78	2 personnel per day when out of field
(b) Yakutat	May-Sept 78	"
(c) Middleton Island	May-Sept 78	"
		"

Cordova and Yakutat: cooperative agreement with USFS Regional Office provides us with quarters as needed when we are out of the field and occasional logistical support on a no-cost basis in return for access to research results and reports submitted to USFS Regional Office. Middleton Island FAA provides quarters to US contract investigators on a fee basis. Forest Service also provides field cabins under coop agreement.

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

We arrange for these cooperative agreements through the Johns Hopkins University and the United States Forest Service Tongass/Chugach Region.

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

No cost in Cordova and Yakutat; Middleton Island FAA $5.00/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?

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 no special logistic problems and have had none in six years Alaskan contract research with USNPS and NOAA.

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)
Marine Birds	Coding sheets	5,000 records	035	P.I. Yes	April/1978 to September/1978	

Submission:
November/1978

MILESTONE CHART

RU #: 96 PI: Bang/Patten

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			
~~Continued analysis of data collected FY76 and FY77.~~	X	X	X															
Preparation of figures and computer generated plots		X	X															
Initial transfer of data to coding forms		X	X															
Literature Review, preparation of Quarterly Report			X															
Serological laboratory investigations on pathobiology				X	X	X												
Preparation of annual report, review of computer runs					X	X												
Departure for field season. Begin on-site collection							X	X										
Field investigations, Dry Bay, Icy Bay							X	X	X	X	X	X						
Field investigations, Middleton Island, Bering River								X	X	X	X	X						
Begin coding information for submission to NODC											X	X						
Begin data analysis, begin preparation of Final Report													X	X				
Submission of Final Report															X			

THE JOHNS HOPKINS UNIVERSITY
SCHOOL OF HYGIENE AND PUBLIC HEALTH
615 NORTH WOLFE STREET
BALTIMORE, MARYLAND 21205, U. S. A.

DEPARTMENT OF PATHOBIOLOGY

RU 96

August 5, 1977
c/o U.S. Forest Service
P.O. Box 280
Cordova, AK 99574

Ref: RFx41-96-532

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

Dear Dr. Bruce:

We are in agreement to the revisions to our FY 78 renewal proposal as enumerated by the Juneau Project Office and sent to us in your letter of 23 Jul 1977.

We will list herein the revisions as indicated. These revisions are to be included in our FY 78 renewal Proposal as a formal Addendum to be attached to the RU 96-78 Work Statement.

ADDENDUM

RU 96 - 78
Work Statement

1. Transfer of oil to eggs will be accomplished by capture of incubating adults with the subsequent oiling of breast feathers, feet and/or food.

2. Additional data will be collected on seasonal density/distribution, migration, and trophic relationship of the Gull populations.

3. The new (NODC)taxonomic code released in March 1977, will be used in the RU 96-78 data submissions (FY 78).

4. An itemised list of parameters to be used in the 035 format will be provided to the Project Office with a definition of the minimum and maximum permissible limits of values expected for these parameters.

5. Photographic materials will be submitted as original photographs, photographic duplicates or be reproduced by processes equivalent to the xerox color copier 6500.

6. Data products schedule should read:
   a. Formatting done by P.I. - yes.
   b. Processing done by P.I. - no.

Sincerely,

Samuel M. Patten Jr

Samuel M. Patten, Jr.
M. Sc. Ph.D. cand.
Associate Investigator
Pathobiology

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98105

TO:	Outer Continental Shelf Environmental Assessment Program National Oceanic and Atmospheric Administration
TYPE OF SUPPORT REQUESTED:	Research Contract
TITLE OF PROJECT:	Dynamics of Near-Shore Sea Ice OCSEAP Research Unit 98
PRINCIPAL INVESTIGATOR:	Robert S. Pritchard Principal Scientist 4059 Roosevelt Way NE Seattle, WA 98105 Telephone: (206) 543-6613
AMOUNT REQUESTED:	$56,807
DESIRED PERIOD:	1 October 1977 - 30 September 1978
UNIVERSITY OFFICE TO BE CONTACTED REGARDING GRANT NEGOTIATION:	Grant and Contract Services 1 Administration Building, AD-24 University of Washington Seattle, Washington 98195 Telephone: (206) 543-4043
DATE:	6 June 1977

Robert S. Pritchard

Stanley R. Murphy
Director, Div. of Marine Resources

OFFICIAL AUTHORIZED TO GIVE UNIVERSITY APPROVAL: Donald R. Baldwin, Director
Grant and Contract Services

C. TECHNICAL PROPOSAL

I. Title: Dynamics of Near-Shore Sea Ice

Research Unit Number: R.U. 98

Contract Number: 03-5-022-67, Task No. 5

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

II. Principle Investigator: Robert S. Pritchard

III. Cost of Proposal, FY'78

Total	$56,807
Distribution of effort by Lease Area:	50% Beaufort Sea,
	50% Chukchi Sea.

IV. Background

This project is designed to determine the motion of the pack ice cover in the region of the Continental Shelf of the Beaufort and Chukchi Seas, especially the ice motion from the Beaufort into the Chukchi Sea near Barrow, Alaska. Motion of the pack ice directly affects the behavior of an oil spill. The motion is one of the variables that may be measured directly in the interaction of the sea ice with its environment and with manmade objects. During FY'76 we deployed an array of twenty buoys in the southern Beaufort Sea. During FY'77 we deployed an array of six buoys in the Chukchi Sea and two more in the Beaufort Sea. Analysis of the motion of these buoys to date has provided a baseline of information on how pack ice responds to winds in the atmosphere and currents in the ocean. Specifically, the results show how the ice moves under these conditions during these years. Deployment of an additional array will provide some determination of year-to-year variability. Also, since we intend to deploy the buoys in the southwest region of the Beaufort Sea to track their motions into the Chukchi Sea, we shall obtain information in an area not yet considered in much detail.

In addition to acquiring a baseline of motion data, this work is closely tied into modeling of sea ice dynamics that is being performed at the University of Washington through the AIDJEX and other projects, including ongoing modeling for OCSEAP. The development and testing of any model of sea ice dynamics depends heavily on measuring both driving forces (winds and currents) and resulting output (ice motion). It should be pointed out that these data are useful not only to modelers at AIDJEX, but are necessary to test models developed elsewhere too.

The region of special interest that shall be considered for buoy coverage is a strip of about 100-200 km offshore of the Alaska coast to the west of Pt. Barrow. Large ocean currents and ice motions as well as anomalous ice conditions appear to provide ideal habitat for mammals and birds (as pointed out at the Barrow synthesis meeting, February 7-11, 1977). It is important to measure these motions accurately to learn what causes this behavior.

V. Objectives

The general purpose of this work is to study the ice dynamics on the Continental Shelf of the Beaufort and Chukchi Seas by determining the ice motions and behavior from satellite-tracked buoys deployed on and drifting with the ice. Interpretation of these data shall help explain the physical mechanisms of the ice behavior. Our aims are to increase geographic coverage and to determine year-to-year variability of the ice behavior in the nearshore environment.

Knowledge of this behavior is critical if we are to learn where oil will be advected by the ice pack when it is spilled. Thus far the data indicate that the pack ice outside the shear zone on the North Slope of Alaska would transport the oil to the west and that if it were far enough north after moving west of Barrow, it would continue to go north and west. Some of this oil could be trapped in the Beaufort Gyre. Depending on degradation rates, this oil could be transported back to Canadian waters. The remaining oil would apparently enter the transpolar drift stream. However, oil remaining near shore could be transported south into the Chukchi Sea. The possibility of oil moving into the Bering Sea cannot be assessed at this point, primarily because we are unsure of the ice motions near the Alaska coast in the Chukchi Sea.

VI. General Strategy

The data for this program is to be taken using air-droppable buoys (ADRAMS). We shall deploy four of these buoys. All will report position and one will also contain a barometric pressure sensor.

The state of development of air-droppable buoys indicates that this is becoming a fully developed technology which can be used to obtain data in arctic surroundings. The present data set from these ADRAMS buoys describes the conditions of ice motion in many locations in the Beaufort and Chukchi Seas.

We expect details of the array geometry and of the time of deployment to be worked out with Dr. Gunter Weller. Generally, the buoys will be deployed during early spring of 1978. This will allow them to drift through the spring and into the summer breakup, a time of special interest.

VII. Sampling Methods

Data buoys will be deployed in an array on the order of 100 km apart. The buoy with pressure sensor shall be farthest from shore to help define the barometric pressure field. Temporal sampling will be adequate for resolving daily displacements of the buoys and to provide daily synoptic scale barometric pressure.

VIII. Analytical Methods

The methods of data analysis are described in:

Thorndike, A. S. 1973. An integrated system for measuring sea ice motion. Ocean '73, Proceedings of the 1973 IEEE International Conference on Engineering in the Ocean Environment.

Thorndike, A. S. and J. Y. Cheung. 1977. "Measurements of Sea Ice Motion Determined from OCS Data Buoys - October 1975 to December 1976." Appendix 1 of Annual Report to OCSEAP, this contract.

Thorndike, A. S. and J. Y. Cheung. 1977. "AIDJEX Measurements of Sea Ice Motion - 11 April 1975 to 14 May 1976," AIDJEX Bulletin No. 35.

IX. Anticipated Problems

None.

X. Deliverable Products:

A. Digital Data:

1. Position of each buoy and barometric pressure as reported.
2. List of digital products: see data products schedule.

B. Narrative reports will not be issued separately but a narrative of the observed motion and deformation of the ice cover shall be a final product.

C. Visual data shall be maps of the buoy (ice) trajectories. There shall be one map of each buoy trajectory and a composite map of all trajectories. A final data report will be prepared.

D. Other non-digital data--none.

E. Data submission schedule. Data will be collected upon buoy deployment and continue as long as the buoys operate (we expect data transmission to end during summer breakup for all buoys in the marginal ice zone). Data will be submitted quarterly (see attached data products schedule).

XI. Information Required from Other Investigators.

None.

XII. Quality Assurance Plans

All buoys shall be bench tested and calibrated before deployment.

XIII. Special Sample and Voucher Specimen Archival Plans

None.

XIV. Management Plan

The principal investigator will coordinate the work of all personnel, including the technical coordinator, who will be in charge of buoy deployment, and the scientific programmer, who will reduce the position and barometric pressure data. He will aid in the interpretation of the motion and behavior of the ice pack. See attached milestone chart.

XVI. Outlook

It is important that the sea ice dynamics study continue. There is a need for continuing to increase geographic coverage and learning more about season-to-season and year-to-year variability. Ocean sensors must be deployed to get better understanding of the currents. These incur greater logistics and hardware costs than the ADRAMS buoys. We anticipate a modest buoy program similar to that proposed here, but with more comprehensive data analysis costing 100 K per year. As stated many times, buoy data alone is inadequate for understanding the complex air-ice-sea interactions. Modeling is required. We shall not pursue that subject in this proposal, but the work is necessary in other phases of the OCSEAP program.

XVII.

1. Updated Activity/Milestone/Data Management Chart 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 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.
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. This does not apply to report requirements (see paragraph 2).
6. Within 10 days of the completion of a data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23) will be submitted to the Project Data Manager.
7. Title for all property purchased with OCSEAP funds remains with the U.S. Government pending disposition at contract termination.
8. 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.

9. 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 Alaska Continental Shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office."

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)

From Barrow to about 200 km offshore. Details of pattern unknown.

2. Describe types of observations to be made.

Buoy deployment

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)

Deployment in February, 1978, as early as light is adequate

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

1-2 days

Total flight hours? 8 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)?

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

none - has been done before

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

4 buoys, 2' diameter, approximately 70 lb. each

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

C-117

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

NARL- convenience of lab to flight support and experience of crew

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

$400.00

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?

Pt. Barrow

5/20/77

D. QUARTERS AND SUBSISTENCE SUPPORT

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) NARL
b) February 1978 when adequate light is available
c) 1 man, 2 weeks

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

NARL - convenience of lab to flight support

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

$76.00, established rate

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?

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)
Buoy Positions	tapes	1 tape	056	yes	2/78 - 9/78	10/78

MILESTONE CHART

RU #: 98 PI: Robert S. Pritchard

△ Planned Completion Date

▲ Actual Completion Date

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		
Buoy deployment					Δ												
Data Acquisition					—	—	—	—	—	—	—	Δ					
Data Analysis													Δ				
Contract for buoys		—	—	Δ													
Quarterly Reports			Δ						Δ			Δ					
Annual Report						Δ											

5/20/77

Robert S. Pritchard - Publications
Arctic Ice Dynamics Joint Experiment

1962

"57 Case structural test," (with J. V. Timmons). Report No. 144, ACF Industries, Albuquerque, New Mexico, December.

1964

"Temperature and thermal stress distributions in circular cylinders," (with W. E. Putman and M. W. Wildin). Technical Report ME-11, the University of New Mexico, Engineering Experiment Station, Albuquerque, New Mexico, August.

1965

"Temperature and stress distributions produced in long circular cylinders cooled by emission of thermal radiation," (with M. W. Wildin). Report No. ME-19, Bureau of Engineering Research, the University of New Mexico, Albuquerque, New Mexico (Master's Thesis, Mechanical Engineering Department, UNM, October 1965).

1967

"On a numerical technique for elastic wave propagation." Report No. ME-32, Bureau of Engineering Research, the University of New Mexico, Albuquerque, New Mexico, December.

1968

"Transient strain and temperature distributions in long circular cylinders cooled by emission of thermal radiation," (with M. W. Wildin). Experimental Mechanics, Vol. 8, No. 6, June.

1970

"Three dimensional elastic wave propagation in bodies of revolution," (with F. D. Ju). Report No. ME-45(69), Bureau of Engineering Research the University of New Mexico, Albuquerque, New Mexico (Ph.D. Dissertation, Mechanical Engineering Department, UNM, August 1970; also published as Air Force Office of Scientific Research Scientific Report, AFOSR-70-2406TR), August.

"Numerical approximations to the deformation of a continuum." Eric H. Wang Civil Engineering Research Facility technical report to Air Force Weapons Laboratory, Albuquerque, New Mexico, November.

1971

"Theoretical calculations for DIHEST Improvement Program -- Event I-A," (with R. O. Davis, W. H. Chown, P. N. Sonnenburg). Air Force Weapons Laboratory AFWL-TR-71-123, Kirtland Air Force Base, New Mexico, August.

"Time history plot package for AFTON 2A Code." Eric H. Wang Civil Engineering Research Facility technical note to Air Force Weapons Laboratory, Albuquerque, New Mexico, November.

1972

"Motion-picture plot package for AFTON 2A Code," (with J. J. Blake). Eric H. Wang Civil Engineering Research Facility technical report to Air Force Weapons Laboratory, Albuquerque, New Mexico, February.

"Generator for AFTON 2A Code." Eric H. Wang Civil Engineering Research Facility technical report to Air Force Weapons Laboratory, Albuquerque, New Mexico, March.

"Stability analysis of AFTON Codes." Eric H. Wang Civil Engineering Research Facility technical report to Air Force Weapons Laboratory, October.

1973

"Dispersion curves for a two-layer elastic half-space," (with H. A. B. Rao). Eric H. Wang Civil Engineering Research Facility technical report to Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.

"Computer code for complex chemical equilibrium studies at elevated temperatures and pressures," (with W. T. Ristau). Eric H. Wang Civil Engineering Research Facility technical report to Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.

1974

"Modeling the pack ice as an elastic-plastic material," (with M. D. Coon, G. A. Maykut, D. A. Rothrock, A. S. Thorndike). AIDJEX Bulletin No. 24, University of Washington, Seattle, Washington, pp. 1-106.

"Application of an elastic-plastic model of arctic pack ice," (with M. D. Coon). The Coast and Shelf of the Beaufort Sea, eds. J.C. Reed and J.E. Sater, The Arctic Institute of North America, Arlington, VA, pp. 173-193.

1974

"What? Strain? What Strain?" AIDJEX Bulletin No. 26, University of Washington, Seattle, Wash., pp 59-74.

"One-dimensional difference shceme for an elastic-plastic sea ice model," (with R. Colony). Computational Methods in Nonlinear Mechanics, the Texas Inst. for Computational Mechanics, Austin, Texas, pp. 735-744. Also in AIDJEX Bulletin No. 26, University of Washington, Seattle, Wa. pp. 48-58.

"Elastic strain in the AIDJEX sea ice model," AIDJEX Bulletin No. 27, University of Washington, Seattle, WA, pp.45-62.

1975

"An elastic-plastic constitutive law for sea ice," Transactions of the ASME, Vol. 97, Journal of Applied Mechanics, Vol. 42, Series E, No. 2, June, pp. 379-384.

"Integration of elastic-plastic constitutive laws," (with R. Colony) AIDJEX Bulletin No. 30, University of Washington, Seattle, WA, pp 55-80.

"A difference approximation to the momentum equation," AIDJEX Bulletin No.30, University of Washington, Seattle, WA, pp.81-93

"Integration scheme for an elastic-plastic sea ice model", (with R.Colony) Proceedings of the 12th Annual Meeting of the Society of Engineering Science, The University of Texas at Austin, Texas

1976

"Applications of the AIDJEX ice model," (with R.T.Schwaegler), in Proceedings of the Third International Conference on Port and Ocean Engineering under Arctic Conditions, Vol.I, Institute of Marine Science, University of Alaska, Fairbanks, Alaska, pp. 513-526; reprinted in AIDJEX Bulletin No. 31, University of Washington, Seattle, WA, pp.137-150.

"A difference scheme for the AIDJEX sea ice model," (with R. Colony), in Numerical Methods in Geomechanics,Vol.II, ed. C.S. Desai, American Society of Civil Engineers, New York, 1976, pp. 1194-1209;reprinted in the AIDJEX Bulletin, No. 31, University of Washington, Seattle, Wa September 1975, pp. 188-203.

"Calculations to test a pack ice model," (with M.D. Coon, R. Colony, D.A. Rothrock), in Numerical Methods in Geomechanics, Vol.II, ed. C.S. Desai, American Society of Civil Engineers, New York, 1976, pp.1210-1227; reprinted in AIDJEX Bulletin No. 31, University of Washington, Seattle, Wa, September 1976, pp.170-187.

1976

"Simulation of sea ice during AIDJEX," (with M.D. Coon and M.G. McPhee), to appear in Transactions of the ASME:Journal of Pressure Vessel Technology; preprinted in AIDJEX Bulletin No. 34, University of Washington, Seattle, Wa., pp.73-93.

"An estimate of the strength of Arctic pack ice," AIDJEX Bulletin No. 34, University of Washington, Seattle, Wa, pp.94-113.

1977

"Winter ice dynamics in the nearshore Beaufort Sea," (with M.D. Coon, M.G. McPhee and E. Leavitt), appendix 3 in Annual Report on contract 03-50-022-67, No. 5 to Outer Continental Shelf Environmental Assessment Programs, April 1, University of Alaska, Fairbanks, Alaska

"Prediction of Arctic ice conditions for operations," (with D.C. Coon and R.T. Hall) in 1977 Offshore Technology Conference Proceedings, Vol.IV, Houston, Texas, pp.307-314.

A. Continuation Proposal
Delineation and Engineering Characteristics of
Permafrost Beneath the Beaufort Sea, Alaska
(RU-105)

Principal Investigators:
Paul V. Sellmann
Edwin J. Chamberlain

Total Science Cost: $102,000

Period of Work:
1 October 1977 to 30 September 1978

Institution:
U.S. Army Cold Regions Research
and Engineering Laboratory
Hanover, New Hampshire 03755

Required Signatures

Paul V. Sellmann — 30 June 1977

Paul V. Sellmann
U.S. Army Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755
Telephone: (603) 643-3200 Ext. 318

Edwin J. Chamberlain — 30 June 1977

Edwin J. Chamberlain
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Frank J. Ferraro — 30 June 1977

Frank J. Ferraro
U.S. Army Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755
Telephone: (603) 643-3200 Ext. 315

30 June 1977

COL Robert L. Crosby, Commander and Director
U.S. Army Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755
Telephone: (603) 643-3200 Ext. 200

Technical Proposal

I. Title and Task Statement:
Delineation and Engineering Characteristics of Permafrost Beneath the Beaufort Sea, Alaska (RU-105, continuation)

Proposed Dates of Contract: 1 October 1977 - 30 September 1978 for FY 78 funding. It may be logical to extend the project for two additional fiscal years if results of the (FY-78) evaluation of the industry seismic data appear as useful as anticipated.

II. Co-Principal Investigators:

Paul V. Sellmann
Edwin J. Chamberlain

III. Cost of Proposal: $120,000

All work in Beaufort Sea area.

IV. Background:

Past subsea permafrost field programs supported by OCSEAP have been restricted to a few locations along the Beaufort Sea coastline, with the most detailed information coming from the Prudhoe Bay area (RU 253, 105 and 271). The resulting drilling and core analysis, probing, and seismic studies have provided much needed information on the distribution and properties of subsea permafrost. These more localized investigations were carried out by RU 105, 204, 253, 271, and 473. Even though the sites studied were selected because of their similarity to large sections of the coastline, they still provide only limited direct subsurface data, considering the extent of the potential Beaufort Sea lease area. Some regional extrapolation of the information has been carried out by RU 253, 473 and 516 as part of the overall program, based on consideration of the thermal regime, shoreline and sea level history.

Our project will attempt to provide more regional data. The regional distribution of permafrost and more specifically the top of bonded permafrost will be examined using available seismic refraction records. The approach used will be much the same as the examination of this type of data made by the Geological Survey of Canada. Commitments have been made by members of the petroleum industry to make available to CRREL the non-proprietary upper part of some of their seismic records. The interpretation of these data will be aided by the studies of RU 271. Analysis of drill cores and other supplementary data will also be carried out but no drilling will take place as part of this program.

V. Objectives:

Provide additional required information on the occurrence and depth to the top of bonded subsea permafrost in the Beaufort Sea continental shelf in order to better assess the hazards that permafrost presents to offshore development.

VI. General Strategy and Approach:

Various members of the petroleum industry have already been approached in writing by CRREL concerning the availability of seismic first return data from the Beaufort Sea. Information from the upper part of industry data, which in some cases will include the first 0.5 second of the seismic records, will be processed and interpreted. This year's analyses (FY78) will be aimed at (1) establishing how much industry data are available, (2) locating the lines surveyed, and (3) processing several sets of data. The locations studied will be selected based on the range of geological settings found along the Beaufort coast. The results of these investigations should indicate in which of these settings high velocity first returns are found, and as a result which settings can be expected to yield the most data. Based on this preliminary interpretation, additional data will be selected for processing and analysis. Concurrently, engineering and chemical property analysis will be continued on samples remaining from the 1977 drilling program as well as on any additional material that is acquired from the ONR drilling program proposed to be conducted along the Beaufort coast in the Oliktok area during the spring of 1978.

VII. Sampling Methods:

Selection of seismic data will be based on geological settings and availability from industry.

VIII. Analytical Methods:

Analytical methods were covered in previous documents for engineering property studies, and methods for seismic studies for the most part will be those used by Hunter, J.A. et al., 1976.*

IX. Anticipated Problems:

No problems are anticipated. The only significant unknown will be the time required for processing of raw field data by geophysical companies.

X. Deliverable products:

A. Digital Data:

Not applicable.

B. Narrative Reports:

Reporting will take place before the end of fiscal year 1978. One report is envisioned, covering methods and results of industry seismic data study. Tabulated engineering and chemical property data from core study will also be provided. Engineering data will include both index and strength properties. Maps included with the report will provisionally locate depth to top of bonded permafrost and general permafrost distribution based on the position and occurrence of high velocity zones in the study areas.

C. D. and E.:

Not applicable, or covered in B or in XV.

XI. Information Required from Other Investigators:

Results of activities in other Geology work units will be closely followed as in the past (see last annual and quarterly report). Arrangements and coordination have already taken place with PI's working on University of Alaska research units.

XII. Quality Assurance Plans:

Covered in original proposal.

* Permafrost and frozen sub-seabottom materials in the southern Beaufort Sea. Beaufort Sea Technical Report #22, Beaufort Sea Project, Dept. of the Environment.

XIII. Special Sample and Voucher Specimen:

Archival Plans:

Not Applicable.

XIV. Logistics Requirements:

None.

XV. Management Plan:

Coordination will be maintained with Beaufort Sea subsea permafrost projects as well as with Canadian co-workers. A working session will be arranged with Osterkamp and Harrison and USGS personnel to review program results and determine future thrust of our activities.

MILESTONE CHART

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
Acquire unprocessed industry data	—	—	—												
Have data adjusted and processed			—	—	—	—	—								
Analyze seismic data				—	—	—	—	—	—	—	—	—			
Analyze core properties	—	—	—	—	—	—	—	—	—	—	—				
Prepare report summarizing results									—	—	—	—	—		

XVI. Outlook:

It is understood that this section is for long-range planning only, and no obligation is implied on the part of either party.

1,2. The nature of the final results and data products of an extended program (beyond FY78) and milestones.

The final end product of a successful program would be a provisional map indicating depth to the first high velocity zone, which we assume in most cases will correspond with the top of bonded permafrost. The map would cover parts of the Beaufort Shelf area for which data are available from industry, which appears to be a significant part of the coastline. A narrative report would cover final results of sample analysis from the RU 105 work as well as from any cores or samples processed as a result of ONR drilling activities. It may prove desirable to selectively field check specific locations, in which case recommendations to NOAA for such direct drilling or probing will be made and the work possibly undertaken in cooperation with ONR- and/or NSF-supported subsea permafrost projects.

3. The cost of a longer-term program can best be determined following this year's program. Based on experience with similar programs in Canada, approximately $125,000/year for an additional two years should cover an evaluation of the Beaufort Sea industry data along the Alaskan coast.

4,5,6. 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 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 or 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 aggreement 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."

Title: SIMULATION MODELING OF MARINE BIRD POPULATION ENERGETICS, FOOD CONSUMPTION, AND SENSITIVITY TO PERTURBATION

Research Unit Number: 108

Principal Investigator: John A. Wiens

Total Cost: $75,000

Institution and Department: Oregon State University
Department of Zoology
Corvallis, Oregon 97331

Date of Proposal: 25 June 1977

Signatures:

John A. Wiens
Principal Investigator, Acting Chairman
Department of Zoology
(503-754-3705)

28 June 1977
Date

Wonenbogh actg for
John V. Byrne
Acting Dean of Research
(503-754-3437)

29 June 1977
Date

Hugh F. Jeffrey, Jr.
Director of Business Affairs
(503-754-3031)

6/29/77
Date

TECHNICAL PROPOSAL

I. *Title:* Simulation Modeling of Marine Bird Population Energetics, Food Consumption, and Sensitivity to Perturbation

Research Unit Number: 108

Contract Number: 03-5-022-68T2

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

II. *Principal Investigator:* John A. Wiens

III. *Cost of Proposal*

Total: $75,000

Distribution of Effort by Lease Area: All studies will be conducted on data related to the St. George Basin lease area.

IV. *Background:*

There are several compelling reasons to believe that consideration of the population energetics of marine birds may be an important avenue of research in OCS programs. First, marine ecosystems are structured around the patterns and magnitudes of energy flows between ecosystem components. Given this, it follows that at least one way to assess the overall impact, role, importance, or potential sensitivity to disruption of a component such as marine bird populations in the system is to measure the energy flow through these populations (e.g., Wiens and Dyer 1977). In addition, energetics directly link marine bird populations to the oceanic areas they use for feeding, and consideration of energy demands may thus provide a means of assessing the importance of feeding areas. Further, several research efforts in the Alaskan OCSEAP program have generated data on diverse aspects of marine bird biology (e.g., breeding colony structure, food habits, pelagic distribution and abundance, flock dynamics), and energetic measures may provide a common organizing framework within which these different data sets may be combined. Finally, since the energy demands of individual organisms directly reflect metabolic processes, they may be among the more sensitive aspects of marine bird biology in responding to local environmental perturbations (e.g., oil development accidents). If we can somehow measure or estimate the energy dynamics of marine bird populations, then, it is likely that we can project the interrelationships between these populations and the marine environment with substantially better understanding than at present.

Obtaining information on the energy demands of natural populations of free-ranging birds at sea, however, is virtually impossible. Faced with this barrier, we may resort to use of simulation models that incorporate data on basic life history attributes to derive estimates of population dynamics and energy demands. A model (BIRD) developed by Wiens and Innis (1973, 1974) and now operative at Oregon State University was expressly designed with such objectives in mind. This model generates estimates of patterns of population size changes, energy demands, and food consumption rates for marine bird species, using data that are generally more readily available than the estimated variables. Briefly, the simulation model contains three submodels. In the population submodel, information on population sizes at selected points in time (as obtained, for example, from occasional censuses), reproductive biology and timing, and mortality is used to project daily estimates of the population size of each age class of each of up to 20 species. The second submodel generates estimates of individual, age class, population, and "community" energy demands using data on ambient temperatures, photoperiod, body weights, growth patterns of young, and basic metabolic relationships. A third submodel combines the daily energy demand estimates with information on dietary composition at several points in time to project food consumption rates for various prey categories.

This modeling approach has now been successfully applied to a wide variety of situations, ranging from local populations of grain-feeding blackbirds (Wiens and Dyer 1975) through breeding bird communities of coniferous forests or grasslands (Wiens and Nussbaum 1975, Wiens in prep.) to variation in population energetics and food consumption over entire continents (Wiens and Dyer 1977). Two applications are particularly relevant to the research proposed here.

1) Wiens and Scott (1975) employed the BIRD model to explore the patterns and magnitudes of population density changes and population energy and food demands in Oregon populations of Sooty Shearwaters, Leach's Storm-petrels, Brandt's Cormorants, and Common Murres on a state-wide basis. Using information no more detailed (and in some cases less detailed) than that obtained in several of the OCSEAP studies, they determined that murres required 3.5 kcal/m^2/year, cormorants 2.3, shearwaters 1.7, and storm-petrels 0.1. The species occupied different-sized ocean areas, however, and when these per m^2 values were adjusted to consider the total area occupied by each species population the overwhelming dominance of shearwaters in the energy dynamics of the bird community became apparent. Shearwaters are transients along the Oregon coast, but during their fall passage they consumed nearly seven times as much energy as any of the other species. By combining information on dietary habits with model estimations of energy demands, patterns of food consumption of these populations could be estimated by the model. Murres annually consumed nearly twice as many herring as any other prey, and consumed roughly equal quantities of anchovey, smelt, cod, and rockfish. Cormorants consumed a relatively small quantity of bottom-dwelling fish, while storm-petrels took roughly equal quantities of euphasids and hydrozoans. Anchovies accounted for 43% of the 62,500 metric tons of prey the

four species were estimated to consume annually (Figure 1), and 86% of this anchovey consumption was by shearwaters. Wiens and Scott calculated that the consumption of pelagic fishes by these four bird species populations within the neritic zone might represent as much as 22% of the annual production of these fish.

2) In a different vein, Wiens and Dyer (1977) conducted an analysis of the energy dynamics and food consumption patterns in granivorous bird populations in various parts of the World, especially in Europe. Here the emphasis was upon House and Tree Sparrows (Passer domesticus and P. montanus), and the results are not so relevant to the research proposed here as are the methods of gathering data. The analysis involved assembling data sets on Passer populations from separate investigators who had conducted field studies over a wide area in both Western and Eastern Europe. We collected the data by devising a

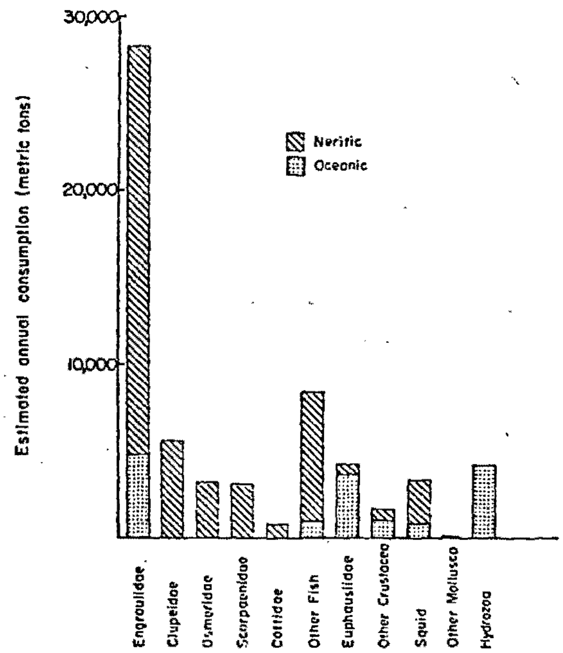


Figure 1. Estimated annual consumption of various prey by the four-species seabird community on the Oregon coast, derived from model estimates of energy demands and information on dietary composition. From Wiens and Scott (1975).

standardized data submission form that requested data from investigators in a form that was easily converted into input for model simulations. In all, 158 data sets from 13 countries were obtained and analyzed to determine local, regional, and continental patterns of energetics and food consumption in _Passer_ populations.

These two applications of the BIRD model demonstrate the ways in which it may be used in the proposed research. First, the model has been tested on marine bird systems, and has provided information that has revealed the significant magnitude of energy flow through coastal marine bird populations, and the consequent food consumption rates. Without such an analysis it is doubtful, for example, that we would have fully realized the importance of the transient shearwater populations in the dynamics of the ecosystem. Second, the _Passer_ applications demonstrates that the model may be turned to the analysis of large data sets gathered by different investigators, using different methods in different areas, and produce a common framework for integrating these separate studies. This is parallel to the challenge of integrating the many separate marine bird studies conducted within OCSEAP.

References:

Wiens, J.A., and M.I. Dyer. 1975. Simulation modelling of Red-winged Blackbird impact on grain crops. J. Appl. Ecol. 12:63-82.

Wiens, J.A., and M.I. Dyer. 1977. Assessing the potential impact of granivorous birds in ecosystems. _In_ Kendeigh, S.C., and J. Pinowski (eds.) Granivorous Birds in Ecosystems. Cambridge Univ. Press.

Wiens, J.A., and G.S. Innis. 1973. Estimation of energy flow in bird communities. II. A simulation model of activity budgets and populations bioenergetics. Proc. 1973 Summer Computer Simulation Conf. Montreal. pp. 739-752.

Wiens, J.A., and G.S. Innis. 1974. Estimation of energy flow in bird communities: A population bioenergetics model. Ecology 55: 730-746.

Wiens, J.A., and R.A. Nussbaum. 1975. Model estimation of energy flow in northwestern coniferous forest bird communities. Ecology 56:547-561.

Wiens, J.A., and J.M. Scott. 1975. Model estimation of energy flow in Oregon coastal seabird populations. Condor 77:439-452.

V. *Objectives:*

The objectives of this research project are to use simulation model analyses to estimate the energy demands and food consumption patterns of marine bird populations in the Bering Sea, emphasizing the dynamics of the Pribilof Island colonies. These analyses will use and synthesize existing data derived from field investigations of these populations to project the daily and seasonal patterns of energy demand and food consumption for major life stages of the dominant and/or most important bird species. In addition, new model structures will be developed to permit evaluation of spatial variations in these measures. These modeling efforts may then be applied, using the techniques of sensitivity analysis, to project the effects of varying baseline conditions of the environment and/or the populations on the patterns of energy demand and food consumption. These exercises will focus on alterations that might accompany environmental changes related to oil development, especially oil spills. Such analyses will serve to identify gaps in the existing knowledge of these marine bird systems and to specify species, time periods, or areas within the lease area that may be especially sensitive to oil development, or that may serve as indicators of environmental quality.

VI. *General Strategy and Approach:*

There are basically three phases of the proposed research, which are described here in decreasing order of time priority.

1) A general analysis of data gathered in studies on and about the Pribilof Islands will be conducted using the BIRD model in its present version. We will deal first with data collected at breeding colonies, because (a) the quality of these data is among the best of that available from OCSEAP studies, and thus we may have the greatest degree of confidence in results obtained from model simulations using these data; and (b) the dynamics of colonies are so important in considerations of continental shelf development, since it is the breeding colonies and attendant concentrations of seabirds that are more likely to be affected by oil development than the broadly-ranging pelagic populations. We will deal primarily with data gathered by Dr. George Hunt, of the University of California at Irving. Hunt's data sets are unusual in their completeness and thoroughness of detail, and a preliminary discussion has indicated that these studies can provide most of the critical input variables needed for model simulations (Table 1). More importantly, Dr. Hunt has expressed a keen desire to work closely with us on both initial model analyses of these data and on further development of modeling capabilities. Modeling using data gathered by other investigators is a sensitive business, and Hunt's willingness to cooperate fully is absolutely critical to this first phase of the research. I plan frequent direct consultations with Dr. Hunt during this initial phase of modeling to insure that the data are being properly interpreted and treated, and to develop ideas for subsequent extensions of the model.

While these colony studies will have the greates priority in the initial analyses of the Pribilof data sets, the studies will also be extended to include an initial analysis of representative pelagic transect census data taken in the

Table 1. Input variables for the BIRD model and a preliminary assessment of the availability and quality of data from Pribilof Islands seabird colony studies (Hunt, personal communication).

Input Variable	Units	Data Availability and Quality
Population at start of run	$indiv./Km^2$	Arbitrary
Population breeding density	$indiv./Km^2$	Values within ± 10%
Population at end of run	$indiv./Km^2$	Arbitrary
Immigration onset	Date	Good
Immigration completed	Date	Good
Adult emigration begins	Date	
Adult emigration ends	Date	Good for some species, less so for others
Juvenile emigration begins	Date	
Juvenile emigration ends	Date	
Onset of incubation	Date	
Incubation of last clutch started	Date	
Incubation period	Date	
Nestling period	Days	
Fledgling period	Days	Good
Proportion of females breeding	Percent	
Clutch Size	Number	
Hatching success	Percent eggs laid	
Fledging success	Percent nestling hatched	
Post-fledging survival	Percent indiv. fledged	No data
Adult body weight	Grams	Good
Weight at hatching	Grams	Good
Fledging weight	Grams	Moderate
Growth rate of young	--	Good
Wintering mortality	Percent	No data

Bering Sea. If enough data sets of sufficient quality are available, we may be able to construct "isoclines" of total marine bird energy demands over various sections of the Bering Sea, as they vary seasonally. Such initial analyses should be important in determining areas in which the birds appear to be energetically most closely linked to the marine system, or times at which the energy demands of seabirds may be especially critical. Both the analyses of the pelagic census data and the Pribilof colony data will produce estimates of energy demands and food consumption rates, as they vary through time.

2) A second phase of the research will involve the development of "second generation" versions of the BIRD model that will add spatial resolution to energy demands and food gathering, especially in relation to breeding colonies. As birds disperse from a colony location to obtain food, they fan out to differing distances from the colony, so that the dispersion of individuals with increasing distance from the colony is not a strictly decreasing linear function. Foraging birds tend to concentrate in areas of food availability that may be located at differing distances from the colony and that shift in abundance and location through time. It is important to consider such detail in modeling efforts, both because this allows greater precision in detecting areas or aspects of colony dynamics that are especially sensitive to perturbation, and because changes in the distances birds must fly to obtain food or in food availability to the colony directly influence individual energy demands, and thus the energy flow and food consumption of the population as a whole. Wiens and Dyer (1975) explored the spatial distribution of energy demand and food consumption from a population focal point (in this case, a roost) using the BIRD model, and that approach defines one development in the BIRD model that will be undertaken. This involves partitioning the area about a colony in concentric

radii of increasing distance (Figure 2A), and then evaluating energy and food demands for each zone separately, given a certain distribution of the birds over the zones (e.g., a Poisson). Preliminary extensions of the BIRD model in this fashion have also incorporated the capacities to effect changes in the distributions of the birds among the zones (or daily flight distances) as food availability in the zones changes due to consumption by the birds or other factors, and to consider the effects of different prey renewal rates for various prey types in each zone. Such efforts will form the foundation for our initial development of a "second generation" BIRD version specifically designed to simulate the spatial patterns of marine bird distribution about breeding colonies.

A second direction of development of the model also will consider spatial patterns, but by using a series of grid locations coded in the model storage rather than a set of concentric zones about the colony (Figure 2B). Prey availability in grids may be varied to influence the distribution of birds from the colony, and thus their energetics, or to portray the effects of consumption of localized food concentrations by the birds. This and the concentric zone version of the BIRD model will permit greater precision in model functions, and will introduce additional dynamics into the simulation model structure, as now we can consider complex interactions between food availability in space or other environmental conditions at sea and the energy and food demands of colonial breeders.

3) The real power of simulation models perhaps resides more in their potential as gaming tools than in their ability to generate estimates from data inputs. By manipulating the nature of data inputs, or of model functions, we may explore the consequences of a variety of "what if" questions. Essentially we will conduct "experiments" using the simulation powers of the models rather than undertaking cumbersome, costly, or perhaps impossible field manipulations

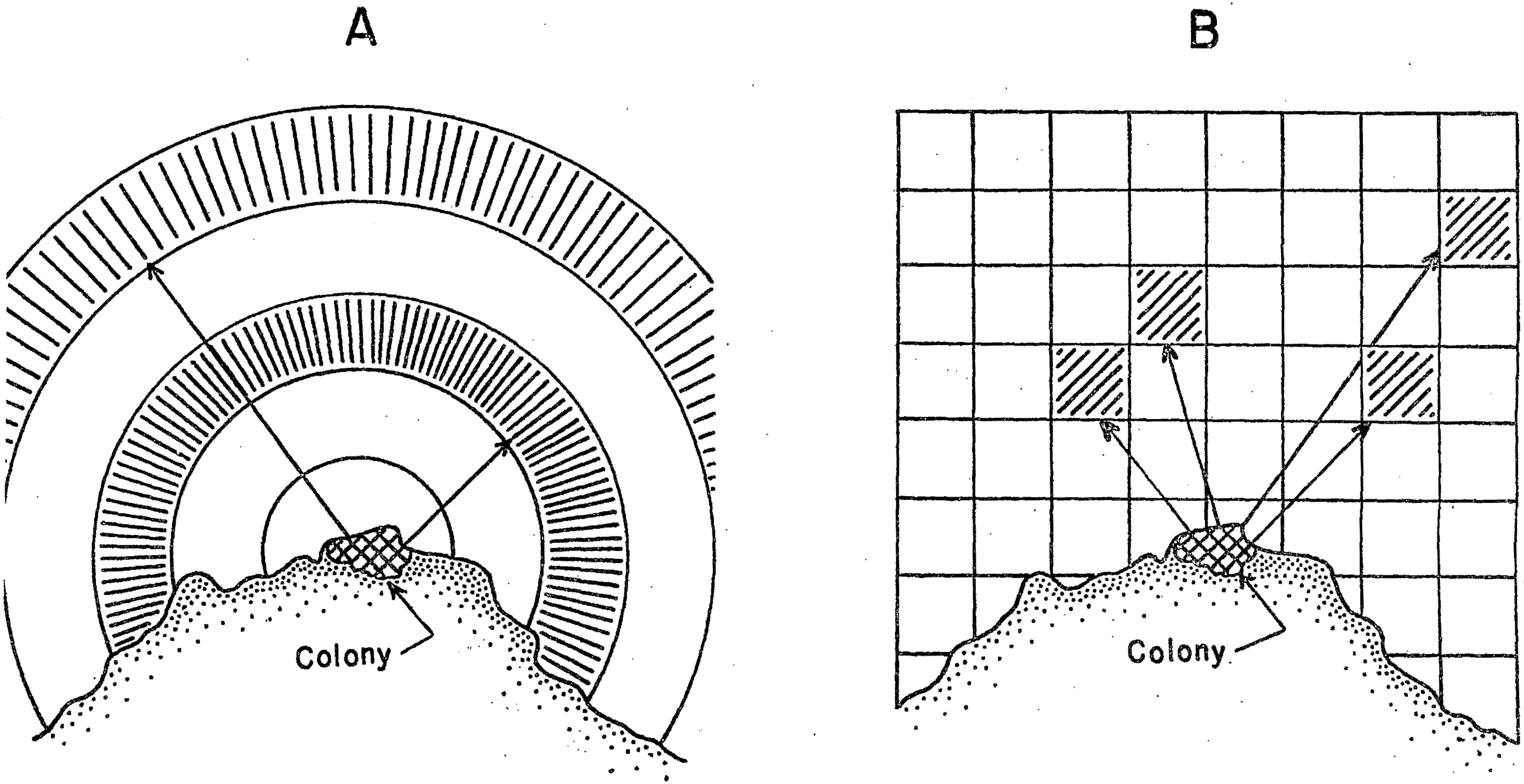


Figure 2. Two ways of modeling the spatial distribution of energy flow and food consumption about a seabird breeding colony. In A, birds disperse over concentric zones of increasing distance from the colony. In B, birds move to specific areas of food concentration to feed. Hatched areas represent feeding areas.

of the system. For example, what might be the effects on the energetics or food consumption rates of marine bird populations of changing the abundance or spatial distribution of food sources, or of increasing or decreasing the sizes of the bird populations, or of unusually good or poor reproductive seasons? We currently have no data and little in the way of intuition to guide us in predicting such effects, but by judiciously manupulating model input values or functions, the model can provide some initial approximations. There is some obvious potential in this approach. What if, say, there is a localized oil spill in a specified area about a breeding colony, which effectively removes an area of ocean from access for foraging? By setting food availability in such zones or grid blocks to zero in the second generation versions of the BIRD model, we can explore the influences of a wide array of potential combinations of oil spill events, oceanic conditions, food availabilities, and breeding colony sizes and compositions. Consultations with marine bird investigators and other scientists involved in the OCSEAP studies will guide us in undertaking the most appropriate simulation exercises of this sort, rather than pursuing absurdities.

This research also has a spin-off benefit, one that is often a feature of modeling efforts that are conducted in conjunction with ongoing field studies. The model analyses and simulations may indicate that certain measures, say at breeding colonies, are critical, while others are of lesser importance. Or the model results may suggest that certain areas or times are quite critical for marine bird energetics, while others are less so. Such information, combined with other objectives of the field studies, may be quite useful in pointing possible directions for these studies as they develop. It is therefore imperative that the results of model analyses be communicated quickly to field investigators, and that this communication is in fact a two-way process. Our initial contacts with George Hunt and other investigators in the Pribilof area will point the direction and reveal the most efficient mechanisms for such two-way communication.

References:

Wiens, J.A., and M.I. Dyer. 1975. Simulation modelling of Red-winged Blackbird impact on grain crops. J. Appl. Ecol. 12:63-82.

VII. *Sampling Methods:* This section is not applicable, since no new data will be generated by the project, other than computer simulation output.

VIII. *Analytical Methods:* The analyses of data sets are built into the model structure, and have been outlined above.

IX. *Anticipated Problems:* With any computer simulation study there are inevitably delays associated with computer program malfunctions. The first-generation version of the BIRD model is now operational on the system at Oregon State University, but the second-generation versions are not. Development of these versions is outlined in section XV. We will attempt to minimize programming delays by hiring a trained computer scientist as a Research Associate with the project.

X. *Deliverable Products:*

A. Digital Data: No new digital data will be gathered in this project. Instead, use will be made of existing data gathered by several OCSEAP investigations (see section XI) to run computer simulations. Implementation of these simulations will involve coding these data in a format appropriate for input to the BIRD model. This will be done by the staff of the project at Oregon State

University.

B. Narative Reports: Reports will provide detailed descriptions of the model, documentation of new computer programs developed, and analysis and interpretation of results based on various inputs to the model. Major information gaps and sensitivity of populations to environmental changes or oil spills will be discussed.

C. Visual Data: Visual displays or computer graphics will be submitted showing (a) areal and temporal changes in population densities and energy demands for major life stages of selected species or species groups; (b) daily energy demand for major life stages of selected species; and (c) effects of altering model constants or input variables on estimates of energy demands and population densities.

D. Other Non-Digital Data: None.

E. Data Submission Schedule: Not applicable, see section XV.

XI. *Information Required from Other Investigators:*

A project such as ours places great reliance on data gathered by other OCSEAP investigators. In particular, our efforts must be coordinated with the field studies of Dr. Hunt (R.U. 83), as described above, and with studies of a more general nature conducted by Dr. Lensink (R.U.s 337 and 341) and Dr. Divoky (R.U. 196). Information gathered during our own studies in the Gulf of Alaska (R.U. 108) will also contribute to model analyses. Efforts are already well underway to coordinate these activities with Dr. Hunt, and will be solidified with Drs. Lensink and Divoky prior to initiation of the project or shortly thereafter. The primary data required from these investigators will relate to the input variables listed in Table 1, but theircommentary on model structure and development will also be solicited.

XII. *Quality Assurance Plans:*

Not applicable to this project.

XIII. *Special Sample and Voucher Specimen Archival Plans:*

Not applicable to this project.

XIV. *Logistics Requirements:*

The project will require no special logistic arrangements. One field trip will be made by the Principal Investigator to the Pribilof Island colonies in spring 1978. Arrangements for air transportation to the area and support while in the area will be made from Oregon State, through consultation with Dr. Hunt. The necessary funds are included in the budget (section D).

XV. *Management Plan:*

All modeling activities will be coordinated at Oregon State University. It is difficult in any modeling effort to construct a precise schedule (computers have a funny way of misbehaving), but the project should approximate the following schedule:

October 1977 - February 1978: Gather data for Pribilof analyses; confer with Hunt; conduct general model analyses; initiate construction of second generation models

February 1978 - June 1978: Complete and test second generation models; confer with Hunt; visit Pribilof colonies; prepare interim report, emphasizing possible data needs and directions for ongoing field studies; analyze pelagic census data

June 1978 - September 1978: Conduct gaming exercises with models and additional analyses using recently-gathered data; establish priorities and plans for extension of application to other OCS areas; prepare final report and publications.

The approximate scheduling of these activities is summarized in the following Milestone Chart.

XVI. *Outlook:*

Emphasis during FY 78 will be placed on the three phases of simulation modeling outlined above. Two additional directions of model development may follow these initial efforts, however. What has been described above deals with energy demands and the proximate effect upon energy demands and food consumption of various environmental conditions. But environmental changes that influence energy or food availablity have secondary and perhaps more profound effects upon the reproductive biology of seabirds. We have not emphasized such effects in our initial modeling exercises because to do so necessitates making a great many more assumptions in structuring the model. Nonetheless, it is surely possible to modify the model to incorporate feedback effects of energy or food availability, or of energy balance of adults, on the reproductive success or growth of young in colonies. Secondly, it has been suggested by several workers that marine birds may play a critical role in recycling nutrients in Arctic and Subarctic oceanic waters, by diving to capture prey from depths below the mixed layer and depositing excrement on the ocean surface or at colony locations. Nutrient flow relations are closely coupled with energy flows, and by using approximations of the nutrient levels of prey and the efficiencies of metabolic processing of these elements by the birds, we may obtain some preliminary estimates of the quantitative magnitude of this recycling function

Beyond this, the model structures developed during FY 78 may be applied to the analysis of information gathered in field studies conducted by other OCSEAP investigators during FY 78. They may serve as a valuable aid in planning continuing studies by these investigators, as well as enabling us to define more precisely the energy and food consumption parameters of interest. Finally, once developed and successfully applied in the St. George Basin lease area, this modeling approach may in following years be extended to parallel analyses of other lease areas.

It is difficult to define the milestones and cost requirements for continuation of a project such as this. Extension to other lease areas would likely involve a 12 to 18 month time period to complete data gathering and analysis for 1-2 lease areas at a time, with an annual cost of perhaps $65,000. Such continuing efforts should require no additional equipment or entail additional logistics requirements, other than transportation to survey primary study areas to develop the biological intuitions necessary to interpret model outputs.

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 schedules 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

RU #: 108 PI: John A. Wiens

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		
Develop data inputs for Pribilof analyses	—	—	—	—	△												
Confer with other investigators; visit field sites.	—		—	—			—	—			—						
Conduct initial model analyses		—	—	—	—	△											
Develop second generation models				—	—	—	—	—	△								
Conduct second generation model analyses							—	—	—	—	△						
Gather data and analyze pelagic censuses						—	—	—	—	△							
Conduct additional model simulations										—	—	△					
Report preparation			△			△			△			△	—	—	△		

△ Planned Completion Date △ Actual Completion Date

Publications:

A. Scientific Papers and Books

1963 Aspects of Cowbird parasitism in southern Oklahoma. Wilson Bull., 75: 130-139.

1965 Nest parasitism of the Dickcissel by the Yellow-billed Cuckoo in Marshall County, Oklahoma. Southwest. Nat., 10: 142.

1965 Behavioral interactions of Red-winged Blackbirds and Common Grackles on a common breeding ground. Auk, 82: 256-274.

1965 The Dickcissel invasion of 1964 in southern Wisconsin. Passenger Pigeon, 27: 51-59 (Junior author, with John T. Emlen).

1966 Notes on the distraction display on the Virginai Rail. Wilson Bull., 78: 229-231.

1966 A specimen of the Vermilion Flycatcher from Oklahoma. Condor, 68: 398.

1966 Post-invasion status of the Dickcissel in southern Wisconsin. Passenger Pigeon, 28: 63069. (Senior author, with John T. Emlen)

1966 On group selection and Wynne-Edwards' hypothesis. Amer. Sci., 54: 273-287

1967 An instrument for measuring light intensities in dense vegetation. Ecology, 48: 1006-1008.

1969 An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr., 8: 1-93.

1970 Metronome timing in behavioral ecology studies. Ecology, 51: 350-352. (Senior author, with S. G. Martin, W. R. Holthaus, and F. A. Iwen).

1970 The water economy of the Sage Sparrow, Amphispiza belli nevadensis. Condor, 72: 265-175. (Junior author, with Ralph R. Moldenhauer).

1970 Effects of early experience on substrate pattern selection in *Rana aurora* tadpoles. Copia, 1970: 543-548.

1970 Habitat heterogeneity and avian consumer populations in grasslands. In Coupland, R. T., and G. M. Van Dyne (eds.). Grassland Ecosystems: Reviews of Research (proc. September 1969 Meeting PT Grasslands Working Group, International Biological Programme, Saskatoon and Matador. Saskatchewan, Canada). Range Sci. Dept. Sci. Ser. No. 7, Colorado State Univ., Ft. Collins, pp. 77-83.

1971 "Egg-dumping" by the Grasshopper Sparrow in a Savannah Sparrow nest. Auk, 88: 185-186.

1971 Pattern and process in grassland bird communities. In French, N. R. (ed.). Preliminary analysis of structure and function in grasslands. Range Sci. Dept. Sci. Ser. No. 10, Colorado State University, Ft. Collins. pp. 147-211.

1972 Ecosystem structure and function. (Book) Editor. Oregon State Univ. Press, Corvallis. 187 pp.

1972 Anuran habitat selection: Early experience and substrate selection in Rana cascadae tadpoles. Anim. Behav., 20: 218-220.

1973 Interterritorial habitat variation in Grasshopper and Savannah Sparrows. Ecology 54: 877-884.

1973 Pattern and process in grassland bird communities. Ecol. Monogr., 43: 237-270.

1973 Estimation of energy flow in bird communities. II. A simulation model of activity budgets and population bioenergetics. Proc. 1973 Summer Computer Simulation Conf., Montreal. p. 739-752 (Senior author, with G. S. Innis).

1973 Application of an avian bioenergetics simulation model to Redwinged Blackbird - crop relations. Proc. 6th Bird Control Seminar, Bowling Green, Ohio. p. 139-163 (Senior author, with M. I. Dyer).

1974 Estimation of energy flow in bird communities: A population bio-energetics model. Ecology 55: 730-746. (Senior author, with G.S. Innis).

1974 Habitat heterogeneity and the structure of avian communities in North American grasslands. Amer. Midl. Natur. 91: 195-213.

1974 Climatic instability and the "ecological saturation" of bird communities in North American grasslands. Condor 76: 385-400.

1975 Organochlorine levels associated with a common murre die-off in Oregon. J. Wildl. Mgmt. 39: 310-320 (Second author, with J. M. Scott and R. R. Clayes).

1975 Model estimation of energy flow in Oregon coastal seabird populations. Condor 77: 439-452. (Senior author, with J. M. Scott).

1975 Simulation modeling of blackbird impact on grain crops. J. Appl. Ecol. 12: 63-82. (Senior author, with M. I. Dyer).

1975 Model estimation of energy flow in northwestern coniferous forest bird communities. Ecology 56: 547-561. (Senior author, with R. A. Nussbaum).

1975 Rangeland avifaunas: Their composition, energetics, and role in the ecosystem. Proc. Symp. Mgmt. Forest and Range Habitats for Nongame Birds. USDA Forest Service, General Technical Report WO-1: 146-182. (Senior author, with M. I. Dyer).

1975 Avian communities, energetics, and functions in coniferous forest habitats. Proc. Symp. Mgmt. Forest and Range Habitats for Nongame Birds. USDA Forest Service, General Technical Report WO-1: 226-265.

1976 A method for estimating species dispersion from transect data. Amer. Midl. Natur. 95: 69-78. (Junior author, with J. T. Rotenberry).

1976 A conceptual model of diet selection as an ecosystem process. J. Theoret. Biol. 60: 93-108. (Second author, with J. E. Ellis, C. F. Rodell, and J. C. Anway).

1976 Population Responses to Patchy Environments. Ann. Rev. Ecol. Syst. 7: 81-120.

in press On Competition and Variable Environments. Amer. Sci.

in press Impact on granivorous birds on ecosystem. In Kendeigh, S. C., and J. Pinowski (eds.). Granivorous birds in ecosystems. Cambridge Univ. Press. (Senior author,with M. I. Dyer).

in press Adaptive strategies of granivory. In Kendeigh, S. C. and J. Pinowski (eds.). Granivorous birds in ecosystems. Cambridge Univ. Press. (Senior author, with R. F. Johnston).

in press Nongame bird communities in Northwestern Coniferous Forests. Proc. Workshop Nongame Bird Habitat Mgmt. in Conif. Forests West. U.S. USDA Forest Service Rept.

in press Nongame bird communities in Northwestern Rangelands. Proc. Workshop Nongame Bird Habitat Mgmt. In Conif. Forests West. U.S. USDA Forest Service Rept. (Junior author, with J. T. Rotenberry).

in press Concluding Remarks. In Pitelka, F. (ed.). Shorebirds in Coastal Ecosystems

submitted Wiens, J.A. and M.I. Dyer. Blackbirds, corn, and models. Natur. Hist.

submitted Wiens, J.A. Model estimation of energy flow through breeding bird communities in North American grasslands. Oecologia.

(the following manuscripts are in preparation)

Wiens, J.A. and J.T. Rotenberry. In prep. Patterns of eco-morphological variation in grassland birds. Auk

Wiens, J.A. and J.T. Rotenberry. In prep. Trophic relationships among grassland birds. Condor

B. Technical Research Reports:

1970 Avian populations and patterns of habitat occupancy at the Pawnee site, 1968-1969. U.S. IBP Grassland Biome Tech. Rept. No. 63, 47 p.

1971 Avian ecology and distribution in the Comprehensive Nework, 1970. U.S. IBP Grassland Biome Tech. Rept. No. 77, 49 pp.

1972 Predictability of patterns and variability of precipitation in grasslands. U.S. IBP Grassland Biome Tech. Rept. No. 168, 23 p.

1974 BIRD Model description and documentation. U.S. IBP Grassland Biome Tech. Rept. No. 246, 133 p.

1974 Dietary relationships among breeding bird populations at U.S. IBP Grassland Biome sites, 1970. IBP Grassland Biome Tech. Rept. No. 262, 92 p.

1974 Avian populations at Ale, Pantex, Osage, and Cottonwood, 1972. U.S. IBP Grassland Biome Tech. Rept. No. 267, 107 p.

C. Reviews, Published Abstracts, etc.:

1965 A physionomically-based system for describing grassland habitats, with special reference to grassland birds (Abstract). Bull. Ecol. Soc. Amer., 46: 199.

1967 Ecological relationships among the breeding birds of a southern Wisconsin grassland and community (Abstract). Bull. Ecol. Soc. Amer., 48: 61.

1968 "A hybrid discipline" (Reviews of Hirsch, "Behavior-Genetic Analysis") BioScience, 18: 143.

1968 "African Birds" (Review of Moreau, "The Bird Faunas of Africa and its Islands"). BioScience, 18: 449.

1968 "Predators" (Review of Errington, "Of Predation and Life"). BioScience, 18: 740-741.

1968 "Evolution" (Review of Dunbar, "Ecological development in Polar Regions: a study in Evolution"). BioScience, 18: 903-904.

1969 "Review Feature" (Review of Lack, "Ecological Adaptations for Breeding in Birds"). BioScience 19: 1123.

1970 "Behavioral Ecology" (Review of Klopfer, "Habitats and Territories: A Study of the Use of Space by Anaimals"). BioScience 20: 122-1223.

1970 Habitat heterogeneity and the structure of avian communities in grasslands (Abstract). Bull. Ecol. Soc. Amer., 51(2): 29.

1970 Early experience and substrate pattern selection in _Rana aurora_ and _R. cascadae_ tadpoles. (Abstract). Amer. Zool., 10: 290.

1971 "Ecosystem: 'Review of Van Dyne, "The Ecosystem Concept in Natural Resource Management"). BioScience, 21: 248.

1971 Pattern and process in grassland bird communities (Abstract). Bull. Ecol. Soc. Amer., 52: (Invited Symposium Paper).

1971 Patterns of inter-territorial habitat variation in grassland birds. (Abstract). Bull. Ecol. Soc. Amer. 52:

1972 An avian population energetics model. Southwestern Rock Mtn. Division AAAS.

1973 Estimation of energy flow in bird communities. II. A Simulation model of acitivty budgets and population bioenergetics. 1973 Summer Computer Simulation Conference (invited paper).

1973 Five articles on Ethology in the World Book.

1974 Two articles on Ethology in the World Book.

1974 Review of Fretwell, S.D. "Populations in a seasonal environment". Auk 91: 204-207.

1974 Review of May, R.M. "Stability and complexity in model ecosystems". Auk 91: 645-646.

1975 Review of "Populations Ecology of Migratory Birds". Wilson Bull. 87: 566-567.

1976 Reivew of Cody, M.L. "Competition and the structure of bird communities Auk 93: 396-400.

1976 Review of Williams, G.C. "Sex and Evolution." Auk 93: 865-866.

1977 Review of Gilpin, M.G. "Group selection in predator-prey communities." Auk 94: 177-178.

D. Theses Directed:

Anderson, S.H. 1968. The avifaunal compostion of Oregon White Oak stands. M.A.

Moldenhauer, R.R. 1969. The water economy of the Sage Sparrow, *Amphispiza belli nevadensis* (Redway). Ph.D.

Gibson, F. 1969. A Behavioral analysis of the American Avocet (*Recurviros americana*). M.S.

Kroodsma, D. E. 1972. Singing behavior of the Bewick's Wren: Development, dialects, population structure, and geographical variation. Ph.D.

Rotenberry, J.T. 1973. A method for estimating species dispersion from transect data. M.S.

Scott, J.M. 1973. Resource Allocation in four synoptic species of marine diving birds. Ph. D.

States, J.B. 1974. Local adaptations in chipmunk (*Eutamias amoenus*) populations and evolutionary potential at species borders. Ph.D.

Technical Proposal Form

I. Gulf of Alaska Shelf Circulation
RU 138
Contract Number:
Proposed Dates of Contract: 1 October 1977 - 30 September 1978

II. Principal Investigators:

Dr. S. Hayes
Mr. R. Charnell
Dr. J. Schumacher
Dr. R. Muench
Dr. H. Mofjeld

III. Cost of Proposal:

Total $449,600
Distribution of Effort by Lease Area: 44% Lower Cook Inlet
22% NEGOA
17% Western GOA
17% Kodiak Island

IV. Background

1. Coordination With Other RUs:

The current meter measurements in the Western Gulf of Alaska Shelf, Kodiak Island, and Lower Cook Inlet experiments will be coordinated with Dr. Royer's (RU 289) CTD operations to provide a data base from which geostrophic components may be deduced. Observed currents and density distribution will be available for Dr. Galt's (RU 140) modeling efforts.

Deployment of transponding drifter buoys in Lower Cook Inlet will be coordinated with measurements of surface currents using Doppler shift radar (RU 48). Spatial and temporal flow variability will be related to geological experiments conducted under RU 327 and to meteorological studies (RU 367).

Drift card and seabed drifter studies in the Kodiak Island region will be coordinated with surveys conducted under RU 341.

2. Relation to Previous Research:

A. Lower Cook Inlet: As a result of the Lower Cook Inlet Synthesis Workshop (November 1976) and subsequent discussion, culminating in the March 1977 Anchorage meetings, it is evident that circulation patterns and prevailing meteorology in this region are not understood to the level of detail required to make reliable predictions of transport of contaminants introduced by OCS development. We will undertake a broad scope physical oceanography/meteorology program to improve understanding of transport process in Lower Cook Inlet.

B. Kodiak Island: As presented at the Kodiak Island Synthesis Meeting (March 1977) and described in the 1977 Gulf of Alaska Anjual Report (RU 138), there is a distinct change in velocity field characteristics between shelf-break current records and those records from moorings on Northern Albatross Bank. Further, recent current records from Southern Albatross Bank (located adjacent to a trough) indicated a tendency for flow to be along the trough. These preliminary results tend to confirm Dr. J. Galt's model results as presented at the Physical Oceanography and Meteorology PI Workshop at Union, Washington (May 17-19, 1977). It appears that the Alaskan Current exerts little influence on Kodiak Island shelf flow, particularly in the mid-shelf to nearshore region. Dr. Galt's modeling effort implied that coastal flow was generated under specific wind stress conditions, with communication between nearshore and shelf break regions occuring through the troughs.

C. Mitrofania Island Shelf: As part of the study of the flow field west of Kodiak Island, we propose an experiment in the vicinity of Mitrofania Island. This region was chosen in order to test the general applicability of the Icy Bay (NEGOA) process experiment results. The continental shelf near Mitrofania is broad (120 km) and relatively deep (100 m). The flow field will be influenced by local winds, the Alaska Stream, local bathymetry and the complex circulation associated with Shelikof Strait. Implementation of this experiment during the FY 78 field year will permit correlations to be made with the upstream flow by using the data collected by the relatively detailed Kodiak Island experiment. Additional complications induced by the Shelikof Strait - Kodiak Island flow, the different wind regime, and the more complex offshelf flow associated with the separation of the Alaskan Stream makes the Mitrofania area fruitful intercomparison with the Icy Bay area.

D. Northeast Gulf of Alaska (NEGOA): No new field work is proposed for this region. The previous research resulted in a large volume of current meter, pressure gauge, and CTD data. Preliminary results from the analysis of the these data have been presented at OCSEAP Principal Investigator meetings, synthesis meetings, and at national scientific conferences. However, much analysis remains. The research effort for FY 78 will concentrate on this analysis with the goal being a final report in September, 1979.

V. Objectives: The general objective of the proposed program is to characterize circulation patterns with emphasis on determining the likely distributions of water-borne contaminants. Specific objectives are:

A. Lower Cook Inlet:

(1) To relate observed and computed over-the-water winds to direct observations of currents.
(2) To correlate surface currents obtained by Lagrangian techniques with subsurface Eulerian measurements.
(3) To relate surface currents obtained by Doppler radar techniques to Lagrangian surface current measurements.
(4) To characterize temporal and spatial variability in the flow field including flows through the Barren Islands and upper Shelikof Strait as a function of season (winter/summer).

B. Kodiak Island:

(1) To examine flow in the troughs and banks off Kodiak Island and on the shelf downstream from Shelikof Strait using current meters, surface drift cards, seabed drifters and density data.
(2) To characterize temporal and spatial variability in the flow field as function of season (summer/winter).
(3) To relate observed and computed surface winds to observed currents.
(4) To determine spatial variability of tidal currents.
(5) To characterize seasonal distribution of density.

C. Mitrofania Island:

(1) To examine correlations between observed currents, meteorological parameters and sea level variations.
(2) Determine influence of bathymetry on the flow.
(3) Examine local and non-local forcing.
(4) Relate Icy Bay results to this new area in order to test their general applicability.

D. NEGOA:

(1) Continue analysis of data from FY 76 and FY 77 in order to:

(a) Interrelate bottom pressure gradients, currents, and wind measurements.
(b) Investigate importance of topographic, tidal, local and non-local forcing upon the current regime in the Northeast Gulf.

2) Summary and synthesis the results of the analysis into a final report.

VI. General Strategy and Approach: To make direct observations that yield current meter, pressure gauge, surface drift card, seabed drifter, radar tracked drifter and CTD data to characterize general circulation. Since the inception of the Gulf of Alaska OCSEAP program in 1974, an immense quantity of physical oceanographic data has been accrued. For example, there have been approximately 5,000 days of usable current meters and 3 pressure gauges in the water (these will be in continuously through FY 77). Some of these data have been presented in reports and publications which have had a pronounced impact on the scientific knowledge of this region; however, the majority of data has not been analyzed nor interpreted fully. Thus, the primary task during FY 78 will be and analysis and interpretation, and synthesis of data collected through FY 76 and FY 77, concomitant with the proposed experimental program (see VII for details).

VII. Sampling Methods:

A. Lower Cook Inlet: The sampling program in Lower Cook Inlet, including Kennedy and Stevenson entrances and northern Shelikof Strait, utilizes moored current meters, shore-mounted sea surface level gauges and CTD grids to study aspects of the regional circulation. Specifically:

(1) Moorings C1 - C7 address circulation details in the low energy region of Lower Cook Inlet, and provide information on net in- and outflow:

(2) Moorings C8 - C10 address the net flow through Kennedy and Stevenson entrances and Shelikof Strait;

(3) Mooring C11 is primarily for support of the geological programs investigating sedimentation in the gyre off Kachemak Bay;

(4) The shore-mounted sealevel gauges will, in conjunction with wind driven data from the environmental buoy and regional NWS stations, aid in interpreting regional flow dynamics; and

(5) The CTD data will aid in determining baroclinic vs. barotropic flow.

The two mooring periods bracket winter and summer to allow detection of seasonal variation. CTD data will be obtained at the beginning and ending of each mooring period, and about 150 stations will be occupied in Lower Cook Inlet. The grid will be most concentrated in the vicinity of moorings C1 - C7 to clarify details in the relatively complex density field there. An interim CTD cruise is required, during peak runoff (mid-July) and should be undertaken by a NOAA ship.

B. Kodiak Island: The locations for moored arrays are shown in Figure 1. Arrays K6 to K13 are part of the Kodiak Island experiment. Array K6 was located to measure cross-shelf flow, possible shoreward flow associated with the Alaskan Current, and to provide continuity with measurements from the Barren Islands. Arrays K7 to K9 will be equipped with bottom pressure gauges to examine cross-shelf sea level slope. Current records from these arrays will be used to characterize the cross shelf velocity field. Array K7 was located to measure possible wind driven near-coastal flow. Current records from K8 and K9 address cross-shelf flow and provide longshelf coherency length scale information when compared to K10. Current records from arrays K11 - K13 will provide information regarding outlflow from Shelikof Strait and velocity characteristics upstream from the Mitrofania Island regional experiment. CTD data will be collected at approximately 150 stations in this experiment to aid in determining baroclinic flow components, to define the seaward edge of the Alaskan current, and to define water masses. Moored arrays and CTD operations will be conducted on a seasonal basis, with the CTD stations being occupied after deployment and prior to recovery. Additionally, about 3000 seabed drifters and 5000 surface drift cards will be released at mid-shelf sites during the June 1978 CTD cruise. Interim CTD cruises are required (during January and July 1978) and should be undertaken either by Dr. T. Royer (RU 289) or via a NOAA ship.

C. Mitrofania Island: Arrays M1 to M4 comprise the Mitrofania Island experiment. Each array will be equipped with a bottom mounted pressure gauge in addition to current meters. Arrays M2 to M4 will provide cross-shelf pressure and velocity gradient information. Array M1 will provide along-shelf flow and pressure gradient data. Three CTD lines consisting of about 25 stations each are proposed: (1) perpendicular to the coast over M1 and extending to 1500 m depth (2) across arrays M2 to M4, and (3) midway between lines 1 and 2. Station spacing will be approximately 5 km on the shelf to resolve complex flow associated with Shelikof Strait, and will expand to 10 km seaward of the shelf break.

VIII. Analytical Procedures

N/A

IX. Anticipated Problems

N/A

X. Products:

1. Digital Data:

A. All current meter, CTD, and pressure gauge data will be in digital form for submission to OCSEAP in approved format on processed data tapes, using formats 015, 022 and 017 respectively. Digital data will include dates, times, release/recovery points and intermediate points for surface drifter trajectories.

B. See attached Data Products Schedule

C. Narrative reports will be provided containing a description of mooring locations; measurement and analysis techniques; sampling frequency and duration. The reports will include the results of statistical analyses of the current meter and pressure gauge records and, to the extent permitted, a description of regional circulation patterns. The report will also contain interpretation and analysis of drift card/sea bed drifter recoveries leading to inferences on nearshore current patterns as related to local weather conditions and supporting oceanographic data. The report for Cook Inlet will also describe thr eelationship between the regional meteorology, river discharge and seasonal circulation patterns.

D. Visual Data: As appropriate, the following types of visual data may be included in the <u>Narrative Report</u>.

- Time plots of filtered current meter and pressure gauge data showing both tidal and non-tidal velocity and pressure fluctuations.
- Progressive vector diagrams.
- Scatter Plots.
- Energy density spectra.
- Plots showing coherence between wind, corrected sea level and currents.
- Charts showing release, intermediate and recovery points, with inferred drifter trajectories.

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)
Current Meter	Tape	250 months	File Type 015	Yes	10/77 to 3/78	6/78
Current Meter	"	200 months	"	"	5/78 to 9/78	12/78
Pressure Gauge	"	20 months	File Type 017	"	10/77 to 3/78	6/78
CTD	"	300 stations	File Type 022	"	10/77	1/78
CTD	"	"	"	"	3/78	6/78
CTD	"	250 stations	"	"	5/78	8/78
CTD	"	"	"	"	9/78	12/78
Transponding drifter	"		N/A			

MILESTONE CHART

RU #: 138 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		
Submit CTD data from LEG VI												Δ					
Submit Final Report for NEGOA studies												Δ					
Submit CTD data from LEG VII															Δ		
Submit current/pressure data from LEG VIII															Δ		

- Seasonal maps of tidal and non-tidal circulation patterns as functions of depth (in Cook Inlet).

- Maps showing seasonal distributions of water properties in Cook Inlet.

- Maps of bathymetry (in Cook Inlet).

E. Other Data: Aerial photographs of surface and recovery sites.

F. Data Submission Schedule: see Data Products Schedule.

XI. Information Required from Other Investigators

Close coordination will be carried out with D. Hansen (AOML), T. Royer (UA), J. Galt (PMEL), R. Reynolds (PMEL), D. Barrick (RU 48), and personnel from RU 341.

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. Exact locations will be furnished for Project Instructions.

3. Optimum chronology of observation is given in TABLE I.

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 (given no problems). CTD work may be undertaken any time, typical on station time is 15-20 minutes. Deployment of 4 nearshore pressure gauges (Lower Cook Inlet) will require a skiff and could take several hours each.

6. Standard electronic testing equipment, CTD system, 7-track digital tape recorder, salinometer, Nansen Bottles, reversing thermometers, Survey Technicians and deck crew (for array deployments).

7. Anchors for the Western Gulf experiment will be railroad wheel tripods (up to 2,700 lbs.), the remaining arrays will be concrete anchors (1 cubic yard, 3,700 lbs.). Subsurface flotation will be either 28 or 41 inch spheres.

8. No.

9. No.

10. Yes. NOAA, for moorings DISCOVERER is recommended.

11. N/A

12. Two people. Participants for LEGS Ia, Ib and II be:

LEG Ia: Chief Scientist, C. Pearson, NOS/PMEL: W. Parker, ET
LEG Ib: " " " " " "
LEG II: Chief Scientist, J. Haslett, PMEL

B. AIRCRAFT SUPPORT - FIXED WING N/A

C. AIRCRAFT SUPPORT - HELICOPTER: When helicopter operations are in Kodiak Island area, will use crew on a not to interfere basis to look for drifters.

D. QUARTER AND SUBSISTANCE SUPPORT - N/A

E. SPECIAL LOGISTICS SUPPORT - N/A

XV. Management Plan: (see attached Milestone Chart)

PIs will maintain a management plan which is an extension of that used in FY 77 work. Additionally, R. Charnell will function as OCSEAP Program Manager for PMEL and will be the focus for program management.

XVI. Outlook:

A. Lower Cook Inlet. Should the field program be successfully completed (September 1978), the program for FY 79 will be devoted primarily to data analysis and interpretation. Some field work may be required; however, such work would likely be on a much reduced scope.

B. Kodiak Island. The proposed FY 78 program in this region is a preliminary experiment on a bathymetrically complicated shelf. We anticipate that additional field operations may be required in FY 79 on a similar level to those presently preposed.

MILESTONE CHART

RU #: 138 PI: ______

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			
LEG Ia, Ib, II: array deployment and CTD	H																	
PI Workshop	H																	
Submit CTD data from LEG II				Δ														
FY 78 1st Quarter Report			Δ															
LEG III: CTD						H												
LEG IV: Array recovery						H												
FY 78 Annual Report						Δ												
LEG Va, Vb: Array deployment									H									
Submit CTD data from LEG III									Δ									
Submit Current meter/Pressure gauge data from LEG IV									Δ									
LEG VI: CTD operations										H								
FY 78 3rd Quarter Report									Δ									
LEG VII: CTD operations												H						
LEG VIII: mooring recovery												H						
FY 78 4th Quarter Report												Δ						

TABLE I

LOGISTICS REQUIREMENTS

LEG	DATE	DAYS	OPERATION
Ia	3 (Kodiak) - 8 (Kodiak) Oct. 77	6	Deploy ten current meter arrays & 5 bottom pressure gauge arrays in Lower Cook Inlet Shelikof Strait and Barren Islands region.
Ib	10-18 (T/G at Kodiak) Oct. 77	9	Deploy eleven current meter arrays (seven arrays include pressure gates) on Kodiak Island Western Gulf of Alaska shelf.
II	19 Oct - 2 Nov 77	15	Occupy approximately 250 CTD stations in Lower Cook Inlet Kodiak shelf and Western Gulf.
IV	15-29 Mar. 78	10	Recover all arrays deployed in October
III	3-18 Mar	15	Occupy all CTD stations
Va	14-19 May	6	Same operation as LEG Ia
Vb	22-30 May	9	Deploy Kodiak Island and Lower Cook Inlet arrays
VI	1-15 Jun	15	Same as LEG II
VII	1-15 Sep	15	Same as LEG II
VIII	18-28 Sep	11	Same as LEG IV

C. Mitrofania Island. As above, this experiment is exploratory in nature and may require additional field work in FY 79.

D. NEGOA. The program will be completed for this region upon submission of a NEGOA Final Report (planned date, September 1978).

E. New field efforts. Upon successful completion of this proposed research, data will be available for analysis and interpretation throughout the proposed Gulf of Alaska lease sites with the exception being the shelf region west of the Shumagin Islands. We recommend that in FY 79 field operations be initiated on the shelf off Unimak Island and that flow through Unimak Pass should be investigated. The latter objective would provide information regarding continuity of the general circulation between the western Gulf of Alaska and Bristol Bay (RU 141). We estimate that required funding for the entire FY 79 program will be similar to FY 78, with emphasis on analysis and interpretation.

XVII. 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. 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."

11. Cost Proposal (see attached form)

Other Information:

a) The principal investigators and PMEL have had considerable experience in Alaskan Oceanographic investigations. In particular, the same team of individuals that designed and carried out the first two years of field effort for OCSEAP will continue the program for FY 77.

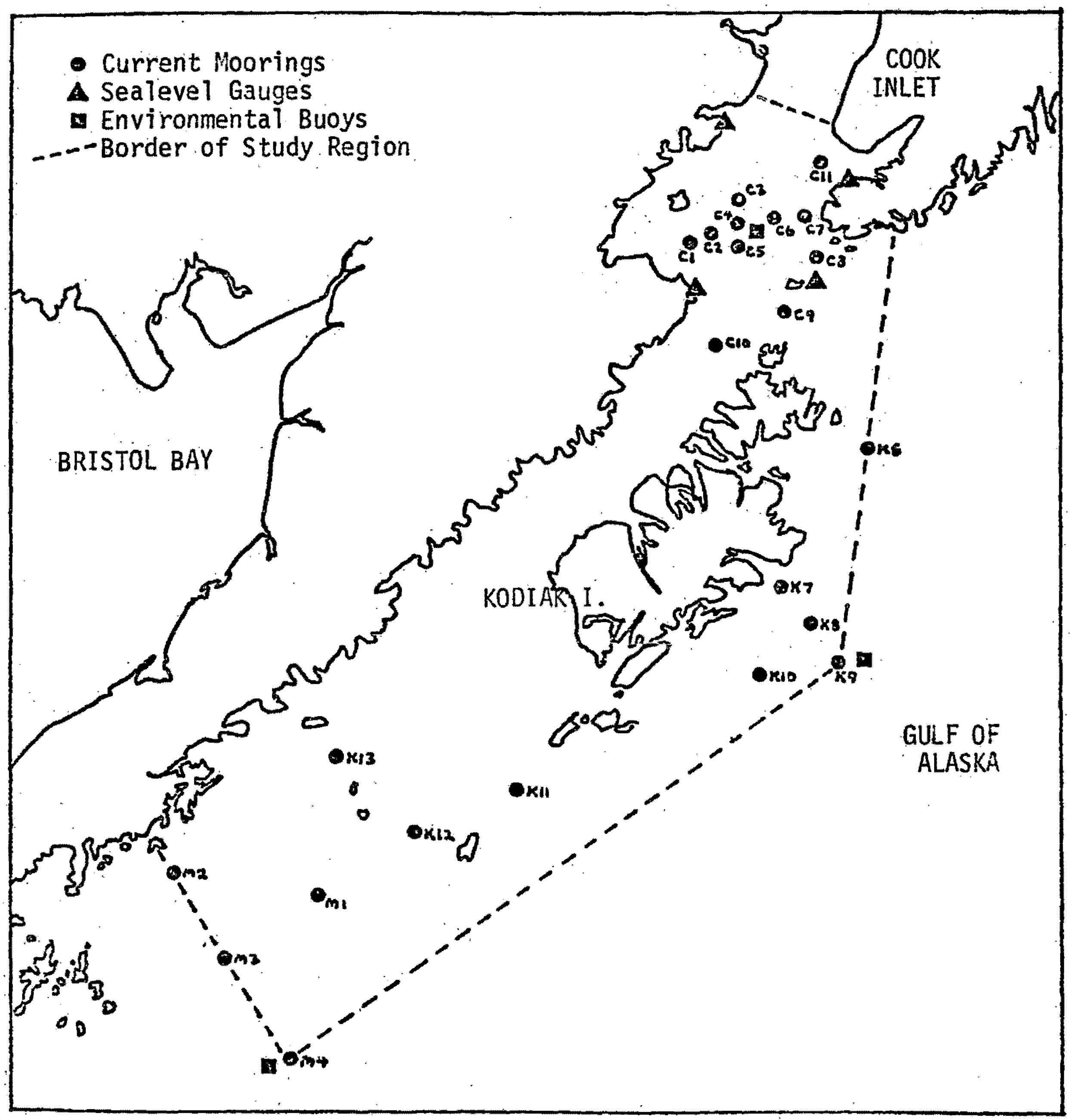
b) The principal investigator shall actively lead and supervise the proposed work and shall take full responsibility for timely completion of all tasks described herein.

c) The persons, other than PIs, who will take an active part in the program are:

D. Pashinski, PMEL
C. Pearson, NOS
G. Krancus, NOS
R. Sillcox
S. Raaum, NOS
J. Haslett, PMEL
M. Grigsby, PMEL

Persons authorized to conduct negotiations are:

PMEL - J. R. Apel (FTS 399-4079)
R. L. Charnell (FTS 399-1960)


Current Moorings
Sealevel Gauges
Environmental Buoys
Border of Study Region
COOK INLET
BRISTOL BAY
KODIAK I.
GULF OF ALASKA

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

PACIFIC MARINE ENVIRONMENTAL LABORATORY
3711 - 15th Avenue Northeast
Seattle, Washington 98105

Date: August 4, 1977

To: Herbert E. Bruce, OCSEAP Project Manager, Juneau

JDS

From: Jim D. Schumacher, Research Oceanographer, PMEL, Seattle

Subject: Research Unit 138

This memo contains revisions to the FY 78 renewal proposal (RU 138) as requested in your letter (27 July 1977) and should be appended thereto.

1. Our proposed drift card study for the Kodiak Island experiment was designed in accordance to the renewal proposal guidance letter (18 May). The use of personnel from RU 341 to search for beached drift cards will also enhance returns of seabed drifters released as part of this experiment. Experiments using these Lagrangian techniques are difficult to interpret even under ideal, i.e. highly populated regions, conditions. The combination of personnel from RU 341, the relatively "high population" (by Alaskan standards) and extensive fishing activities will yield the greatest probability of success for both drift cards and seabed drifters in the Kodiak Island area. If the drift card experiment is either moved to "near Hinchinbrook Entrance" or the number of drift cards split between the two regions, we believe the value of the experiment will be diluted.

Therefore, we strongly recommend that the drift card experiment remain as a pilot study described in the proposal.

2. Add to Milestone Chart:

   (a) Historic Data Analysis: Lower Cook Inlet - in March 1978.

   (b) Submit return data from drift card and seabed drifter experiment - December 1978.

3. Add to Section VI, "General Strategy and Approach" to paragraph:

The FY 1978 field work addresses the problem of circulation through the Cook Inlet, Shelikof Strait and NW Gulf of Alaska shelf region west to Mitrofania Island. This entire area is treated in the study as a single system; divisions into sub-areas are for logistical purposes only. This unity is reflected in the field work, as single continuous cruises (several legs) are utilized to occupy stations consecutively through the region and thus obtain data representative of a single period for the whole region.

Add to Section XI, "Information Required from Other Investigators", the statement:

Radar tracked Lagrangian drifter data will be acquired by verbal or written request from Dave Burbank (ADF86). Satellite tracked Lagrangian drifter data will be obtained by verbal or written request from Don Hanson (AOML).

4. Add to Section X-D, "Visual Data", the following: During the first quarter of FY 78 we will evaluate various techniques for presentation of visual data to help summarize research efforts. Such techniques are expected to evolve in part from discussions with personnel from Boulder and Juneau OCSEAP project offices, NODC and BLM and will not be limited to those which PMEL expected to provide. One example of such a presentation which could routinely be provided by NODC is use of motion picture techniques (time series vectors) to demonstrate coherence of currents over an area. Other data display techniques will be identified and presented in the quarterly report.

5. Replace Section XVII-6 with the following: Data will be submitted to the Project Office 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.

6. Add to Section XII, "Quality Assurance Plan", the statement:

Our methods for gathering, processing and checking routine data are documented in the PMC Manual and will not be reiterated with each submission of such data. Such submissions will be accompanied however by a statement that gathering, processing and checking have been carried out according to the PMC Manual. In cases where new procedures are utilized, these will be documented with a supplementary report detailing the procedures. (cf. for example, "A processing system for Aanderaa current meter data" by R. L. Charnell and G. A. Krancus, NOAA Tech Memo ERL-PMEL-6).

7. Add to Section X-A1, "Digital Data". No additional digital data parameters are needed informats 015, 017 and 022 for quality data reports. No format redesign will be necessary.

Technical Proposal Form

I. Alaska Numerical Modeling
RU 140
Contract Number:
Proposed date of contracts: 1 October 1977 - 30 September 1978

II. Principal Investigator: J. A. Galt

III. Cost:
A. Science . . . .
B. P.I. provided logistics . . . .
C. Total $150,000
D. Distribution of Effort by Lease Area:

NEGOA	40%
KODIAK/LCI	35%
Aleutians	10%
Development applicable to all areas	15%

IV & V. Background and Objectives

The proposed research will be a continuation of an ongoing project at PMEL. The goal is to describe, synthesize, and communicate observational and theoretical results on the distribution and movement of hydrocarbon pollutants in areas identified for potential oil and gas development. This work is part of a larger and more general oil spill research study being done at PMEL and is coordinated with R and D efforts sponsored by MESA, EPA and Marine Services that are primarily focused at other geographical areas but that share a certain commonality in both software and theoretical development. Major costs associated with this years work are for personnel. This reflects a more intensive effort at applying modeling techniques and in using computer and graphics hardware developed in previous contract years. In addition, more observational field data is becoming available all of the time and this requires a more personnel intensive effort to effectively utilize the model and simulation programs. The modeling program, as it is set up, will interface with a number of other both theoretical and observational programs currently being carried out under OCSEAP sponsorship.

Meterological input data will be needed from the NEGOA area, the Hinchinbrook/Prince William Sound area, and the Lower Cook Inlet/Kodiak area. In this case the major interface will be the work that is being carried out by Mike Reynolds at this laboratory. STD measurements will be required for both the Hinchinbrook and Kodiak area. These will have to be coordinated through PMEL and NOS efforts as well as research that will be carried out by Dr. Tom Royer's contract at the University of Alaska. In addition the project will call upon research that is being done at EDS in CEDDA by Dr. Jim Mattson covering spreading processes and oil sediment interaction. Finally it will be necessary to interface with other NOAA spills studies being carried out in the National Weather Service with EPA passthrough money by Dr. Celso Barrientos.

VI. General Strategy and Approach

To meet the objectives set forth in this proposal a series of numerical models have been designed along with a conceptual model for their implimentation. The starting point for these considerations is a description of the environmental assessment process. The general steps required in an environmental assessment are summarized in figure 1. Each of these boxes represents studies that must be carried out. In addition, it is crucial that the results of these studies be synthesized and communicated to the next component of the general assessment process. Without this communication any program, no matter how ambitious, will be little more than isolated pieces. These may be of interest to the specialists but they are not likely to be strong contributors to the complex interdisciplinary process of coming up with an accurate estimate of environmental alternatives.

Clearly the first step in an environmental evaluation of potential impacts from hydrocarbons is to come up with estimates of when, where and how much oil is likely to be introduced. This will require projections of expected development, historical analyses of spill records from similar gas and oil fields and an evaluation of special regional hazards. The information from these studies specify the source distribution for the next element in the general assessment study.

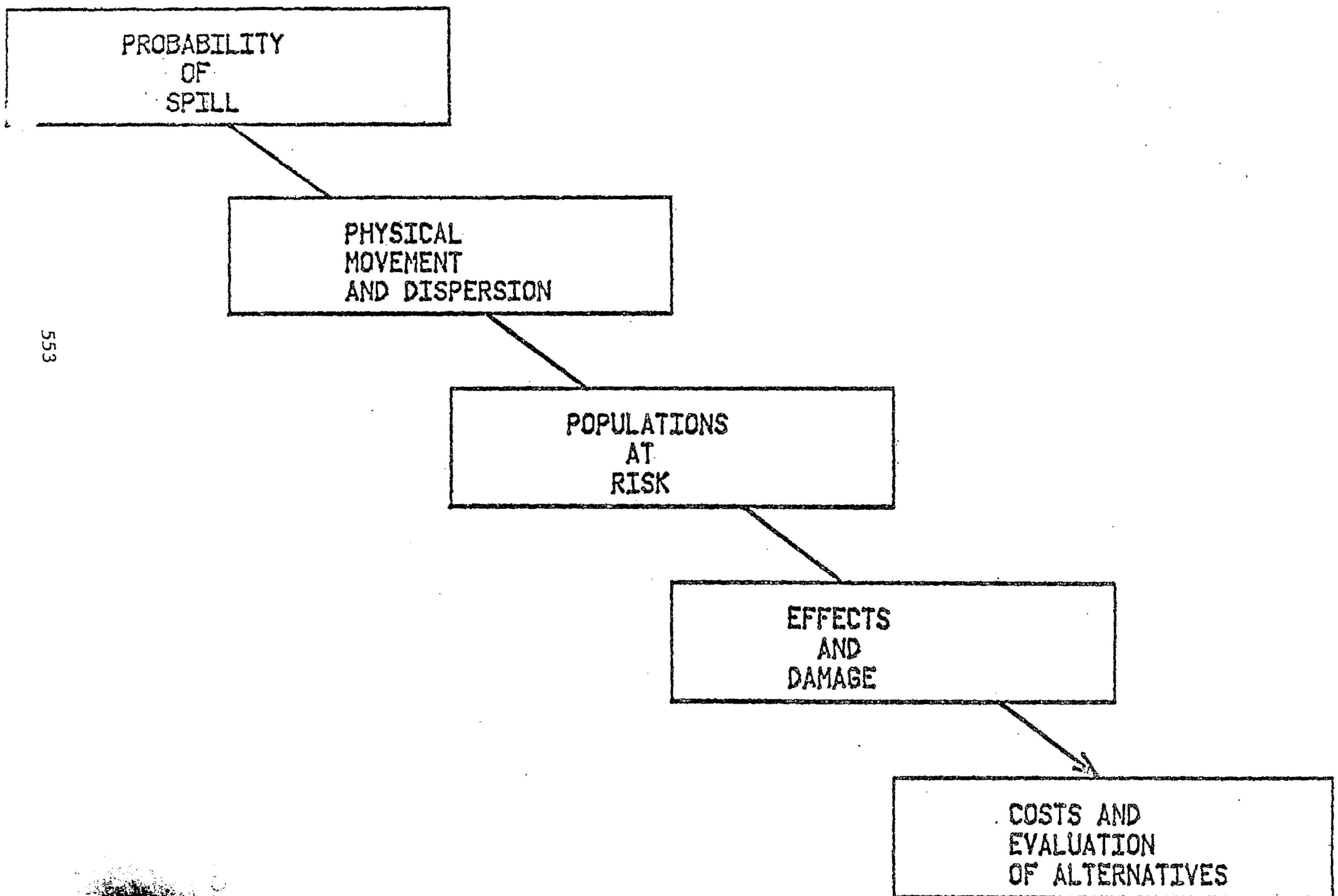
Once the amount of pollutant is given, the next question is where will it go, and what will the distributed concentrations be? This study is represented by the second box in figure 1 and is associated with physical oceanographic studies and trajectory modeling. This information generated by these studies gives guidance for the next series of studies relating to biological investigations.

Once it is determined where and how much oil is introduced into the environment the question of who it will impact must be answered. These studies then must identify what populations are at risk. After potentially impacted populations have been identified, effects work and the expected extent of damage must be estimated. Input for these studies will typically be spill concentration and duration of exposure data combined with biological census information.

The final step in an environmental assessment is to cost out the damage and evaluate alternative development scenarios.

Although considerable effort is going into the general problem of assessing the environmental impacts associated with oil and gas development of the OCS the author knows of no coordinated effort that is carrying through all of the steps outlined above. Most of the presently proposed studies concentrat on physical movement and dispersion studies and obviously can't address the complete assessment problem, either. While this is being carried out, however, an effort will be made to insure that these studies are conceptually compatible with the communication demands implied in figure 1. This will be done by looking at spill statistics and examining the forms of probability

GENERAL STEPS TO BE CARRIED OUT IN AN ENVIRONMENT ASSESSMENT FOR OIL AND GAS DEVELOPMENT



DISTRIBUTION OF VARIABLES EQUATION

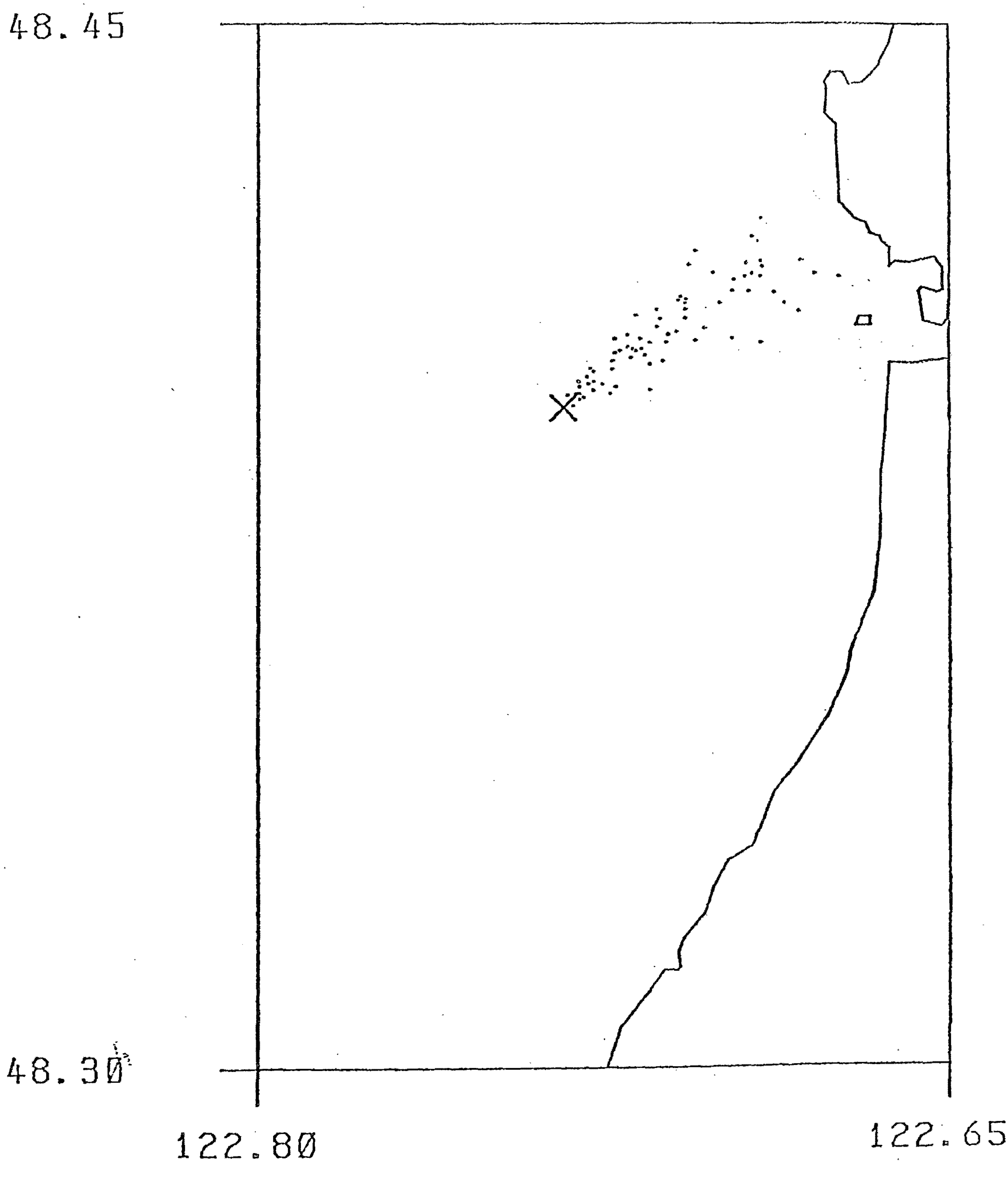
$$\frac{\partial C}{\partial t} + \nabla \cdot ((U_w + U_c)C) = \nabla (K \nabla C) + R$$

LAGRANGIAN
ELEMENTS

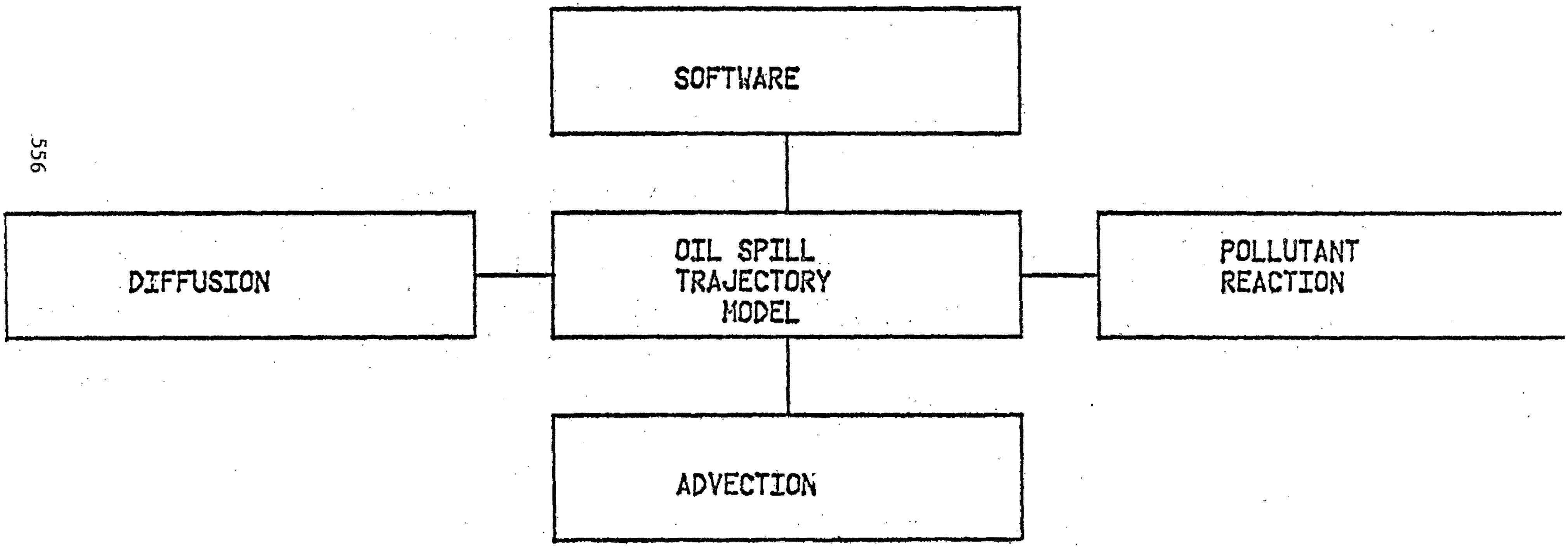
POSITION AGE

SPILL OR REMOVAL RATE

MASS SUBSTANCE


48.45
48.30
122.80
122.65

GENERAL COMPONENTS TO OIL SPILL TRAJECTORY MODEL



computer terminals which can be carried around to wherever a sponsor is interested in looking at the oil spill model and which can communicate back to the basic computer by telephone.

Diagonostic Model Utilization. The computer programs for the diagnostic model are well developed and tested for a number of different cases. Work with the diagnostic model this contract year will be primarily in the exercise of the model for new data sets. In particular we will be looking at the NEGOA case. Also we will be looking at the Kodiak and entrace to Lower Cook Inlet data. Some of this data is already available. However, we want additional sets so this will be one of the areas where coordination with the observational program will be required. The third area where we will apply the model is in the Hinchinbrook entrance region. This is another area where data sets do not exist, and we will be interested in coordinating this with the observational program. Diagnostic model output will be presented by itself in the form of vector current maps for use in briefings and synthesis meeting and, where appropriate, results will also be incorporated into the general oil spill trajectory model by including them in the environmental libraries. Finally a set of publications that will completely describe the diagnostic model, outline its use, and propose strategies for setting up boundary conditions will be presented this contract year.

Regional Meteorological Modeling. We have settled on a variant of Lavoie's model (1972, 1974) as the prototype for application along the Alaskan coastline. Mathematically, the model consists of a system of primitive equations couched in terms of horizontal velocity and inversion height. Computationally, major changes have been made to Lavoie's original formulation, most notably the choice of a more basic finite difference lattice which eliminated numerical noise in the solution and the problem of overspecification of boundary conditions. In addition, provision had to be made for the marine boundary layer to actually intersect the topography of the high coastal mountain peaks along the south coast of Alaska. To date, we have had considerable experience in applying the improved model to idealized geometries for the Puget Sound Basin and the Icy Bay Region. During the coming year we will establish the model for Lower Cook Inlet, Kodiak Island, and Prince William Sound.

Along with its versitility, the primitive equation system is also rich in solutions. This feature coupled with the necessity of specifying four open boundaries for a meteorogically small regional area, makes application to a new area a non-trivial exercise. Numerical as well as meterological factors must be considered. To this end, our task will be to provide the initial adaptation to all new areas. This includes developing the model for each region until it is completely documented so that it can be used as a general tool in understanding the local meteorogical response.

Once the model has been calibrated for the NEGOA region, additional studies will be carried out where climatological large scale pressure patterns are used to drive the model. In this way small scale wind climatologies can be synthesized for use in model predictions.

distributions that are likely to represent source terms for the trajectory studies. In addition, the model output from the studies in this research unit will be presented in a variety of graphical desplays that can be readily adapted to the needs of any biological studies which follow.

The central component of this research plan is the general oil spill trajectory model. This model basically solves the distribution of variables equation (figure 2) using a Monte Carlo technique, where the distributions are represented by a number of Lagrangian particles or elements. Their movement and spreading are then statistically determined in such a way to simulate the differential operators shown in the governing equation. A test example of one form of graphics output from a simulated spill is shown in figure 3.

The distribution of variables equation has terms in it which represent the major processes that control the movement and spreading of a pollutant. These processes and the algorithms that simulate them make up the general components of the trajectory model and are represented in figure 4. Advective processes are given by the last term on the left hand side of the distribution of variables equation. This includes the effects of ocean currents and wind drift and as such incorporates the output from both our regional meteorological studies and the diagnostic model. Diffusion represents spreading and turbulent mixing processes and uses the analyses and modeling of observational data as well as algorithms derived from theoretical studies. Pollutant reaction processes are represented by the last term in the distribution of variables equation and this requires data on spill characteristics as well as algorithms representing weathering of hydrocarbons.

The general oil spill trajectory model is a focus for all the work being carried out in this research unit. It incorporates the output from each of the other models, or theoretical studies, and synthesizes the results, presenting them in easy to interpret graphical form. In many respects this model acts as a communications interface between other study components and is an integrated response showing the advective and spreading behavior of a hypothetical spill.

VII. Proposed Program Components

General Oil Spill Trajectory Model. The basic components of a general oil spill trajectory model have all been designed and many of them carried through to software development. This work will continue and should be essentially completed in the early part of the oncoming contract year. Continued work will concentrate on graphics and output techniques which can present the model results in a variety of ways compatible with researchers and sponsor needs. In addition, the model will have incorporated into the algorithms the research that is being carried out at CEDDA to simulate spreading and sediment oil interaction, as well as the results that we get from theoretical studies looking at oil interactions with short gravity waves and with Langmuir circulation. (Both of these will be discussed later as separate projects). A final area that will be developed in connection with the general oil spill trajectory model is the use of mobil graphic techniques, that is

Development of an Environmental Library for the NEGOA Region. The physical design of the oil spill trajectory model requires three discs to be used in conjunction with the computer. This is schematically represented in figure 5. The first disc is strictly related to the computer operation and tells the computer what language it's going to use and so forth. Once this has been designed, it is never modified again and the model essentially uses the same disc for every run. The second disc contains all of the computer codes that define the model. All of the algorithms to do the graphics and present the results as well as carry out the operations associated with oil movement and dispersion are on this disc. Once this disc is completed it will also remain unchanged for all model runs. The third disc contains all of the regional environmental information required to run the model. This will be local in nature and each disc will represent some specific area. Conceptionally, it is thought of as a library where the model can look up local information. Local information will include such things as the digitized coastline, the current fields related to whatever input or independent variables we are interested in, the wind fields, the distribution of sediment loads, temperatures, and whatever other independent variable information that the model requires. These will be put together in sets so that when it is necessar to run the model you can go and take one of these discs and run the model for Cook Inlet, or NEGOA or Prince Williams Sound or wherever else you have an environmental library disc already compiled.

One of the key aims of the research this year is to compile an environmental library for the NEGOA region. This will be our first prototype library and it will depend on the large amount of current meter, STD, and wind data that we have compiled for that region. All of the other regions we're looking into, Kodiak, Hinchinbrook, etc., are places where we are gathering the pieces that will form the basis of their environmental libraries. The first test case, NEGOA, will be completed this year. We can expect that any of the areas we're working in this year can have environmental libraries ready to run, in more or less real time, starting early the following year.

Studies Related to Oil Movement and Advection on Intermediate Scales. Each time we have had observations of oil in the Marine Environment we find that spreading on a ten to hundreds of meters scale is very much more complex than our simple theories would suggest. In many cases the oil forms long streamers or pancakes or thick and thin patches, and doesn't come anywhere close to the uniform distributions that a simple diffusion model would suggest. We are, therefore, looking into these kinds of phenomena in a number of ways. From a theoretical point of view, two studies are proposed. One is to consider a numerical model that can simulate oil slicks and Langmuir cells together. Then we will look at the parameters which control whether an oil slick will end up in wind rows (Langmuir convergence lines), or whether it can actually spread out against Langmuir circulation. The Langmuir study will be carried out by a National Research Council Post-Doctoral Researcher who will be joining the lab in September. He will bring with him a completed Langmuir model and his efforts will be primarily to introduce oil as a floating pollutant and study those results.

A second study will look at the hydrodynamic implications of high wave attenuation associated with oil slicks. In particular, a commonly observed phenomena in oil spills is the rapid attenuation of the shorter surface waves within the oil slick. Stewart (1976) examined the dynamics of two dimensional waves in an air/oil/water system under the assumption of zero tangential and normal stress at the oil/air interface. In that report, Dr. Stewart concluded that the capillary waves were the most strongly effected and that the important dynamical parameters were the interfacial elasticity and the nondimensional spill thickness ($d \div (\upsilon/\omega)^{1/2}$). This latter parameter measures the thickness of the oil relative to the Stokes depth. The Stoke depth determines the amount of oil entrained by oscillatory motions at the interface. The interfacial elasticity and the nondimensional oil thickness combine to determine the phase velocity of logitudinal compressive waves at the interface much as the modulues of elasticity and the linear density determine the phase velocity of longitudinal waves in steel beams. Maximum attention occurred when this phase velocity matched the phase velocity of the surface wave.

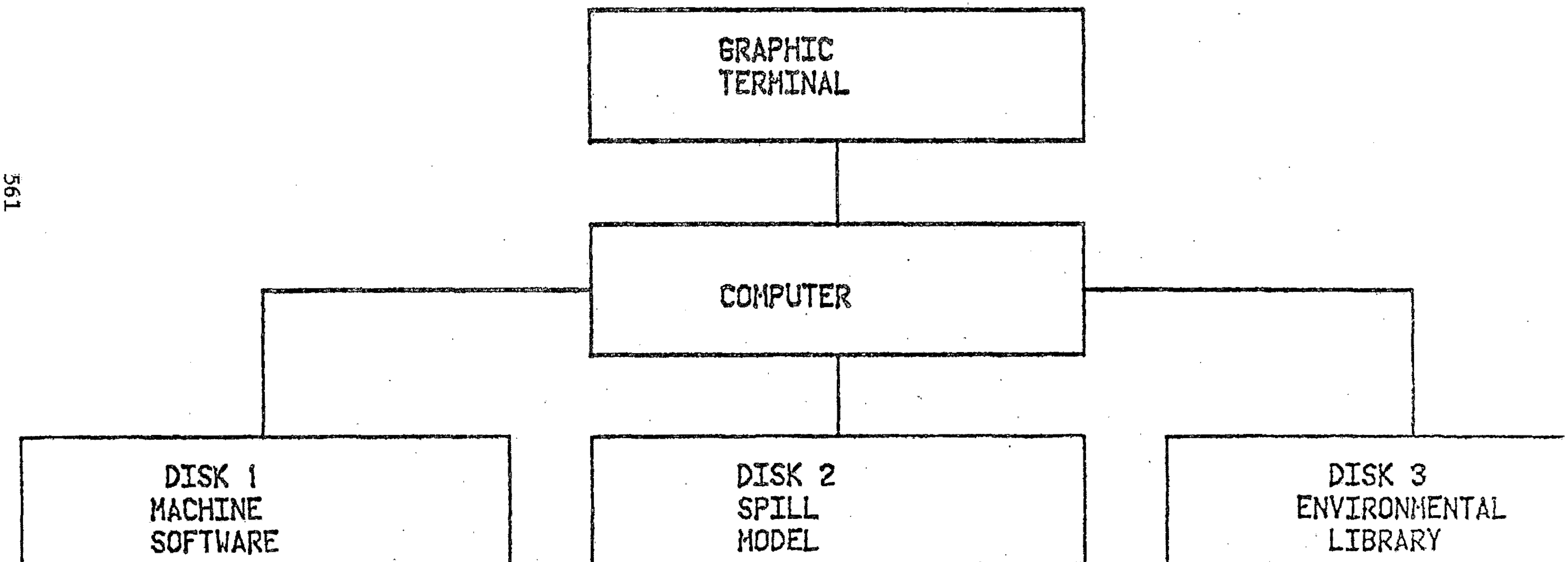
This understanding of the dynamics of the process has been difficult to exploit mainly because there appears to be no way to generalize the problem. The interfacial elasticity will vary both in time and space as the surfactants are extracted from this oil by the underlying water, or as they are advected from one spot to another within the oil by weak higher order steady currents. Further, the spill thickness will also vary from spot to spot, ranging from .001 mm to several centimeters.

One approach in this situation is to simply ignore the complicated dynamics. If we assume that an anomolously large attenuation takes place in a localized region, then it is possible to establish the nature of the higher order interactions in the surface boundary layer region. Dr. Stewart (1976) performed such an analyses using Eulerian coordinates and showed that the attenuation produced a large velocity shear at the lower edge of the surface boundary layer. Unfortunately, because of the use of Eulerian coordinates, the analyses is limited to waves having a height smaller than the Stokes depth of the water. An important result of this limitation is that it causes all terms that might lead to the advection of vorticity to be discarded. Consequently, this result cannot be generalized to the more interesting large amplitude case. To avoid this small amplitude limitation, we propose to reformulate the problem in Lagrangian coordinates. There are three references that bear upon the revised problem. They are Pierson (1962), Unlata and Mei (1970) and Milgram (1977). None of these treats the enhanced attenuation problem specifically, although Milgram comes the closest. Nor do they speak to the special tangential stress condition associated with the interfacial elasticity.

Our approach will be to derive a series of inner and outer solutions in a fashion analogous to the Eulerian approach of Dr. Stewart's previous report The first order properties will be rederived in way of verifying the previous results. The second order kinematic problem will then be formulated and the boundary layer behavior examined.

Both of these theoretical studies will depend heavily on observational data that has been and will continue to be collected by SOR-team efforts. This is coordinated through the regular SOR-team planning so that obtaining data for both of these studies will be high priority items for the observational teams, whenever they are at a spill.

PHYSICAL COMPONENTS OF OIL SPILL TRAJECTORY MODEL



In addition to the theoretical studies related to this intermediate scale advection, we are also beginning some observational analyses of SOR-team data to try and phenomenalogically describe what is occurring on these scales. The first analyses will be of the NASA overflight pictures that appeared in the Argo report. There were a number of retakes at various times over identifiable slick features, and these will be carefully analyzed to get differential water velocity straining, shearing, convergence, and divergence fields. These, in turn, will be related to the time dependent change in the shape of the slick. This is a relatively straightforward, but time consuming, operation of looking at the original 10" x 10" negatives from the NASA flight, and making sure that the scales and conversions are all carried out in a consistent manner so that one can determine actual oil slick movement.

Extension of Bayesian Methodology to Censored Spill Volume Samples. A key function in environmental impact assessments for petroleum related marine activities is the estimated probability distributions for the size of the oil spills which might accompany the proposed activities. Typically we are forced to use small data sets of uncertain reliability to estimate these distributions. In order to deal logically with these problems, a Bayesian methodology has been developed by Stewart, Devanney and Kennedy. This procedure assumes that oil spills are generated by the Gamma, Lognormal, or Inverse Gamma probability density functions. The data is assumed to be uncensored. This means that no event is discarded because of its size. A Bayesian hypothesis test was developed by these authors which is then used to assign weights to the three possible underlying probability density functions.

A dramatic example of the use of this technique is provided by the volume distributions calculated for spillage from the major U.S. tankers (some 235 vessels). Two classes of spills are identified. One class result from hull rupture. The other class encompasses all other spills (hose ruptures, valve leaks and the like). The first class is composed of 53 events (in the period 1973-1975), the other class 317 events. It is found using this method that the hull rupture category spill is distributed like the Inverse Gamma probability density function while the other category is lognormally distributed.

It is not correct to interpret these results as proof that spills are distributed in a Lognormal or Invers-Gammic fashion. All the test says is that of the three families considered, they are or are not consistant with the data to the extent indicated by the weighting and relative to one another.

We propose to extend these results to samples where we arbitarily throw out all spills beneath some threshold level. This is typically the case with oil spill data, because of the very large number of very small spills reported. The USGS, for example, only records spills over 1 BBL (42 gallons). Alternatively, some spill data resources are composed of clippings from the popular press. Here we can be fairly confident that most of the smaller spills are neglected.

The data source most subject to substantial censoring in this fashion is the worldwide tanker spill data. Here only the large, catastophic events are reported. The technique we will implement will allow us to deal with this data in a much more consistent fashion than is now the case. Estimates will be made for future Argo Merchant type spills based on the historical data presently available.

The techniques will also allow for a more consistent treatment of USGS data than is now possible.

References

Milgram, Jerome (1977), "Mass Transport of Water and Floating Oil by Gravity Waves in Deep Water", submitted for publication. Written under NSF Grant ENG72-03943 A04; Department of Oceanagraphic Engineering, MIT.

Pierson W. J. (1962), "Perturbation Analyses of the Navier Stokes Equation in Lagrangian Form with Selected Linear Solutions", JGR, 67, (8), 3151-3160

Unluata, U. and Mei, C. C. (1970), "Mass Transport in Water Waves" JGR 75 (31), 7611-7618.

Stewart, Robert J., "The Interaction of Waves and Oil Spills", MIT Sea Grant Report MITSG 75-22, 15 September 1976.

VII. Analytical Methods-NA

IX. Anticipated Problems-no specific problems identified at this time.

X. Deliverable Products.

1. The completion of the general oil spill trajectory model can be expected this contract year including complete documentation of how it works and all of the associated software.

2. A prototype operational form of this model including the environmental library disc required to make it run. This prototype will be set up for the NEGOA area and can be used in any sort of interrogative form that a researcher or sponsor may be interested in.

3. The continued development of communication and graphics techniques. We expect to have, by the end of the contract year, the software required to transport model results to a variety of graphics terminals. Some that are portable and can be carried around into a sponsor's office or to an oil spill site, or to another researchers lab. In addition, we will begin developing routines for overlaying model results, for summarizing the results of long model runs, and for development of animation techniques so we can watch time history developments of spills and so on.

4. Diagnostic and MET model results for new areas. Both the diagnostic model and the regional model will be exercised in new areas the coming year to develop appropriate advection fields. In particular we will be investigating them in Kodiak, Lower Cook Inlet, and the Hinchinbrook area.

5. Publication and documentation for the use of the diagnostic model. By the end of the contract year, the appropriate technical reports and journal articles for the use of the diagnostic model will be completed and the model then will be available for any NOAA or sponsor researcher to use in any way they like.

6. Theoretical work on the physical spreading and movement of oil on intermediate scales should be carried out this year and documented in two forms. One form will be a technical report form which explains the research that has been carried out and the second will be the algorithms that can be incorporated into the general circulation model to insure the highest possible accuracy and state-of-the-art representation of these intermediate scale processes.

XI. Information required from other investigators.

Modeling studies proposed in this work unit will require observational data from a number of other OCSEAP programs.

1) STD, current meter and pressure gauge data for regions where the diagnostic model is to be run. Recommendations for measurements in the Prince William Sound/ Hinchinbrook have been forwarded to the Juneau project office. Sampling plans for the Kodiak and Aleutian area have been discussed with PMEL PI's.

2) Meteorological data for verification and calibration of wind models will be required and discussions have been held with the PI who will be collecting the data.

3) Weathering and spreading algorithms will be needed for incorporation into the general oil spill model. Some of these will be coming from the OCSEAP funded CEDDA contracts and regular coordination with this group will be carried out.

4) SOR-team data is expected to be a continual source of information for model development and verification. Personnel from this research unit are participating on the SOR-team and making regular input to the decisions setting the teams research priorities.

XII - XIII - XIV NA

XV. Management Plan

A management plan which is an extension of that used in FY77 work will be maintained. See attached Milestone Chart for significant activities.

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:	Bristol Bay Oceanographic Processes
PRINCIPAL INVESTIGATOR:	L. K. Coachman, 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:	$96,000
DESIRED PERIOD:	1 October 1977 - 30 September 1978
UNIVERSITY OFFICE TO BE CONTACTED REGARDING CONTRACT NEGOTIATION:	Grant and 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

T H Kinder
Associate Principal Investigator

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

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

OFFICIAL AUTHORIZED TO GIVE UNIVERSITY APPROVAL:

D R Baldwin
Donald R. Baldwin, Director
Grant & Contract Services
1 Administration Building, AD-24

REF: P77-51

7-5-77

Southeastern Bering Sea Circulation

Research Unit: 141

Principal Investigators: J. D. Schumacher
L. K. Coachman
T. H. Kinder
R. L. Charnell

Total Cost: $322,000

Date: 1 October 1977 - 30 September 1978

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

Required Signatures:

J. D. Schumacher, Principal Investigator, PMEL

R. L. Charnell, Research Oceanographer, PMEL
OCSEAP Program Coordinator

J. R. Apel, Director, PMEL

R. Cunningham, Administrative Officer, PMEL

Technical Proposal Form

I. Southeastern Bering Sea Circulation
RU 141
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

Total $96,000
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

Type Intertidal, ic Organisms,)	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)	Submission (Month/Year)
ent meter	Tape	66 months	File type 015	Yes	9/77 to 7/78	10/78
	Tape	25 stations	" " 017	"	3/78	6/78
	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.

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			△												
First Quarter Report			△												
Through ice CTD helicopter operations					⊢										
CTD Cruise LEG I (in conuunction w/above ops.)					⊢										
FY 78 Annual Report						△									
Submit CTD data from helicopter/LEG I operations								△							
LEG II cruise: CTDs/moored array recovery										⊢					
3rd Quarter Report									△						
Submit CTD, current meter, and pressure gauge data from LEG II													△		
4th Quarter Report												△			

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."

11. Cost Proposal (See attached form)

Other Information

a) The principal investigators and PMEL have had considerable experience in Alaskan Oceanographic investigations. In particular, the same team of individuals that designed and carried out the first two years field effort for OCSEAP will continue the program for FY 77.

b) The principal investigator shall actively lead and supervise the proposed work and shall take full responsibility for timely completion of all tasks described herein.

c) The persons, other than PIs, who will take an active part in the programs are:

D. Pashinski, PMEL
C. Pearson, NOS
G. Krancus, NOS
R. Sillcox, NOS
S. Raaum, NOS
J. Haslett, PMEL
R. Charnell, PMEL
H. Mofjeld, PMEL
R. Tripp, UW

Persons authorized to conduct negotiations are:

PMEL - J. R. Apel (FTS 399-4079)
R. L. Charnell (FTS 399-1960)

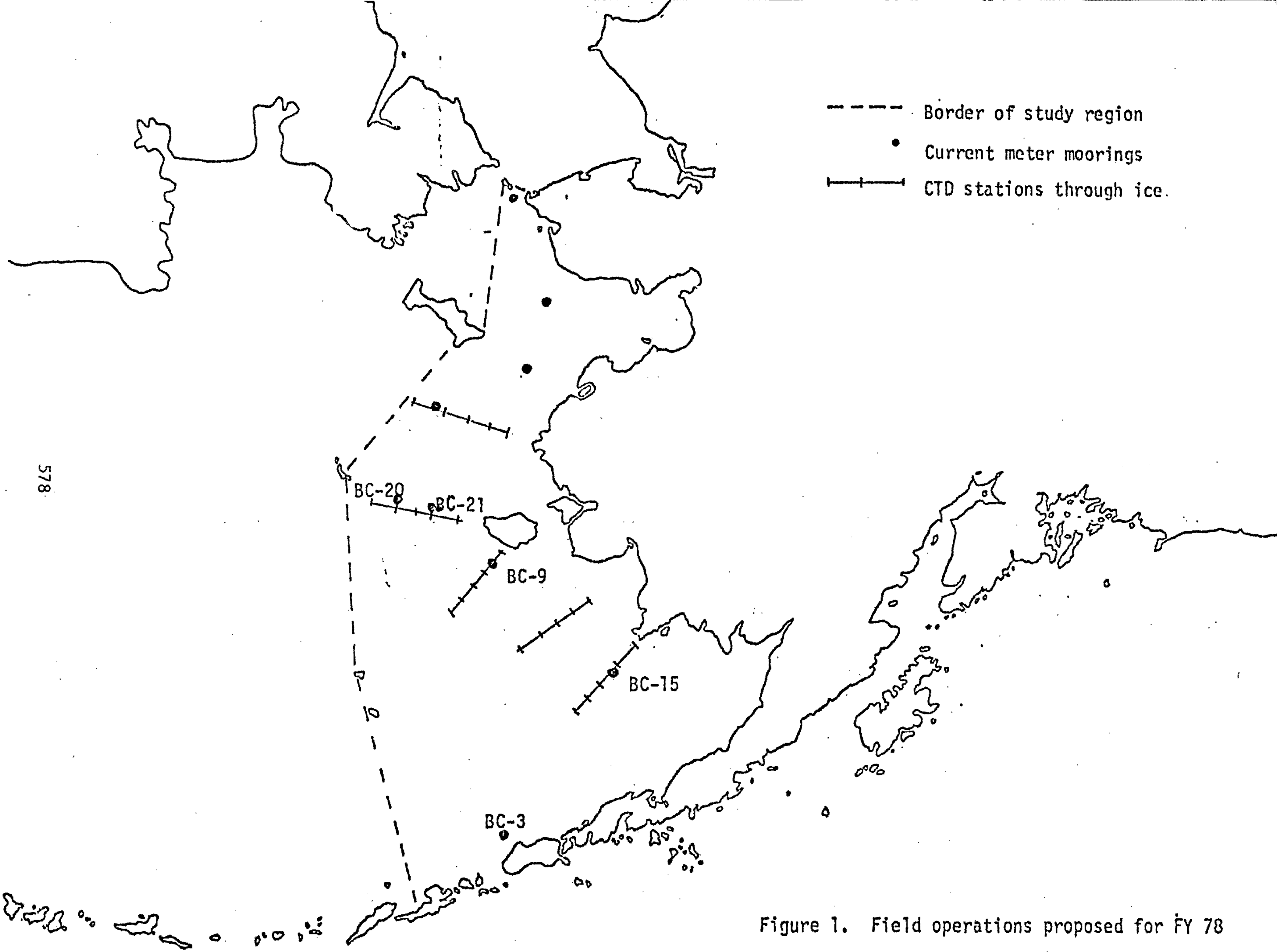


Figure 1. Field operations proposed for FY 78

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Outer Continental Shelf Environmental
Assessment Program
Juneau Project Office Alaska Project Office
P.O. Box 1808
Juneau, Alaska 99802
PH: 907-586-7432

RFx41-549-915

RECEIVED
NOV 1977

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
PACIFIC MARINE ENVIRONMENTAL LABORATORY
3711 - 15th Avenue Northeast
Seattle, Washington 98105

Date: October 5, 1977

To: Herbert E. Bruce, Director, OCSEAP Project Office, Juneau

From: Robert Charnell, PMEL OCSEAP Coordinator

Subject: RU 141, 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 B. Tripp

for L. K. Coachman
Professor and
Principal Investigator

RBT:LKC:af

TITLE: Transport Mechanisms and Hydrocarbon Adsorption Properties of Suspended Matter in Lower Cook Inlet

RESEARCH UNIT: 152

PRINCIPAL INVESTIGATORS: Dr. Richard A. Feely and Dr. Joel D. Cline

COST: $139.9K

WORK PERIOD: October 1, 1977 through September 30, 1977

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

DATE OF PROPOSAL: October 21, 1977

ENDORSEMENTS:

Principal Investigators

Richard A. Feely 11/9/77
Richard A. Feely Date

Joel Cline 11/9/77
Joel Cline Date

Director, PMEL

(for)
John R. Apel Date

TECHNICAL PROPOSAL

I. Title: Transport Mechanisms and Hydrocarbon Adsorption Properties of Suspended Matter in Lower Cook Inlet

Research Unit Number: 152

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

II. Principal Investigators: Dr. Richard A. Feely
Dr. Joel D. Cline

III. Cost of Proposal: $131,500

IV, V and VI. BACKGROUND, OBJECTIVES AND GENERAL STRATEGY

The development of petroleum and natural gas resources on the Alaskan outer continental shelf will undoubtedly result in an increased potential for crude oil contamination of its coastal waters. Of particular concern are the major accidents which cause massive oil spills, such as the ARGO MERCHANT oil spill on Fishing Rip near Nantucket (NOAA Special Report, 1977). However, chronic release of oil through minor spills and localized transfer operations may be more important over the long term.

Oil spilled onto the surface of the ocean is acted upon by several physical processes, including evaporation, solution, emulsification, and injection into the atmosphere (Kreider, 1971; McAuliffe, 1966, 1969; Baier, 1970). With respect to the oceanic environment, only the solution and emulsification processes represent important mechanisms by which spilled oil becomes entrained in the water column, thus increasing its potential for impacting marine organisms.

Since crude oil is sparingly soluble in seawater, it tends to form emulsions when introduced into seawater, especially under intense wave action. The emulsions have a high affinity for particles and tend to be adsorbed rapidly. Recent studies of oil spills in coastal waters containing high suspended loads have indicated rapid dispersal and removal of the oil by adsorption onto suspended matter (Forrester, 1971; Farrington and Quinn, 1973).

There is very little published information about the processes by which oil is transported in association with suspended particles or the quantities of oil that can be adsorbed onto the particles. Early investigators have shown that flocculation of oil bears an inverse relationship to salinity (Chipman and Galtsoff, 1949; Hartung and Klinger, 1968). Later investigations indicate that sedimentation of oil involves a two-step process (Bassin and

Ichiye, 1977; Huang and Elliott, 1977). This process begins with the adsorption of oil onto the suspended particles and is followed by the flocculation of these oil-sediment emulsions by electrostatic interactions. The amount of oil that can be accommodated by a specific quantity of suspended matter appears to be dependent upon the physical and chemical nature of the suspended particles as well as the amount of naturally occurring organic matter that is associated with the particles (Poirier and Thiel, 1941; Meyers and Quinn, 1973).

Once oil is adsorbed to suspended particles, it can easily be injested by marine organisms, particularly by detrital feeders. Following the spill of the ARGO MERCHANT, oil particles were observed in some species of zooplankton and on the surfaces of Pollock eggs (NOAA Special Report, 1977). After the breakup of the oil tanker ARROW in Chedabueto Bay, Conover (1971) determined that zooplankton could assimilate up to 20 percent of the oil particles less than 1 mm in diameter and sediment them as fecal matter. Since fecal matter is an important food source for other marine organisms, oil transmitted to the sea floor in this form becomes an important mechanism by which benthic detrital feeders may be impacted by oil. Many of these species, including shrimp, clams, oysters, and crabs, are economically important renewable resources in Lower Cook Inlet.

After oil is sedimented on the bottom, it is usually degraded by microbial activity. However, in many cases this process is very slow and depending upon the bottom circulation oil contaminated sediments may persist for a considerable amount of time. For example, Blumer and Sass (1972) have documented benthic changes that have resulted from the Buzzards Bay oil spill in 1969. They show that fuel oil was retained in the sediments for at least 2 years and seriously retarded the recruitment rate of organisms into the infected area.

In more active bottom environments oil contaminated sediments may be resuspended into the water column by the actions of waves and storm surges and may reinfect the water column. For example, the preliminary report of the ARGO MERCHANT oil spill indicates that oil contaminated sediments southwest of the grounding point were probably the result of resuspension and transportation of contaminated sediments by the area's southwesterly bottom sediments (NOAA Special Report, 1977). Thus, the persistence of oil in the sediments and its resuspension into the overlying water column may seriously affect not only the recruitment rate of organisms into an infected area, but also the feeding and reproductive behavior of planktonic organisms (Wilson, 1975).

For the past 2 years we have been conducting integrated studies of the distribution, composition, transport and adsorptive properties of suspended matter from Lower Cook Inlet and the Gulf of Alaska. While detailed descriptions of the results of these studies are not appropriate for the present discussion, brief summaries of the most significant findings which are relevant to the discussion of processes occurring in Lower Cook Inlet are listed below.

1. Cook Inlet is characterized by unusually high horizontally suspended matter gradients (Figure 1). On the eastern side, the inflowing Gulf of Alaska water, which has been traced as far north as Kalgin Island, has suspended matter concentrations ranging between 0.5-5.0 mg/ℓ. On the western side, the outflowing turbid water, which contains mechanically abraded rock debris from Upper Cook Inlet and has particulate concentrations ranging from 5.0 to 200 mg/ℓ, is transported past Augustine Island to Kamishak Bay, where a portion of the suspended material settles out and the remaining material is transported around Cape Douglas into Shelikof Strait and is dispersed. Because of the high suspended loads and the relatively sluggish water circulation in Kachemak and Kamishak Bays, these embayments may be expected to be the major receptors of contaminated sediments.

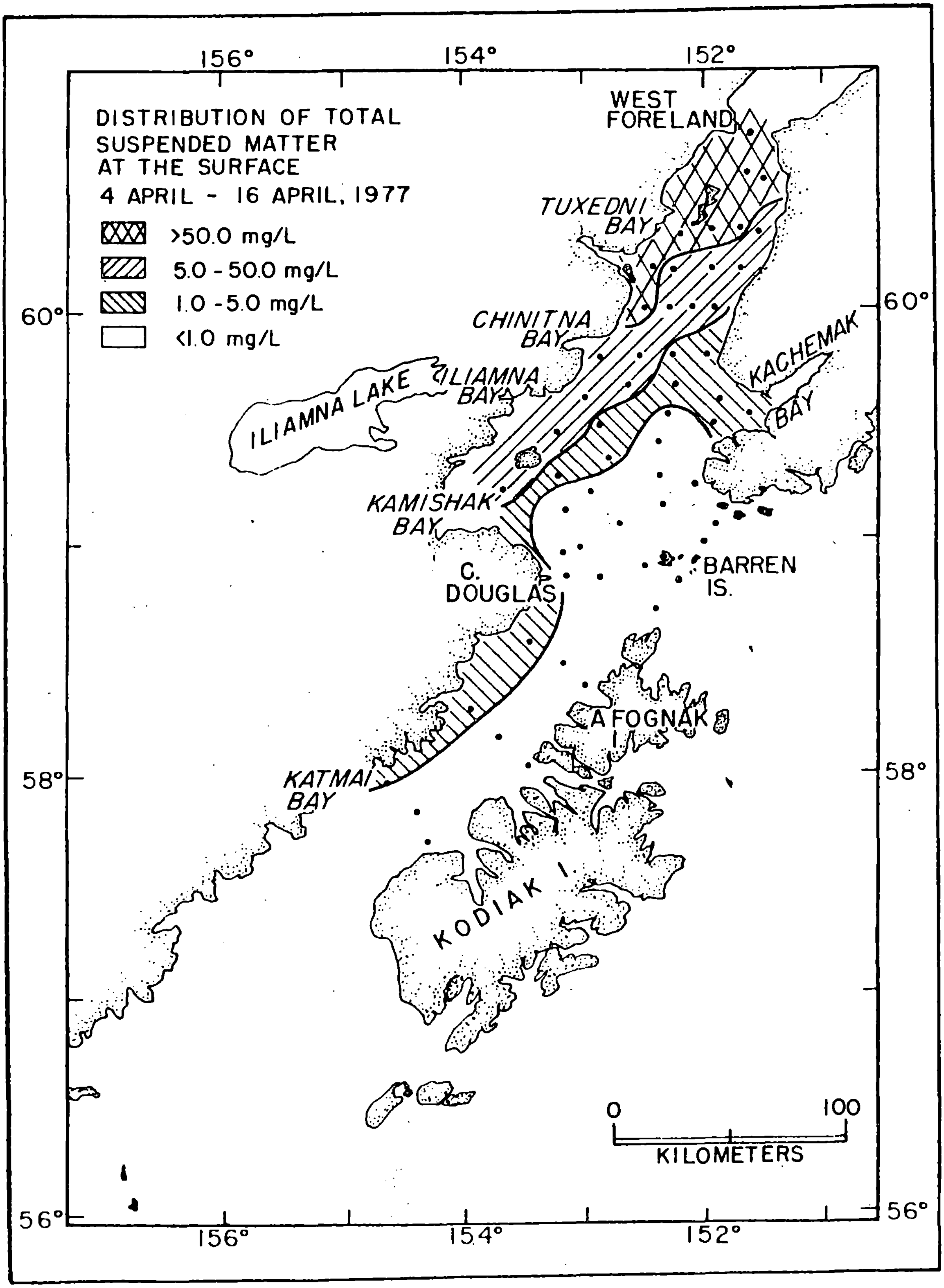


Figure 1. Distribution of total suspended matter at the surface in Lower Cook Inlet and Shelikof Strait (Cruise RP-4-Di-77A-IV, 4-16 April 1977).

2. Time-series studies of the concentrations and composition of suspended matter near the bottom in the Gulf of Alaska and Lower Cook Inlet show evidence for resuspension and redistribution of the fine grain fraction of the sediments. The resuspended fine sediments are then transported to quiescent near-shore environments where they are redeposited. Thus, it is possible that once dispersed contaminated sediments may be concentrated in areas of active sedimentation by the interactions between tidal and storm-induced bottom currents and surficial sediments.

3. Preliminary studies on the adsorption of Cook Inlet crude oil by suspended matter from Lower Cook Inlet show that a maximum of approximately 400 mg of oil per gram of suspended matter may be vertically transported through the water column.

These findings clearly show that suspended matter could play an important role in the dispersal and deposition of petroleum hydrocarbons in Lower Cook Inlet. However, the picture is incomplete and more data is required before the fate of petroleum hydrocarbons in Lower Cook Inlet can be accurately predicted. Specifically, at present there is no quantitative information about the physical processes and mechanisms controlling the accommodation of oil at the ocean surface by suspended particles or the resolubilization of particle-associated oil in uncontaminated seawater. In addition, there are no quantitative estimates of the vertical fluxes of suspended matter in the regions of active sedimentation, i.e., Kachemak and Kamishak Bays. Accordingly, we propose to conduct integrated field and laboratory experiments which will quantitatively delineate these important transport mechanisms for petroleum hydrocarbons in Lower Cook Inlet. The general strategy and objectives of the field and laboratory experiments will be briefly described below.

A. Field Experiments

As part of the suspended matter field program for FY 78, we will conduct an integrated study of the seasonal variability of the vertical fluxes, distribution, and composition of suspended particulate matter at selected locations between Kachemak and Kamishak Bays by deploying a number of sediment traps and one nephelometer on some of the proposed current meter moorings (Hayes, Schumacher, and Muench, RU #138). The sediment traps will be used to determine the vertical fluxes and composition of the suspended matter. The data from the nephelometer will be used to determine the in-situ variability of suspended matter concentration which occurs as a result of local variations in water circulation. The moorings that contain the sediment traps and nephelometer will be placed in three locations between Kachemak and Kamishak Bays (Figure 2). Mooring C11, located in Kachemak Bay, will consist of a nephelometer, one Aanderaa current meter, and two sediment traps. The other two moorings, C1 and C4, will contain two Aanderaa current meters and two sediment traps. The current meters will be deployed and recovered, and the data will be analyzed under the direction of the physical oceanographers. We will be responsible for the deployment and recovery of the sediment traps and the nephelometer. Our objectives for this portion of the suspended matter studies include:

1. Determine the vertical fluxes of suspended matter in areas of high sedimentation.

2. Determine the correlation between high frequency velocity fluctuations and temporal variations in suspended matter concentrations.

3. Determine the elemental composition of the settled material within the traps.

This portion of the field studies will be closely coordinated with the geologists from the USGS in Menlo Park (Drs. Drake and Cacchione, RU #430).

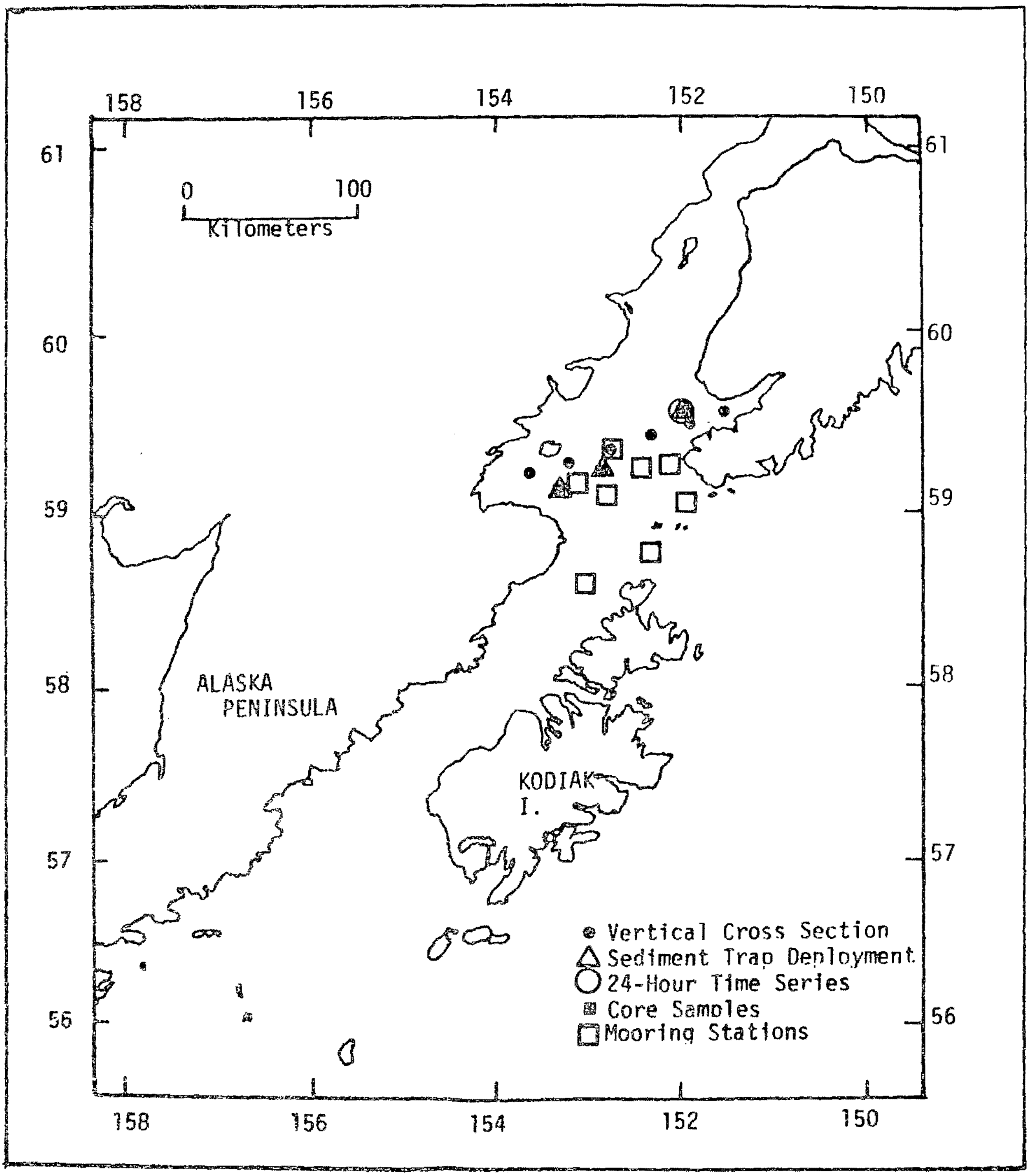


Figure 2. Proposed locations of combined sediment trap-current meter moorings in Lower Cook Inlet.

Tentatively, we plan to have the bottom tripods placed in proximity to the current meter-sediment trap moorings. In this way variations in suspended matter concentrations and vertical transport can be directly related to temporal changes in water circulation and sediment transport.

The second part of the field program will consist of a cooperative study of the partitioning of certain trace element species among their major reservoirs at two locations in Lower Cook Inlet, Kachemak Bay and Trading Bay. In cooperation with Drs. D. Robertson (RU #506) and D. Burrell (RU #162) selected samples of water, suspended matter, biota, and sediments will be analyzed for total and extractable trace metals. Our group will be responsible for the analysis of total and extractable Al, Fe, Mn, Cr, Cu, Pb, Ni, and Zn in the suspended material. The objectives of this cooperative study will be twofold: (1) determine whether or not high primary production in Kachemak Bay causes seasonal variations in the trace element content of water, suspended matter and biota; and (2) determine whether or not present oil production activities in Upper Cook Inlet contributes significantly to the metal content in Lower Cook Inlet.

These cooperative studies will be implemented on two cruises, a spring cruise (early May) during the period when primary production in Kachemak Bay is relatively high (Larrance, 1977), and a summer cruise (middle of August) during the period when suspended sediment discharge from Upper Cook Inlet is near its maximum (Sharma et al., 1974). At each of the two sampling locations water samples from two depths, surface and 5 m above the bottom, will be collected and filtered for particulate matter every 12 hours for a 48-hour period. In this manner we will obtain seasonal data on the concentrations of trace elements in suspended matter which are normalized for diurnal and tidal variations.

In addition to the field experiments described above, we will provide supportive data for the chemists involved in the analysis of hydrocarbons associated with suspended matter in Upper Cook Inlet (RU #153). The supportive data includes the following:

a. CTD-nephelometer profiles.

b. Total suspended matter determinations.

c. Al, Si, C, and N analyses of suspended matter entering and leaving the centrifuge.

These data will be supplied to the principal investigator, Dr. Cline, for his use in preparing reports to the OCSEA program office.

B. Laboratory Studies on Suspended Matter-Petroleum Hydrocarbon Interactions

We propose to continue and expand the investigations of the adsorptive characteristics of Cook Inlet suspended matter relative to Cook Inlet crude oil. These studies are now progressing smoothly and reveal that suspended matter in the concentration range of 100 mg/ℓ will flocculate large quantities of oil. Under laboratory conditions simulating the natural environment, suspended matter has been found to agglutinate up to 30 percent its weight in crude oil, when the concentration of oil was varied from 10 to 150 mg/ℓ. To continue this program, relatively large quantities of suspended matter have been extracted from the near-surface waters of Cook Inlet with the aid of a continuous flow centrifuge. The suspended matter has been analyzed for its chemical composition, size, distribution, and morphology.

Crude oil obtained from the Auke Bay laboratory will be combined with suspended matter in natural seawater under simulated laboratory conditions. The environmental parameters of interest include salinity, temperature, and dissolved organic carbon. These parameters will be systematically varied in accordance with the seasonal ambient conditions observed in LCI. Salinity and temperature will be varied between 0 and 30 $^{o}/_{oo}$ and 0° and $20^{\circ}C$, respectively, with emphasis on the adsorptive capacity at 30 $^o/_{oo}$ and 10^oC. The adsorptive behavior of Cook Inlet suspended matter will be investigated in normal seawater from which the DOC has been removed.

The waters of Upper Cook Inlet are characterized by high concentration of suspended matter (> 100 mg/ℓ) and the present experiments serve to elucidate the capacity of sediments at these concentrations to accommodate oil. An attempt will be made this year to extend the experiments to lower concentrations of suspended matter (approx. 10 mg/ℓ) to evaluate a lower threshold of oil agglutinization. In all experiments, the concentration of oil is varied in accord with the suspended load concentrations. The weight ratio of oil to sediment spans the range of 0.2 to approximately 2. However, the quantities of oil are systematically increased until no additional oil is flocculated and sedimented. This serves to assess the loading characteristics of the sediment under optimum mixing conditions.

The quantity of oil retained under simulated environmental conditions will be determined gravimetrically. Weights of oil extracted from sediments and the residual seawater are measured on a Cahn electrobalance. Compositional fractions of the adsorbed petroleum will be characterized by gas chromatography (glass capillary) and UV-fluorescence spectroscopy and compared to a similar analysis of Cook Inlet crude oil. Compositional fractionation of the oil during adsorption to suspended matter will be evaluated by classes of compounds (paraffins, 2, 3, 4, and 5 ring aromatics) with several representative marker compounds from the aliphatic and aromatic fractions identified for special discussion.

Two additional studies will be initiated in FY 78. First, in order to investigate the resolubilization of oil from suspended matter, separate aliquots of oil-contaminated particles will be introduced into clean, filtered seawater and the resulting aqueous phase extracted for petroleum hydrocarbons as outlined below. In this manner, realistic estimates of resolubilization rates resulting from dispersal of oil contaminated particulates may be determined.

In an extension of the present study, the physical interaction between suspended matter and a surface oil slick will be investigated in a small tank. The oil will be allowed to evaporate during the experiment. Filtered seawater containing known amounts of suspended material will be placed in a thermostated reservoir to which oil has been added. The interaction between the suspended matter and the surface oil slick will be monitored over time to assess the significance of competitive weathering. Also, by adding the sediment to the tank after the oil has weathered for a period of time (to be determined), the affinity of weathered oil for sediment particles may be assessed. Suspended matter will be removed from the tank at appropriate times and analyzed for its agglutinated hydrocarbons. Microscopic techniques will be employed to describe the nature of the sediment-oil flocs.

Utilizing these techniques, and others, it will be possible to provide a more complete physio-chemical description of the interactions between oil and particles under natural conditions, opening the door for more meaningful modeling efforts on the fate of spilt oil.

VII. SAMPLING METHODS

Immediately prior to the deployment of the current meter-sediment trap moorings, the distribution of temperature, salinity, and suspended loads will be determined using a CTD-nephelometer-rosette system. Water samples will be collected in 10-liter PVC Model 1070 Drop-Top Niskin^{R} bottles and filtered through preweighed 47 mm 0.4 μm Nuclepore filters. The filters will be washed with three 10 mℓ aliquots of deionized filtered water, dried in a desiccator, stored in plastic petri dishes, and frozen to reduce bacterial activity. At the laboratory the filters will be reweighed on a seven-place Cahn Electrobalance.

The sediment traps are designed after those described by Gardner (1977) with some slight modifications. Figure 3 shows an exploded isometric view of the sediment trap. The basic design consists of a PVC cylinder (diameter = 152 mm; length = 475 mm) equipped with the following: a guillotine-type closing lid to maintain sample integrity during retrieval operations; a self-contained presettable timer to actuate lid closure; a PVC side chamber containing reagent grade sodium azide which slowly diffuses through a membrane into the trap to reduce bacterial activity; and a grid (mesh size = 12 mm) mounted at the mouth of the trap to prevent large organisms from entering the trap and for reducing turbulence at the mouth. The sediment traps will be positioned side by side on the mooring approximately 7-10 meters above the sea floor. They will be deployed for two 90-day periods, October-December 1977 and May-July 1978.

The samples from the sediment traps will be filtered onto 142 mm 0.4 μm Nuclepore® filters and dried, stored in plastic petri dishes, and returned to the laboratory following the same procedures as for the 47 mm filters. For the hydrocarbon adsorption studies, seawater from Lower Cook Inlet will be filtered through 142 mm 0.4 μm Nuclepore® filters stored in 13 gal. plastic carboys and returned to the laboratory.

VIII. ANALYTICAL METHODS

The trace (Cr, Al, Mn, Fe, Cu, Ni, Zn, and Pb) element chemistry of the particulate matter will be determined by x-ray fluorescence. This technique has been used successfully for the determination of the elemental composition

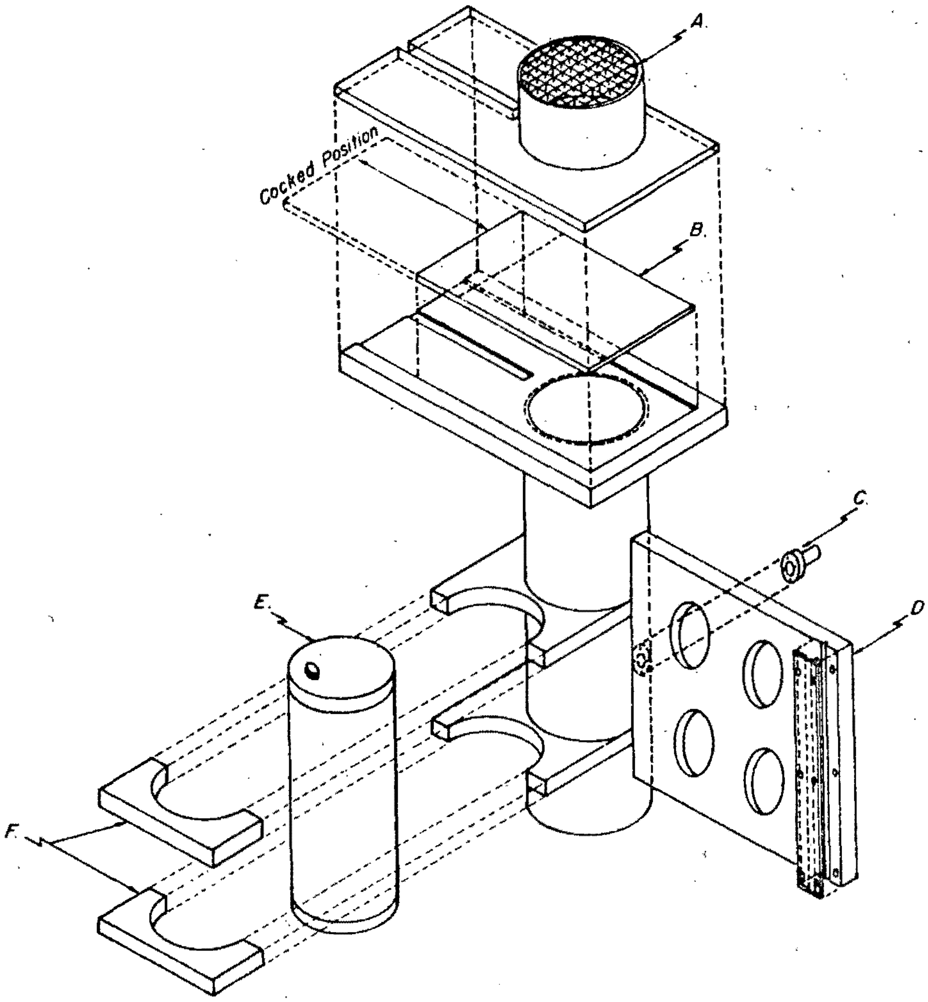


Figure 3. Exploded isometric design of the PMEL sediment trap. The major components of the sediment trap consists of the following: a. plastic grid for preventing large organisms from entering the trap; b. guillotine-type closing lid; c. sodium azide diffusion chamber; d. clamping brackets; e. presettable timer; and f. timer brackets.

of the particulate matter coastal and deep water environments and the techniques are well established (Cann and Winter, 1971; Baker and Piper, 1976). We will be using USGS and NBS standard reference materials for our calibrations.

Particulate carbon and nitrogen will be analyzed by the micro-Dumas combustion method, employing a Hewlett Packard 185B C-H-N analyzer (Sharp, 1974). Particulate matter will be removed from 1-liter volumes by vacuum filtration and the carbon and nitrogen combusted to CO_2 and N_2. After separation by standard gas-solid chromatography, the gases are quantitatively determined by thermal conductivity. Standardization will be effected with acetanilide (Sharp, 1974). Solutions resulting from chemical extraction of suspended matter samples will be analyzed by flameless atomic absorption following the techniques outlined by Feely (1975).

The hydrocarbon adsorption experiment will be conducted in 1-liter separatory funnels to which has been added various quantities of suspended matter (10 to 200 mg/ℓ) and Cook Inlet crude oil. The mixtures are shaken gently at preselected temperatures (0, 10, 20°C) for a period of 1 hour, then allowed to stand for 2 hours, during which time the oil flocs settle to the bottom of the separatory funnel. The sediment-oil flocs are removed from the funnel with a small pasteur pipet and extracted with methylene chloride. The sediment is separated from the associated seawater and methylene chloride by filtration through a 0.4 μm Selas silver filter. The amount of material remaining after removal of hydrocarbons will be determined gravimetrically and compared to the original starting material. The tare of the residual particulate matter will be used as the adsorbed hydrocarbon reference weight. Hydrocarbons extracted from the sediment are transferred into hexane and reduced to 2 mℓ volumes. The quantities of oil are determined gravimetrically on a small aliquot of the extract.

Dissolved and emulsified oil remaining in the water is back-extracted with methylene chloride to effect recovery of nonassociated oil. Corrections are also made for the extractable organics obtained from both the added sediments and the seawater.

The analysis of the various hydrocarbon extracts will focus on the heavier hydrocarbon fractions, including paraffins (C_{12}-C_{32}) and aromatics, including the polycyclic aromatics through 5 ring compounds. The paraffins will be analyzed by GC techniques according to the methods outlined by MacLeod et al. (1976).

Individual paraffins will be identified and quantified on selected samples by glass capillary gas chromatography, after separation from the aromatic fraction by silica gel liquid chromatography. Similar treatment will be accorded the aromatic fraction, except the enormous complexity of crude oil will result in a complex chromatogram. Only selected samples will be run for the purpose of evaluating compositional fractionation. Attempts will be made to characterize the bulk aromatic fraction by UV-fluorescence (Zitko and Carson, 1970). GC-MS spectroscopy (Brown et al., 1974; Warner, 1976) will only be used on those samples where individual component identification is required. In all cases, the quantities of aliphatics and aromatics in each fraction will be determined gravimetrically on a Cahn electrobalance.

The measurements of total hydrocarbons and the aliphatic and aromatic fractions will be directly compared to similar extracts of Cook Inlet crude oil. Thus, a reasonable estimate of the adsorptive efficiency for the various classes of hydrocarbons will be available as a function of sediment composition and environmental parameters (i.e., salinity, temperature, and DOC).

IX. ANTICIPATED PROBLEMS

We anticipate no significant problems with this program as we have outlined it. If major modifications in the scope of the research are initiated, we may have to modify our posture and response to the above deadlines.

X. DELIVERABLE PRODUCTS

The results of the elemental composition of the suspended matter will be arranged into tabular format and submitted to EDS on IBM cards. In addition, distribution cross sections and narrative discussions of the above will be discussed in the quarterly reports. The results of the hydrocarbon adsorption studies will be presented in narrative form, including tables and graphs which describe the relationships between adsorbed petroleum, its composition, and the environmental control parameters.

The data from the field studies will be submitted by cruise according to the following schedule:

Collection Period Month/Year to Month/Year			Data Submission Month/Year
10/77	-	10/77	9/78
5/78	-	5/78	2/79
8/78	-	8/78	5/79

XI. INFORMATION REQUIRED FROM OTHER INVESTIGATORS

The suspended matter program will require information from portions of the geological and physical oceanography programs. Detailed maps of the size distribution and mineralogical composition of the sediments should be made available to us as soon as possible. We also need detailed descriptions of the circulation patterns. Special emphasis should be placed on net water mass transport through the study region.

XII. QUALITY ASSURANCE PLANS

For the elemental composition of the particulate matter, we will be using USGS standard rocks and NBS standards for our calibrations. We will also participate in all appropriate intercalibration studies among individual principal investigators involved in the OCSEA program.

For the hydrocarbon and adsorption studies, we will be using extraction and analytical procedures which are compatible with those currently being adopted by OCSEAP for hydrocarbon analysis. We also will be working closely with the organic analysts within NMFS and will intercalibrate those analyses that we perform with them.

XIII. SPECIAL SAMPLE AND VOUCHER SPECIMEN ARCHIVAL PLANS

We presently do not have any sample archival plans.

XIV. LOGISTICS REQUIREMENTS

See attached forms.

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 Pacific Marine Environmental Lab. PRINCIPAL INVESTIGATORS Feely and Cline

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.

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.

   Nephelometer-CTD hydrocasts will be taken at every station. In addition, water samples will be taken from depths for subsequent filtration.

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.)

   Winter Season: Deployment - 1st week in Oct. Recovery - 1st week in March. Summer Season: Deployment - 1st week in May Recovery - 1st week in Sept.

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.)

   Deployment Cruises - 7 days Recovery Cruises - 5 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?

   Piggyback with physical oceanography cruises.

   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.

   (1) 4 hrs/day (2) 1 hr/station (3) 2-3 hrs between stations

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

   10 Drop-top Niskin bottles, CTD and a rosette

7. What is the approximate weight and volume of equipment you will bring?

   2000 lbs and 200 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.

    DISCOVERER - We require the large laboratory space provided by the DISCOVERER.

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.

    Approximately 4 persons

XV. MANAGEMENT PLAN

The suspended matter program for Lower Cook Inlet will be under the direct supervision of Dr. Richard A. Feely. He will be responsible for planning the field programs, laboratory analysis of the suspended material, and preparation of the final report.

The hydrocarbon adsorption studies involving Cook Inlet suspended material and Prudoe Bay crude oil will be under the direct supervision of Dr. Joel D. Cline. He will be responsible for the sampling program, laboratory experimentations, and preparation of the final report.

XVI. OUTLOOK

The field portion of the suspended matter program represents an interdisciplinary approach to understanding the dynamics of suspended matter transport in Lower Cook Inlet, requiring inputs from the physical and geological programs. It is expected that this first cursory investigation of the system will present new questions which will require more intensive study. However, it is impossible at this point to project what will be the actual nature of and scope of the studies until the results of this year's work have been thoroughly examined. Nevertheless, we can anticipate that because of the tentative schedules for the field programs additional funding in FY79 will be required to complete the analysis of the data collected in FY78.

For the laboratory experiments involving the adsorption properties of suspended matter, we anticipate two possible directions for continued research in FYs 79 and 80. First, the work may be expanded to include suspended matter and petroleum hydrocarbons from some of the other lease areas on the Alaskan OCS. Second, the resolubilization experiments may lead into experiments related to submarine weathering of oils under varying environmental conditions. For this work we would probably expect funding which would be comparable to present levels.

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. 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.

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 according to the schedule outlined in the Management Plan.

6. 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.

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

8. 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.

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

MILESTONE CHART

RU #: 152 PI: Feely and Cline

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	J	F	M
Deploy moorings in Lower Cook Inlet																		
Recover moorings in Lower Cook Inlet																		
Submit Quarterly Report																		
Deploy moorings in Lower Cook Inlet																		
Recover moorings in Lower Cook Inlet																		
Submit Annual Report																		
Submit Quarterly Report																		
Submit IBM cards on November Cruise																		
Submit Quarterly Report																		
Submit IBM cards on May Cruise																		

TITLE: Sources, Composition and Dynamics of Natural and Petrogenic Light Hydrocarbons in Cook Inlet, Alaska

RESEARCH UNIT: 153

PRINCIPAL INVESTIGATORS: Dr. Joel D. Cline and Dr. Richard A. Feely

COST: $101,600

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: October 21, 1977

ENDORSEMENTS:

Principal Investigators	Joel Cline	11/2/77 Date
	Richard A. Feely	11/2/77 Date
Director, PMEL	John R. Apel	11/4/77 Date
Financial Officer, PMEL	Ralph Cunningham	11/2/77 Date

Background

Low Molecular Weight Hydrocarbons

Observations into the distributions and abundances of the low molecular weight aliphatic hydrocarbons in several OCS areas of Alaska have been carried out over the past two years. These studies have shown that, under certain constraints, the abundances of the higher homologs of methane, together with the alkane/alkene ratio, serve as an operational indicator of the presence of petroleum-derived hydrocarbons. This was shown to be the case in Norton Sound with the discovery of a submarine gas seep (Cline and Holmes, 1977) and more recently in Cook Inlet.

A recent survey of LMWH in the region just north of The Forelands documented the occurrence of unusually high concentrations of ethane, propane, and butanes, not accompanied by a similar increase in the olefins. Examples of the distributions of ethane and propane are shown in Figures 1 and 2 for the month of July 1977 (Cline, 1977). The source of these hydrocarbons appears to be the MacArthur oil field located in Trading Bay, but no attempt was made to delineate the source or nature of the input. In a survey of dissolved LMWH conducted in 1968, elevated concentrations of methane were observed in the region between The Forelands and just to the north in Trading Bay (Kinney et al., 1970). Unfortunately, analytical difficulties precluded the analyses of the higher homologs of methane although we assume they were present.

The source of these gaseous hydrocarbons may include subsurface seepage from structural faults or leakage from production platforms. The earlier measurements of Kinney et al. (1970) and those of ours in April and July of this year suggest that the source is chronic in nature. Moreover, the

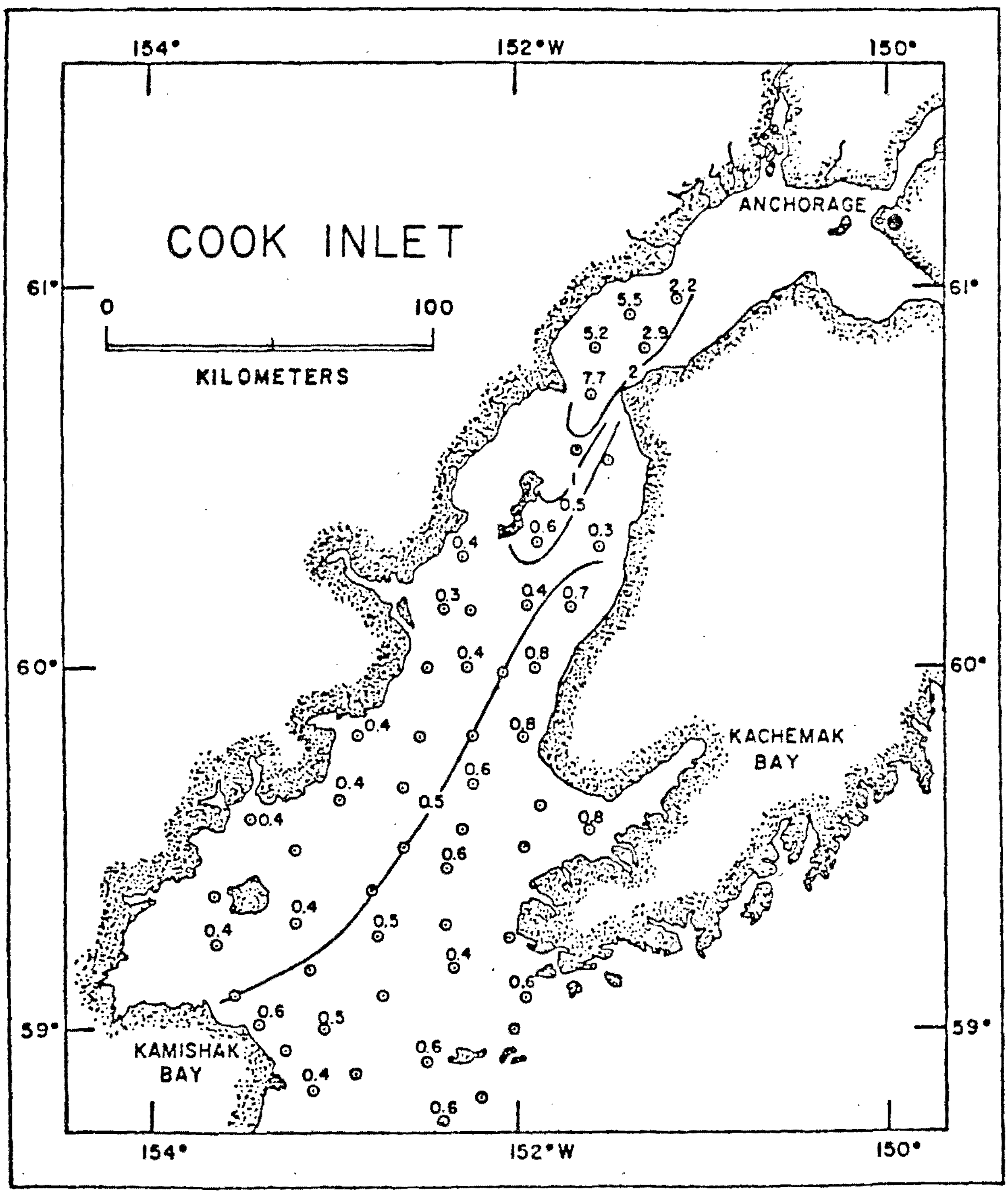


Figure 1. Distribution of ethane (nℓ/ℓ, STP) in the surface layers during July 1977. Concentrations not shown at all stations for the purpose of clarity.

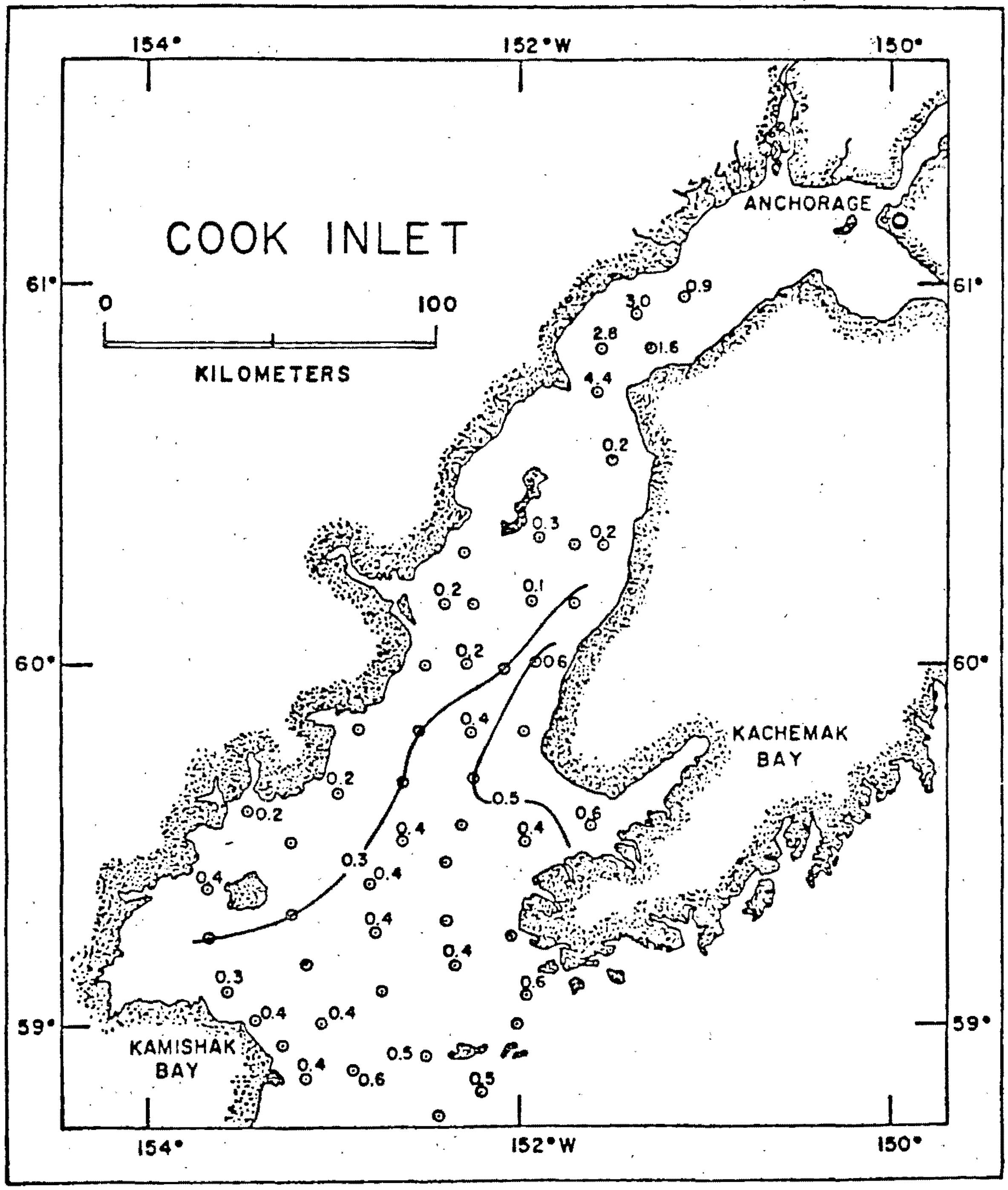


Figure 2. Distribution of propane (nℓ/ℓ, STP) in the surface layers during July 1977. Concentrations not shown at all the stations for the purpose of clarity.

heavier fractions of petroleum may be associated with it, since the MacArthur field produces mostly petroleum (API 33) with the dry gas component being used to run machinery associated with the liquid extraction plant (Blasko, 1974).

The detection of the LMW alkanes is largely confined to the region between Trading Bay and Kalgin Island. It is assumed that strong tidally-induced vertical and horizontal mixing (see Figures 1 and 2) results in rapid dilution and volatilization of these components. The lower inlet, in contrast to the area above The Forelands, reflects a strong seasonal biological component of LMWH (Cline, 1977). Lower Cook Inlet, in particular the region near Kamishak and Kachemak Bays, reveals elevated concentrations of the C_2 and C_3 alkenes during summer, which is presumably related to primary productivity, either directly or indirectly, or to possible photochemical effects (Wilson et al., 1970). Our work has shown that under normal conditions the ethane/ethene ratio rarely exceeds 0.5 in most shelf areas and is more nearly 0.1-0.2 for Cook Inlet during summer. There is a concomitant rise in the concentration of ethane that accompanies increases in ethene, but the $C_{2:0}/C_{2:1}$ ratio rarely exceeds 0.5. How these two C_2 aliphatics are related is not clearly understood, but that relationship has direct bearing on the utility of the LMW aliphatics for the detection and discrimination of petroleum-induced hydrocarbons, whether it be in Cook Inlet or elsewhere over the Alaskan OCS.

The LMWH also appear to be produced in marine sediments (Bernard et al., 1977). A systematic transect across the Texas Gulf coast shows a preponderance of methane, followed by ethene, propene, ethane, and propane in order of decreasing abundance. The average pore water concentration of LMWH shows that concentration of ethene generally exceeds that of ethane by a factor of 2, not unlike the results of our extensive water column work. To our knowledge, no systematic analyses of pore waters for LMWH have been undertaken in Cook Inlet, although the influence of this source on the composition observed in the water column must be assessed. This is particularly true in the southern portion of Cook Inlet where fine-grained sediments are more prevalent, but not necessarily abundant.

One of the relevant transport mechanisms of oil in the marine environment involves its association and retention by suspended particles. Preliminary experiments conducted in this laboratory (in vitro) have shown that substantial quantities of crude oil (up to 30% of the sediment weight) will agglutinate to natural suspended sediments and form large, rapidly settling flocs. These flocs may be transported great distances from their original source and impact both detrital-feeding pelagic and benthic organisms. The studies involving the nature of the sediment-oil interaction is continuing in this laboratory under research unit #152 (Feely and Cline).

Cook Inlet has a history of chronic exposure to crude oil arising from both production and transfer operations. Preliminary estimates place the input in the range of 9,500-17,500 bbl/hr (Kinney et al., 1970), mostly above The Forelands, where suspended matter concentrations generally exceed 100 mg/ℓ (Feely and Cline, 1977). While our measurements in the laboratory suggest that these sediments have a large capacity to retain oil, the measurements by Kinney et al. (1970) and Shaw (1977) show no significant increases in the levels of hydrocarbons in the water or associated with suspended sediments north of The Forelands. In the former case, the sample volumes were 4 ℓ; in the latter, the volume was 1 ℓ. While these results show no gross pollution of either the waters or the suspended matter, the sample volume may have been too small to detect incipient contamination of suspended matter with crude oil. More refined techniques are required to assess the importance of suspended matter in the transport of oil in Cook Inlet, particularly in view of the high transport rates of water and associated suspended matter.

Objectives

The objectives of this study are twofold. They include an expanded assessment of the validity of LMWH (aliphatics and aromatics) to detect low level input of petroleum-related hydrocarbons and the evaluation of the significance of suspended matter in the transport of petroleum through The Forelands.

LMWH

During the forthcoming year, detailed hydrographic studies will be conducted north of Kalgin Island into Trading Bay for the purpose of delineating the composition and concentration of dissolved LMW aliphatics and aromatics. These compositions will be related to the constituents of petroleum crude presently being produced from the region. Within navigational and time constraints, an attempt will be made to identify the source of the hydrocarbons, although intense tidal mixing in the area will necessarily complicate this objective.

In a continuing effort to refine our knowledge concerning the utility of the LMWH as an early warning system for the introduction of petroleum hydrocarbons, a detailed study of the relationships between the occurrence of LMWH and primary production will be initiated in Kachemak Bay. This study will focus on various alkane/alkene ratios and will attempt to correlate our findings with primary production, incident light levels, chlorophyll, hydrographic parameters, and wind speed. This last factor is important because the hydrocarbons of interest are gaseous and readily transported across the air-sea boundary. This particular study will be supported by a systematic analysis of interstitial waters for the LMWH with the aim of identifying compositional relationships prevalent in the near surface sediments. In shallow, highly productive areas (e.g., Kachemak Bay), the production of hydrocarbons from the bottom may represent a significant local source.

Suspended Sediment - Oil Transport Studies

The principal objectives of this work element are to assess the significance of suspended sediments in the transport of oil through The Forelands and to evaluate the composition of any agglutinated hydrocarbons. In an ancillary study, an effort will be made to identify the nature and amount of petroleum-related hydrocarbons transported vertically via suspended matter. These estimates will be constructed from a hydrocarbon analysis of suspended matter collected in sediment traps placed in an east-west array between Kachemak and Kamishak Bays. An attempt will be made to correlate the composition of petroleum hydrocarbons retrieved from the sediment traps with the probable source area to the north.

Scientific Approach and Sampling Strategy

The implementation of the proposed interdisciplinary chemical and biological study will be initiated in late spring of 1978. The field program will consist of two cruises to Cook Inlet, the first in May 1978, to coincide with the season of maximum primary production; the second in August of 1978 during a period of biological subsidence. The study will be fully integrated with other PMEL components (physical and biological studies) as well as other institutions such as the University of Alaska and the University of California at Los Angeles.

This study will focus on two quite dissimilar subregions of Cook Inlet. These include the area north of Kalgin Island, including Trading Bay, and the biologically active Kachemak Bay. The first of these is characterized by minimum biological activity and high concentrations of suspended matter; the latter by higher biological activity and much reduced concentrations of suspended matter.

Upper Cook Inlet Including The Forelands

Studies in this region will focus on the distribution of low molecular weight aliphatics and aromatics in the water column and their trajectory south past Kalgin Island. The region of interest is shown in Figure 3 with station spacing approximately every 5 naut. mi. Vertical sampling will be conducted at 3 depths at each station. Because of the intense vertical mixing encountered in this region, this number of samples should be sufficient to document "average concentration" profiles.

The second major effort will focus on the distribution of the heavy molecular weight aliphatic and aromatic hydrocarbons associated with suspended sediments. For this study a 48 hr. time series station will be occupied in Trading Bay with the aim of collecting suspended matter every 6 hours. Assuming a mean concentration of suspended matter of 100 mg/ℓ, approximately 18 g (dry weight) of sediment can be retrieved every 6 hours. Thus, it should be possible to delineate tidally-induced variations in the source material. The sediment will be collected with a continuous flow centrifuge. In concert with these activities, the water column will be monitored every 6 hours for LMWH.

The aforementioned observations will be supported by vertical C-T-D profiles at each station, including the time series station in Trading Bay. A minimal survey of suspended matter concentrations in upper Cook Inlet will be performed under the supervision of Dr. Feely. Because of the vertical homogeneity of the water column in the area north of The Forelands, suspended matter samples will be taken from surface and bottom at 4 stations and analyzed for TSM, C/N ratios, and Si/Al ratios. Similarly, at the pumping station in Trading Bay, suspended matter samples will be taken from both the inflow and outflow of the centrifuge and analyzed for TSM, C/N and Si/Al ratios. This will be accomplished every 12 hours on a routine basis to document extraction efficiency and compositional variability, should it occur.

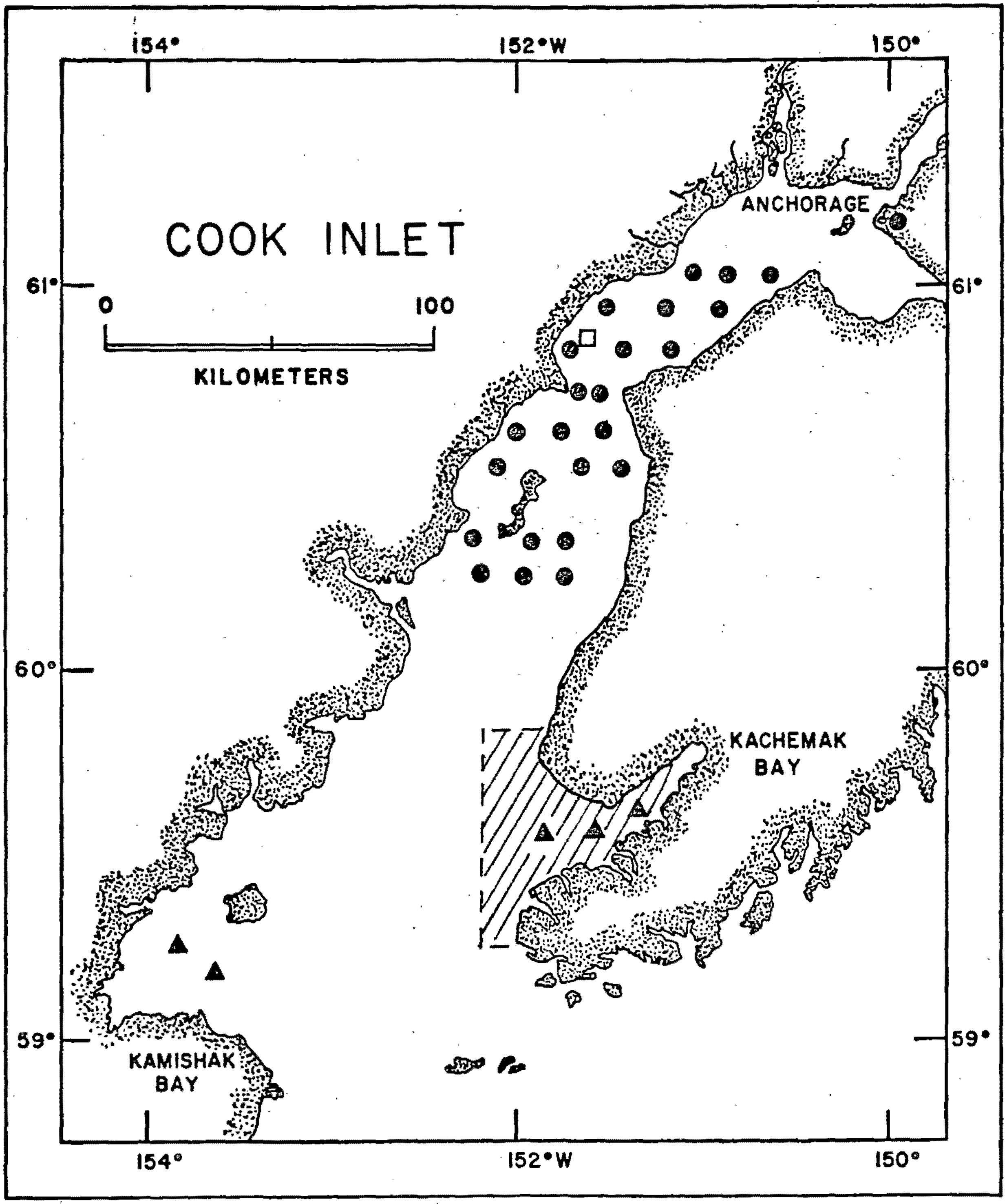


Figure 3. Proposed sampling grid for Cook Inlet. The solid circles represent water column stations; the solid triangles the location of gas harpoon stations. The open square in Trading Bay is the tentative location for the 48-hour pumping station. Water column sampling for LMWH in Kachemak Bay will be in concert with elements of the biological program and at their discretion. The cross-hatched area represents the general region of interest.

Lower Cook Inlet - Kachemak and Kamishak Bays

This study will focus on the relationships between primary productivity and LMW aliphatic hydrocarbon production primarily in Kachemak Bay. Water samples will be taken from selected stations and analyzed for the aliphatic hydrocarbons in conjunction with certain biological measurements. The necessary support measurements include, but are not necessarily limited to, salinity, temperature, primary productivity, chlorophyll, suspended matter, nutrients, oxygen, incident light, and sea state. Our responsibilities under this proposal include LMWH analysis, suspended matter characterization, salinity, temperature, and sea state. We assume that the other variables will be routinely monitored by the biological component. Because of the large diurnal effect associated with primary production, and because of the tidal influences, there is considerable merit to conducting a study of primary productivity at one location for at least 48 hours.

The water column observations in Kachemak Bay will be supported by similar measurements of LMWH in pore waters. The nature of the gas harpoon requires that only fine-grained sediments be sampled, hence the sampling be limited to soft sediments in the interior regions of both Kachemak and Kamishak Bays. We propose three harpoon drops in Kachemak Bay and two in Kamishak Bay. Sampling protocol will be repeated during each cruise in order that seasonal changes in the near-surface sediments may be evaluated.

As a part of our study to document the significance of suspended matter in the transport of petroleum, suspended particulate material retrieved from the array of sediment traps in LCI will be analyzed for heavy hydrocarbons, both aliphatic and aromatic fractions. A total of 3 arrays will be deployed with duplicate traps mounted within 7-10 m of the bottom. One of the duplicates from each array will be set aside for heavy hydrocarbon analysis. The experiment will be repeated twice yielding a total of 6 samples. The sediment will be recovered from the traps, frozen immediately, and returned promptly to the laboratory for analysis. The suspended material from which the hydrocarbons are extracted will be characterized under research proposal R.U. #152 (Feely and Cline).

Sampling Methods

Sampling of the water column and suspended matter for petroleum-derived hydrocarbons will be conducted during two cruises to Cook Inlet in May and August 1977. The general geographical areas of interest are shown in Figure 3, together with preliminary estimates of the station locations.

1. Upper Cook Inlet. It is proposed to occupy 23 water column stations (●) in the vicinity of Kalgin Island and north of The Forelands. The location of the individual stations is not precise at this time and may be shifted or eliminated altogether depending on water depth, weather, and navigational difficulties. Tentative location of the 48-hour pumping station is shown as an open square symbol on Figure 3.

2. Kachemak Bay. Water column sampling for LMWH will be largely constrained by the nature and scope of the biological program. The aim is to sample concurrently with measurements of primary productivity. The general area of interest is cross-hatched in Figure 3. Gas harpoon samples will be taken at the 3 stations shown in Kachemak Bay. Because the evaluation of bottom sediment textures and organic carbon concentrations is necessary to interpret gaseous hydrocarbon production, this aspect of the study should be coordinated with trace metal studies of bottom sediments.

3. Kamishak Bay. The field study in Kamishak Bay will be largely limited to the acquisition of two gas harpoon samples in the southwestern sector. Again, station locations are tentative as soft sediments must be sampled. As before, ancillary data requirements are bottom sediment textures and organic carbon concentrations.

4. Lower Cook Inlet - Sediment Trap Studies. The location of the 3 sediment trap arrays will be shown in the proposal by Feely and Cline (R.U. #152).

Analytical Methods

1. LMWH-Water Column. LMWHs are stripped from a 1-ℓ volume of seawater using a modified procedure recommended by Swinnerton and Linnenbom (1967). A diagram of the gas phase extractor is shown in Figure 4. Although the system actually used by us is somewhat simpler in detail than that reflected in Figure 4, the principal remains the same.

Chromatography of the components is effected on a column of Poropak® Q (4' x 3/16"), 60-80 mesh, in series with a small column of activated alumina (3/16" x 2") impregnated with 1% silver nitrate by weight. This dual column configuration results in sharper peaks, better separation of olefins, and reduced component retention times. Chromotography of LMWH components through C_4 is accomplished in less than 6 minutes. Detection of the component hydrocarbons as they emerge from the column is performed with a flame ionization detector.

Aromatics will be stripped from solution in an analogous fashion and trapped on Tenax GC®, which does not retain water. The LMW aromatics will be backflushed off the Tenax column at > 250° C and chromatographed on 6' x 3/16" columns of 5% SP-1200/1.75% bentone 34 on Supelcoport (100-200 mesh).

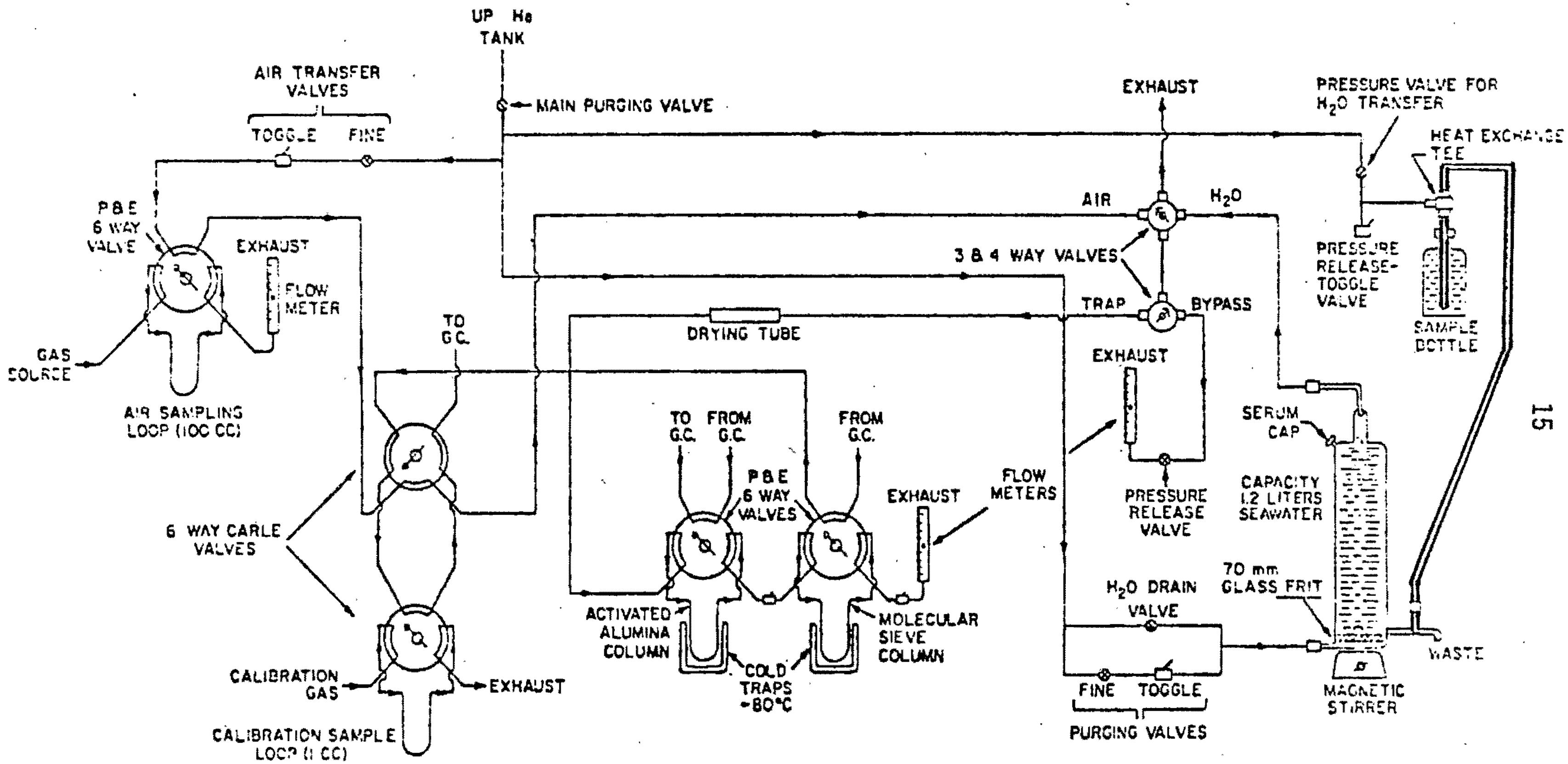


Figure 4. Schematic diagram of gas extractor.

Preliminary laboratory studies have been performed with the column material, and resolution of benzene, toluene, xylenes, and ethylbenzenes has proven highly successful. However, much more work is needed to define stripping parameters of the LMW aromatics as well as their systematic recovery from heated Tenax. At the present time, the procedure is specific up to ethylbenzenes. We shall attempt to extend our measurements up to napthelenes.

2. LMWH - Interstitial water. Interstitial water samples will be taken with a harpoon sampler (fig. 5) similar to that described by Sayles et al. (1973). Its obvious advantage is that dissolved gases in pore waters can be sampled without contaminating or exposing the sediment to ambient degassing. This instrument acts as a large syringe with a spring loaded master cylinder providing the suction. Full 1½-m penetration triggers the suction, and at each of the 8 to 10 sampling ports interstitial water is drawn through a Whatman filter into precalibrated stainless steel loops. The maximum capacity of each port is 20-25 mℓ. The captured pore water is extruded into a 25-mℓ gas stripper and purged of its hydrocarbon gases. Analysis of the components is the same as presented in subsection 1 above.

A shorter version of the harpoon was successfully deployed in the Northeast Gulf of Alaska in April 1977. Ambient concentrations of the LMW aliphatics (not in a seep area) were sufficiently high to give a strong signal for each of the C_1-C_4 hydrocarbon components stripped from 20 mℓ of pore water.

3. Suspended Matter - Heavy Hydrocarbon Analyses. Suspended matter collected from the traps and by continuous flow centrifugation will be analyzed according to the procedures established by MacLeod et al. (1976). Briefly, an appropriate weight of sediment (10-50 g) is dewatered with methanol, then extracted with a methylene chloride/methanol mixture for

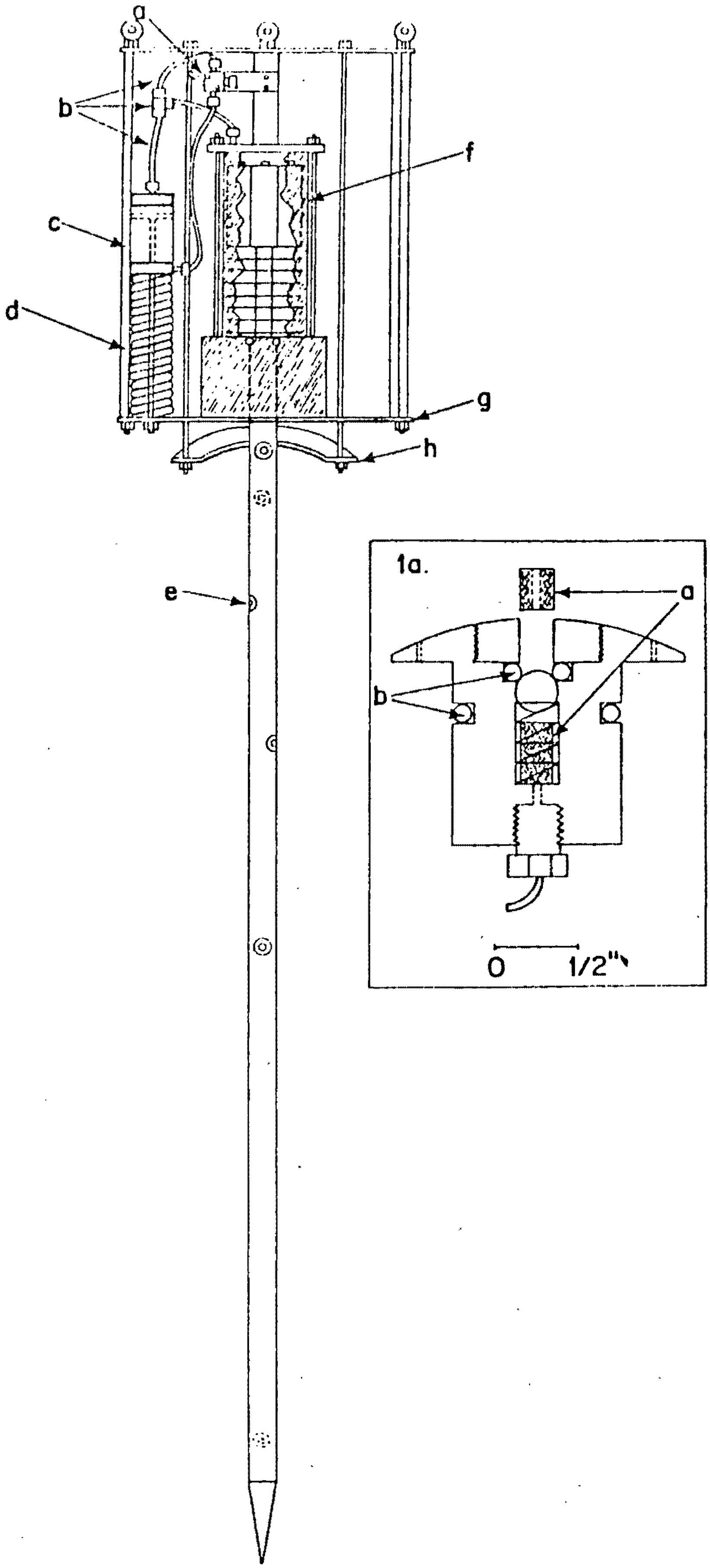


Figure 5. Gas harpoon, interstitial water sampler.

18-24 hours in a ball mill tumbler. The extraction is repeated and the washings and extracts combined. Additional dewatering is accomplished and removal of particulates and humic material is effected by passing the extracts through a small bed of silica gel and washing with methylene chloride. The eluate is concentrated to approximately 2 mℓ and the solvent changed to hexane. At this point the sample is chromatographed on silica gel to separate the aliphatic and aromatic fractions; sulfur is removed from each fraction. After concentration of each fraction to approximately 0.5 mℓ, the two samples are ready for GC analyses.

This laboratory will collect the samples, extract the petroleum hydrocarbons, and determine the major aliphatic components (C_{12}-C_{32}), including pristane and phytane. We are also capable of analyzing the aromatic fraction, but component identification may require GC-MS spectroscopy. This will be done only after a preliminary screening in our own facilities has been carried out. All of our procedures and calibrations will be coordinated with OCSEAP/BLM requirements and cross-checked with the same procedures in NNAF.

Analysis of the aliphatic fraction will be made with a Packard model 5730 GC equipped with a model 3385 microprocessor and automatic sampler. Resolution of components will be made with a wall-coated, 30-m open tubular glass capillary column. The column is 0.25 mm i.d. and coated with SE-30.

4. Analyses of Suspended Matter. The aluminum and silicon concentration of the particulate matter will be determined by x-ray secondary emission (fluorescence) spectrometry utilizing a Kevex^{R} model 0810A-5100 x-ray energy spectrometer and the thin-film technique (Baker and Piper, 1976; Massoth et al., in preparation). The inherent broad band of radiation from an AG x-ray tube is used to obtain a series of characteristic emission lines from a single element secondary target which then more efficiently excites the thin-film sample.

Standards are prepared by passing suspensions of finely ground USGS standard rocks (W-1, G-2, GSP-1, AGV-1, BCR-1, PCC-1) and NBS trace element standards through a 37-μm mesh polyethylene screen followed by collection of the size fractionated suspensates on Nuclepore^R filters identical to those used for sample acquisition. The coefficient of variation for 10 replicate analyses of a largely inorganic sample of approximately mean mass was less than 3% for the major constituents and as high as 5% for the trace elements. However, when sampling precision is considered, the coefficients of variation increase, averaging 12% and 24% for major and trace elements, respectively.

Analysis of total particulate carbon and nitrogen is carried out with a Hewlett Packard model 185B C-H-N analyzer. In this procedure, particulate carbon and nitrogen compounds are combusted to CO_2 and N_2 (micro Dumas method), chromatographed on Poropak^R Q, and detected sequentially with a thermal conductivity detector. NBS acetanilide is used for standardization. Analyses of replicate surface samples yield coefficients of variation ranging from 2% to 10% for carbon and 7% to 14% for nitrogen.

Anticipated Problems

We foresee no major difficulties for the implementation of the program, as all procedures have been successfully employed in the field, except the analysis of LMW aromatics in marine waters. However, ample time is available between October 1, 1977 and the proposed cruise in May 1978 to perfect the stripping and chromatographic analyses of the aromatics.

Deliverable Products

1. Digital Data. The low molecular weight aliphatic components (methane, ethane, ethene, propane, propene, iso- and n-butanes) will be reported in digital form on IBM punch cards. An OCSEAP format currently exists for their submission to NODC/EDS.

The aromatic components, benzene, toluene, o-, p-, m-xylenes, and several of the chromatographable ethylbenzenes will be reported in digital form, but to our knowledge no format exists for their inclusion in the data base of NODC/EDS. Discussions will commence immediately with Mr. Dean Dale of EDS on how this can best be accomplished.

Analyses of suspended matter for associated petroleum hydrocarbon will include the quantifiable range of both aliphatics and aromatics. Major aliphatic contributions in the range C_{14} to C_{30} will be reported, as well as 2- to 5-ring aromatics determined by GC-MS spectroscopy. The data format to be used is currently being developed for MESA for the reporting of hydrocarbons in beach sediments, but should adapt well for our purposes. Data will be submitted in digital form on punch cards.

The characterization of the suspended matter will include the total suspended load concentration, organic carbon and nitrogen concentrations, and the analyses of the major element compositions of the suspended matter. The data will be submitted in digital form on IBM cards in accordance with an existing OCSEAP format.

2. Reports. Quarterly and annual reports will be submitted in narrative form in accord with preestablished schedules. For the purpose of brevity, the results presented in graphical and tabular form will be kept to a minimum and will contain the most relevant findings relative to the stated objectives.

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 Formatting done by PI (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
LMW-aliphatics[1]	cards	300 cards	043	completed	May/1978 and August/1978	Sept. 1978
LMW-aromatics[1]	cards	approx. 400 cards	none	no	May/1978 and August/1978	Oct. 1978
Heavy hydrocarbons-suspended matter	cards	60 cards	044	completed	May/1978 and August/1978	Dec. 1978
Chemistry of suspended matter	cards	20 cards	021	completed	May/1978 and August/1978	Oct. 1978

[1]No format exists for the reporting of interstitial water aliphatics or aromatics.

These reports will be augmented with formal reporting of significant findings through scientific journals and technical memos, as seems appropriate. Because of the integrated nature of this study, it is highly likely that several journal publications will result.

All reports and publications will contain, in addition to the narrative discussion, relevant tables and graphs depicting relationships and distributions of the various parameters being observed. Various hydrocarbon parameters will be tested for uniqueness in the identification of petroleum-derived hydrocarbons. Data on the subsurface distribution of LMWH will be presented in vertical profiles. Information on sediment distributions will be presented on areal surface charts; compositions of suspended sediments at typical selected sites will be described in tabular form, much the same way as it is now done in research unit #152.

3. Nondigital Data. All hydrocarbon analyses performed with a GC result in analog chromatograms showing concentrations and retention times (component identification). These recorder traces are available for inspection or inclusion in the data base at the request of the project office.

Ancillary Information

The work to be performed under this proposal will be supplemented by hydrocarbon and trace metal analyses covered under separate research units (Nos. 275, 162, 480, 290, and 5). These studies will be coordinated with our efforts as suggested above. The biological interface with primary production studies needs to be focused; presumably the necessary coordination will be accomplished this coming November during a biological planning session covering activities in LCI for FY 78.

Quality Assurance

The low molecular weight hydrocarbon analyses will be calibrated against NBS standards. An intercalibration procedure involving the aromatic fraction has not been worked out at this point, but similar analyses are currently being performed at NBS in Washington, D.C., and we will attempt to intercalibrate with them, or with Dr. Brooks of Texas A&M University.

The heavier aliphatic hydrocarbon fraction (C_{12}+) will be calibrated with coinjected standards (C_{12}-C_{32} paraffins) and compared to similar analyses being performed by the National NOAA Analytical Facility. This laboratory is also proposing to intercalibrate with a number of other institutions across the country (e.g., NBS, IMS, UCLA, Battelle-Columbus). In this regard, the BLM reference hydrocarbon mixture shall be used to evaluate the extraction, separation, and recovery efficiencies of our (NNAF) analytical procedure for the analysis of suspended sediment. To assess intralaboratory precision and methodologies, we will analyze a sediment split to be provided by OCSEAP. The sediment sample will be analyzed in triplicate.

Analytical results obtained on the aromatic fraction will be substantiated by selected GC-MS analyses performed by NNAF. Our aim is to identify major components by their retention times compared to co-injected standards and to use mass spectra where applicable. It should be possible to identify the relative contributions of the 2, 3, 4, and 5 ring aromatics based on retention time "windows."

Analytical results on the composition of suspended matter will be based on USGS standard rock samples. Calibration of the organic carbon/nitrogen analysis will be based on the organic compound acetanalide and gas standards (CO_2, N_2 in helium) provided by Matheson Gas Products.

Sample Archival

No samples as a part of this study will be archived, except the suspended matter samples taken for elemental analysis by nondestructive energy dispersive x-ray fluorescence. These samples will be retained on Nuclepore membrane filters for subsequent analyses of intercalibration. These samples will be retained by the principal investigator at no cost to the project for the duration of the program; longer if special archiving procedures are developed.

Management Plan

The management of this program, including the planning and implementation of the cruises, is the responsibility of Drs. Joel Cline and Richard Feely. Their responsibility also extends to the coordination of efforts by other P.I.'s involved in the Cook Inlet study in order that the goals of the program are fully understood and the final results are comprehensive and scientifically integrated. The timely submission of reports and their scientific credibility is also the sole responsibility of the principal investigator.

All of the observations and analyses stated above will be performed by PMEL staff members. Mr. Anthony Young is in charge of program logistics, field operations, analyses of LMWH, and instrumentation development. Mr. Gary Massoth will direct the suspended sediment sampling and analysis program, and be responsible for the analysis of suspended matter for carbon and nitrogen.

The analysis of the suspended matter for petroleum hydrocarbons is the responsibility of the laboratory chemist (to be hired in December) and Ms. Susan Hamilton, a graduate student at the University of Washington. Mr. Charles Katz is a graduate student in the U.W. Department of Oceanography and will be responsible for the development of the analysis of the low molecular weight aromatics. Secretarial duties required under this contract will be performed by Ms. Giese. With the exception of Ms. Giese, all personnel will participate on the cruises.

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 PMEL/NOAA PRINCIPAL INVESTIGATOR Dr. Joel Cline Dr. Richard Feely

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 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.

   (1) Water samples, (2) CTD, (3) Grab samples, (4) Gas harpoon samples, (5) Continuous pumping of water for suspended matter.

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) Early May 2) Early August

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.)

   Approx. 10 days/cruise

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

   Sampling and processing ~ 3 hr/sta; approx.

6. What equipment and personnel would you expect the ship to provide?
   (1) Survey technicians, (2) Sample bottles, (3) CTD fish and rosette, (4) Van Veen Grab sampler

7. What is the approximate weight and volume of equipment you will bring?

   3,000 lbs.

8. Will your data or equipment require special handling? Yes If yes, please describe:
   Gas harpoon may be difficult to field in rough weather

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.

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.

    NOAA: (1) Discoverer or (2) Miller Freeman

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
    R/V Acona must be used in upper Cook Inlet and shallow waters in Kachemak and Kamishak Bays.

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

    We will field 3 people per cruise.

Outlook

Upper Cook Inlet is presently the site of significant gas and oil production, and it appears that Lower Cook Inlet might achieve similar status. The input of spilt oil into the waters of Cook Inlet could conceivably double in the next few years. With this in mind, it is suggested that a concerted effort into the fate of oil in Cook Inlet be initiated. Evidence derived during our April 1977 cruise to LCI showed high concentrations of LMWH in the southward-flowing current west of Kalgin Island. Numerous small tar balls (~ 1 mm dia.) also were observed in the water samples.

Emphasis should be placed on the identification of sources of oil in Upper Cook Inlet (i.e., subsurface and surface platforms, natural seeps, transportation, biogenic production from intertidal areas, etc.), quantities being introduced, and the ultimate fate of the oil. Distribution and composition of the LMWH (aliphatic and aromatic) should provide identification of the sources, as well as the residence times, of the dissolved components of petroleum.

A continuing effort should be given to the interactions of oil and sediment particles. Environmental control parameters regulating the active transport of oil by suspended matter need to be clarified (Research Unit #152). Deserving special attention are the physico-chemical processes responsible for the agglutinization of oil and particles and what controls the size of the particles. Work already proposed for FY 78 under Research Unit #152 should provide the basic strategy for supplemental studies.

Studies currently underway on plankton distribution in Puget Sound have shown what appears to be small tar balls in the gut of certain zooplankton. If this observation is supported by hydrocarbon analyses of the organisms, then herbivores, and possibly detrital feeders, are assimilating oiled particles directly from suspension. In view of the substantial quantities of oil entering Cook Inlet, zooplankton populations should be examined for petroleum hydrocarbon content.

This year's chemical effort will focus on Cook Inlet, primarily because of leasing schedules and minimal logistical difficulties. However, if the Norton Sound seep is found to be accompanied by liquid petroleum, subsequent planning should include studies of dispersion mechanisms, including sediment transport, chemical weathering, and the potential impact on sensitive benthic biological communities. These studies would require an interdisciplinary approach, similar to that presently being planned for lower Cook Inlet.

Our response to this site-specific study in Norton Sound will include (1) plume tracer studies, (2) sediment transport mechanisms, (3) oil solubilization from particulate matter, and (4) chemical weathering of oil entrained in bottom sediments. A necessary adjunct to this work would be oil-sediment interaction studies, similar to those being performed with Cook Inlet sediments. Sediments derived from the Yukon River are characteristically enriched in clay minerals (i.e., chlorite, illite, montmorillonite) compared to the detrital abraided rock material found in Cook Inlet.

General Stipulations

It is understood that the principal investigators will:

1. Submit updated quarterly activity/milestone/data management charts.

2. Submit quarterly reports 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 April 1. Also, the final report will be submitted within 90 days of the termination of the contract.

3. At the option of the project office, travel to the project office at least twice during the contract year to review the project status and progress.

4. Submit all data in a form and format specified by OCSEAP, accompanied by a data documentation form (NOAA 24-13).

5. Submit data within 120 days of the completion of the cruise or 3-month data collection period, unless a written waiver has been received from the project office.

6. Submit to the project data manager within 10 days of the completion of the cruise or data gathering effort, a ROSCOP data collection inventory form (NOAA 24-23).

MILESTONE CHART

RU #: 153 PI: Drs. Joel Cline and Richard Feely

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
Planning, instrument development, methodologies															
Cruise, LCI															
Results, LMWH; water column, pore waters															
Results, heavy hydrocarbons; Quarterly Report															
Cruise, LCI															
Results, LMWH; water column, pore waters															
Results, heavy hydrocarbons; Quarterly Report															
Draft Report on Cook Inlet Studies															

RESEARCH PROPOSAL

to

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

DISTRIBUTION AND DYNAMICS OF HEAVY METALS IN ALASKAN SHELF ENVIRONMENTS SUBJECT TO OIL DEVELOPMENT

RU# 162

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

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C. TECHNICAL PROPOSAL

I. Title

Distribution and Dynamics of Heavy Metals in Alaskan Shelf Environments Subject to Oil Development

Research Unit No. 162

II. Principal Investigator

Dr. David C. Burrell

III. Cost of Proposal (FY 78)

C.	Total	$172,000
D.	Lower Cook Inlet	85%
	Beaufort Sea	15

IV. Background

Studies of heavy metal distributions have been an integral part of the OCSEAP program from its beginnings in the Gulf of Alaska. Studies undertaken for this program have now been conducted in all the projected Alaskan lease areas. In every previous annual report and proposal we have discussed the possible ways in which the natural geochemical distributions of the metals may be affected by industrial development and potential impact of massive doses of hydrocarbons in the shelf and coastal regions. Three types of impingements have been emphasized in particular:

i. Heavy metals indigeneous to crude oil;
ii. Toxic metals from the associated formation waters, drilling muds and engineering structures;
iii. Perturbations of the geochemical environment from massive oil spills leading to remobilization or removal of "available" forms of the metal.

We have always maintained that the only possible quantitatively important impact must be of type (iii). A brief background on the toxicity of heavy metals in the marine environment was given in this years Annual Report (Burrell, 1977a). This latter included a brief mention of the liklihood of soluble toxic concentrations being attained in the oceans. A more thorough discussion of this topic, with specific reference to copper, has been given by Burrell (1977b). In brief, it appears possible that natural concentrations of some heavy metals may overlap toxicity thresholds for some marine species under certain conditions: this latter largely having to do with the chemical form of the metal in solution (marine chemical speciation is a very complex and poorly understood topic; our laboratories in Alaska have worked in this field for many years). Certainly, on the basis of presently available evidence, there are grounds for believing that subtle changes in the pertaining geochemical environment, such as could well be associated with massive oil spills, could drastically affect the bioavailability of toxic metals. Continuing research on distribution and dynamics of the heavy metals continues to be of prime importance.

It is believed that no useful purpose is served by continuing to pursue large scale surveys of heavy metal concentrations over the vast lease areas involved in the Alaskan OCS. Studies of concentrations of a wide range of heavy metals in solution and in total sediment samples has demonstrated no anomolous trends (see Burrell, 1975a). Soluble concentrations in particular are generally lower than commonly accepted oceanic "means". Sediment contents are a function of the sediment grain size, with possibly a trend to enhancement of some metals (such as copper) in coastal areas.

Our overall focus in the past has been on the benthic boundary layer and on the biological communities living there. It is at this interface that remobilization of heavy metals from the sediment reservoir may occur (as recently demonstrated for copper under natural conditions by Heggie, 1977). However, multidisciplinary data presented at the Gulf of Alaska Synthesis Symposium appears to indicate that major oil impact would occur at the sea surface, and that little would reach the deep sea sediments. Similar work during FY 77 by other OCSEAP investigators has shown that oil is not strongly sorbed to Alaskan coastal marine particulates (presumable because of the highly polar nature of the predominantly glacially derived material) so that this potential transportation route to the deep waters has been challenged. Work in FY 77 was therefore focussed on open sea surface biota (notably marine mammals) and on estuarine and coastal intertidal benthic communities. This latter mostly involved work on *Mytilus* and *Fucus* indicator species and on physical transport processes in Gulf of Alaska estuaries.

In FY 77 we also narrowed our focus away from broadbrush coverage of the entire lease areas and adjacent regions to concentrate on specific study sites. The impetus for this redirection came out of the workshop held at the University of Alaska in July 1976. Use of small study areas, chosen for each lease area on well considered, multi-disciplinary grounds has enabled us to commence seasonal sampling, and to tie in ancillary biological and chemical studies with the heavy metal program. Because OCSEAP does not want a major emphasis in the Gulf or Bering Sea for FY 78, the major study site sampled this year has been deleted but the same work concept will be retained for Cook Inlet and the Beaufort Sea as described in the following sections.

References:

Burrell, D. C. 1977a. Natural distribution of trace heavy metals and environmental background in Alaskan shelf and estuarine areas. Annual Report to OCSEAP, Institute of Marine Science, University of Alaska. 204 p.

Burrell, D. C. 1977b. A review of the chemical speciation of copper in seawater. M.S. submitted for publication.

Heggie, D. T. 1977. Copper in the sea: a physical-chemical study of reservoirs, fluxes and pathways in an Alaskan fjord. Ph.D. dissertation, University of Alaska. 222 p.

V. Objectives

1. Lower Cook Inlet

The major emphasis of the FY 78 program will be to study the bio-uptake of selected heavy metals by benthic organisms. The major components and rationale are:

a. The importance of the benthic boundary layer with regard to potential release and transport of heavy metals. Sediments are the major reservoir for the metals and we are now beginning to describe natural fluxes back into the water column. It is necessary to further describe and understand the mechanisms involved prior to attempting to determine potential anthropogenic disruptions. For example, sediment surface remobilization reactions are almost certainly microbially mediated but little definitive information is available. It should be noted also that bacteria present at this interface are thought to constitute the primary food source for the deposit feeding clams discussed below.

It is most unlikely that such fluxes from the sediments into the base of the water column can be detected in Cook Inlet itself because of the atypical circulation patterns. Such work must be pursued in an environment where the bottom waters are sufficiently "static" to permit the development of detectable gradients, and will therefore have to be carried out in an adjacent Kenai peninsula estuary which is otherwise environmentally similar to Cook Inlet.

b. The choice of heavy metals to be studied. It is obvious that only a limited number of metals can be studied in a program such as this. We have chosen elements which may be considered paradigms of particular classes of metal or biogeochemical reaction. Thus:

i. Cu and Zn as micronutrients which are toxic in excess. Copper is particularly important because more is understood of the water column scavenging/release and sediment boundary reactions than any other heavy metal.

ii. Mn and Fe in the sediments as geochemical (particularly redox) indicators. It is also intended, where possible, to continue water-sediment flux work on Mn.

iii. Cd as a representative of metals which are highly toxic yet serve no (or minimal) metabolic role. OCSEAP has also requested work on Hg which would fall in this category.

iv. OCSEAP has requested some distribution studies on metals which are particularly associated with crude petroleum: nickel and vanadium.

We shall also include a number of particulate Al analyses as this parameter is required to determine organic/inorganic fractionation.

c. The choice of portions of the trophic web which are of particular concern as commercially important food species. It should be unnecessary to emphasize the importance of crab in Alaskan waters; Lower Cook Inlet is one of the more important fishing and breeding grounds for both snow and king crab. These species feed largely on detritivore clams, and *Macoma* and *Nuculana* in particular. Hence there is a short pathway only between the sediment and man, and induced changes in the bioavailability of metals at the surface of the sediments may be of practical concern.

d. Flux of metals through the food chain. To date we have determined the static levels of the heavy metals in a number of species. It is necessary now to try and determine the pathways and rates of flow of these metals within the food chain noted previously. This goal is only now potentially obtainable because, concurrent with the chemistry program, data is beginning to be generated by the benthic biologists regarding preferred foods and feeding/depuration rates. The chemistry program proposed here can only be accomplished in close cooperation with the ongoing biology and microbiology programs. Two approaches are proposed:

i. Field collection of sub-tidal clams and crab together with substrate samples and analysis of metal contents. These latter data to be correlated with the biological carbon flow work.

ii. Culturing of these same species in our Seward facility aquaria and initial attempts to monitor the uptake and release of added metal contaminants in conjunction with the oiling experiments. This work is also to be strictly in conjunction with the concurrent biology and hydrocarbon chemistry investigations.

In addition to this major food chain investigation we also have a requirement to determine the distribution of metals in the water column at each of two stations within Cook Inlet. Katchemak Bay is primarily impacted by inflowing Gulf waters and has a complex gyral circulation. A contrasting station is to be selected higher in the Inlet in an area adjacent to ongoing petroleum production and one impacted by out-flowing glacially derived, turbid water.

2. Beaufort Sea

We have quite insufficient baseline data for the nearshore Beaufort Sea and efforts will be made to extend this coverage in FY 78. At the same time, however, there appears to be sufficient biological information to indicate the importance of certain epibenthic species within the restricted Arctic food web. *Mesidotea* and *Mysis*, for example, appear to service a range of higher organisms including fin fish and marine mammals. Again, trophic relationships (feeding habits, carbon flow) are planned for this area according to the Coastal Lagoon Ecosystem proposal and we will cooperate closely with this program if at all possible. In addition there is just now some interest in starting some type of controlled food web aquaria studies at the Barrow laboratory. If this work progresses sufficiently during FY 78 we should like to add a heavy metal component similar to that proposed for the Seward experiments.

VI. General Strategy and Approach

1. Lower Cook Inlet

Three major sampling expeditions are planned for this region in FY 78: November 1977, and spring and summer of 1978. During the winter trip it is proposed to collect the benthic biota species specified above together with coexisting sediment. This latter will be analysed for extractable heavy metals according to a scheme to be agreed upon (see below) and also for grain size fractionation and organic carbon content. The relationship of grain size to specific clam species habitats and food supply is most important; likewise the amount of biologically "available" metal is also a function of sediment surface area.

Heavy metal uptake and transfer experiments on aquaria organisms are being currently planned. The background to this phase of the work is as follows:

i. A running seawater system has been installed in the Seward lab facilities where both stationary and flow-through experiments are available.

ii. Perturbation experiments by crude oil on intertidal *Macoma* samples have begun.

iii. Plans have been made to collect the sub-tidal *Macoma* and crab prey species in November and to transport these live to Seward.

iv. The capacity of the controlled habitat available for use will be greatly extended by bringing into use large "aquaculture ponds".

During the spring and summer cruises water column sampling will be conducted at the two stations noted previously along the lines of the scheme discussed at the September (1977) OCSEAP Chemists Coordination Meeting, and in conjunction with the other participating chemists, biologists and microbiologists. Where possible, water column samples adjacent to the sediment boundary will also be collected in an adjacent Kenai peninsula estuary for reasons noted above.

2. <u>Beaufort Sea</u>

The proposed program has been briefly outlined above. It is not possible to provide specific details until after the Beaufort Sea Coordination Meeting to be held early in the new year (1978). Field work will not be possible until mid-summer.

VII. Sampling Methods

Sub-tidal benthic species will be collected by trawl and dredge by the cooperating biologists. Samples for tissue analysis will be purged on board ship and transported frozen to the laboratory. Sediment substrate samples will be collected using the Haps corer for heavy metal analysis and *via* the Haps or van Veen grab for size fractionation and organic carbon determinations. Water column samples will be collected in go-flo Niskin bottles and filtered at 0.4 μm.

VIII. Analytical Methods

Analytical methods used will be basically as described and accepted in previous work statements. Modifications reflect both the primary focus on analysis of biota tissue and on aligning our procedures more closely to those used by other OCS investigators. The time limiting dissolution step for biological samples will be greatly speeded by use of an oxygen-plasma system and teflon bombs. Solution analysis will be by flameless atomic absorption using matrix matched standards.

A new sediment extraction scheme will be adopted after consultation with the other chemistry investigators. In order to obtain the very large number of sediment size analyses required, an automatic sizing system will be installed. This should remove one of the major problems plaguing the current contract work. Although Dr. C. M. Hoskin of this Institute is responsible for some of this work, his contract provides only one week of salary and it would hence be impossible to obtain the required data *via* conventional pipet analysis. Particulate organic carbon analysis will be by currently used methods.

Water column analysis will be largely by neutron activation analysis (Hg, Cu, Mn, and V) and this phase of the work will be under the supervision of Dr. H. V. Weiss who is an expert in this field. Cd analysis will be by stripping voltammetry.

The specific techniques are described in the latest Annual Report.

References:

Burrell, D. C. 1977. Natural distribution of trace heavy metals and environmental background in Alaskan shelf and estuarine areas. Annual Report to OCSEAP, Institute of Marine Science, University of Alaska. 204 p.

IX. Anticipated Problems

We anticipate no major problem with the work proposed. However, the aquaria experiments are still in the design stage and some problems in execution are unavoidable. Personnel problems with regard to water column analysis noted in the original June 1977 version of this proposal are still relevant.

X. Deliverable Products

This project will submit quarterly narrative reports which will include a discussion of current objectives, methods and techniques used in sampling, analysis and calibration. Discussion of data and significance of results will utilize graphical and tabular presentations where appropriate. Any digital data requirements will be handled by the University of Alaska OCS Coordination Office.

XI. Information Required from Other Investigators

Information from other investigators is essential to the scientific meaningfulness of this project. In particular, close cooperation with Drs. Feder and Shaw is essential and cooperation with other chemistry, biology, and microbiology investigators highly desirable. We have good working relationships with all of these investigators. However, they all have their own programs to operate as first priority and close coordination can only be achieved at the OCSEAP management level.

XII. Quality Assurance Plans

In the past, analyses of heavy metals in solution and whole rock analyses have been monitored by NBS. Duplicates of approximately 10% of all such samples have been submitted to this agency as required by contract, to date, no data have been returned however.

For some of the water analyses we have set up intra-laboratory calibration programs using fundamentally different instrumental techniques. The results of these have been given and discussed in the current Annual Report.

During FY 78 mostly biota tissue will be analysed for which reasonably good NBS standard reference material is available to monitor accuracy and precision of technique. A new NBS *Mytilus* standard is also being prepared. An inter-laboratory calibration program for the sediment extracts will also be initiated.

XIII. Special Sample and Voucher Specimen Archival Plans

Several years ago we proposed that sediment core and other samples be archived for future reference. This suggestion was not taken up by OCSEAP. In the intervening years our available freezer capacity has allowed us to retain sample material for approximately six months only after initial analysis, hence, we have no archived material on hand. It would be a simple matter to retain sub-samples of all material collected in the future if the program management required this.

XIV. Logistic Requirements

1. Lower Cook Inlet

Three cruises as specified by OCSEAP.

2. <u>Beaufort Sea</u>

Logistic plans not determined.

XV. Management Plan

Technical management will be provided by the principal investigator. Fiscal and data management will be provided by the University of Alaska OCS Coordination Office. A milestone chart is attached.

XVI. Outlook

This project starting as a broad survey of the natural heavy metal contents of seawater, selected biota and sediments in the various Alaskan OCS areas. This phase of the work was largely completed last year and final baseline data will be submitted this contract period. We first proposed last year that the best future direction of the heavy metals program should be towards an understanding of the dynamics of potentially toxic metals in the areas likely to be stressed by industrial development. This new focus - from baseline survey to transfer mechanisms and effects - is reflected in the present project title. During FY 77 period, work was started on several specific study sites. Formal approvement for these was never officially received, however, and FY 78 work will represent the same type of work approach but in newly requested areas; primarily in Lower Cook Inlet. The new dynamics emphasis necessitates primary focus on the biota. Water analysis will be deleted as a major component; sediment analysis will be strictly in support of the biology program, i.e., characterization of the benthic substrates.

The new approach of the heavy metals program is upon:

1) Changes in bioavailability of heavy metals to benthic species (predominantly intertidal as emphasized above) as a consequence of oil development impingement.

2) Pathways and transfer efficiencies of mobilized heavy metals through selected food chains. In this respect most attention will be given to that portion of the food web involving human food species.

3) Role of river bourne suspended sediment in interacting with, and transporting, heavy metals in the marine environment in the presence of industrial impact.

The extent and emphasis of this program depends largely upon OCSEAP needs at any particular time, i.e., on the weight to be given to each particular lease area, and the time permitted for scientific study. As described in the proceedings of last year's specific study site workshop, each region of Alaska suggests emphasis on particular oceanographic processes or food webs.

MILESTONE CHART

R.U. # 162 P.I. Dr. D. C. Burrell

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
Cook Inlet Cruises		Δ						Δ		Δ					
Report Submission			Δ			Δ			Δ			Δ			
Aquaria Experiment Start Up				Δ											

Δ Planned Completion Data ▲ Actual Completion Data

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R.U. 162 - FY 77 RESEARCH PROPOSAL

Addition to Section X: Deliverable Products

Tabular data will be supplied to the University of Alaska OCS Coordination Office on a timely basis.

University of Alaska, Fairbanks
Fairbanks, Alaska 99701

Institute of Marine Science

20 December 1977

Dr. John Calder, Staff Chemist OCSEAP
NOAA-ERL
Boulder, Colorado 80302

Dear John:

Please find attached additional documentation for R.U. 162 FY 77 research proposal as requested in your letter of December 14. This material is, of course, presently quite unofficial but I am sending it to you now in case there is some urgency. Our OCS Coordination Office will prepare the final official modification document in the usual way but this will take some time I imagine since it will necessitate, in turn, an official budget from San Diego S.U.

I have not, at this stage, included an addition regarding digital data production since I am not entirely sure what you are asking. As I read it you require a duplication (verification) of the work presently done by our OCS Coordination Office Data Manager. Further, you want me personally and not somebody in my lab to do this. If I have interpreted this correctly then I believe - and this is just a guesstimate - that about two weeks of time would be involved; possibly three since it would necessitate learning the programs etc. I am not sure right now if I can allocate this amount of extra time in FY 78 but, assuming I can, the addition to the budget would be around $5-6,000; considerably less if you would allow one of my technicians to do it. Let me know what you want and I will incorporate it in the "official modification package".

Have a good Christmas.

Very sincerely,

David Burrell

D. C. Burrell

DCB/sjc

cc: Hadley, OCS Coordination Office

enclosure

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Boulder, Colorado 80302

December 14, 1977

Dr. David Burrell
Institute of Marine Science
Univ. of Alaska
Fairbanks, AK 99701

RU 162

Dear Dave

Your revised renewal proposal for FY78 has been reviewed by OCSEAP and found satistactory, with the following exceptions:

1. A statement of justification for the purchase of capital equipment, especially the "sediment size analyzer", is required.

2. A budget breakdown for the subcontract to Weiss is required.

3. Even though Hadley (RU350) may prepare digital data products, it is your responsibility to provide tabular data on a timely basis and to verify the accuracy and completeness of digital data products. Please supply a statement indicating your assumption of this responsibility.

With the above modifications, your proposal will be funded at a level ~~of $XXX~~ to be determined.

Sincerely,

John A. Calder, Staff Chemist

cc. Ray Hadley

1. Title: Shorebird Dependence on Arctic Littoral Habitats
Research Unit #172

Principal Investigator: Robert W. Risebrough

Research Coordinator: Peter G. Connors

Institution: The Regents of the University of California

Date of Proposal: October 1, 1977 - September 30, 1978

Required Signatures

Principal Investigator: Robert W. Risebrough

Name Robert W. Risebrough Date 27 June, 1977
Address Bodega Marine Lab., Box 247, Bodega Bay, CA 94923
Telephone Number (707) 875-3511

Required Organization Approval: Cadet Hand, Director

Name C. Hand Date 24 June '77
Address Bodega Marine Lab., Box 247, Bodega Bay, CA 94923
Telephone Number (707) 875-3511

Institutional Official: August G. Manza

Name ______ Date ______
Address Campus Research Office, Univ. California, Berkeley
Telephone Number (415) 642-0120

3. Technical Proposal

I. Title: Shorebird Dependence on Arctic Littoral Habitats
Research Unit #172
Contract Number #03-5-022-84
Proposed Dates of Contract: October 1, 1977 to September 30, 1978

II. Principal Investigator: Robert W. Risebrough, Research Ecologist

III. Cost of Proposal:

Total: $65,652

Beaufort Sea 50%; Chukchi Sea 50%

IV. Background:

Before 1975, almost no quantitative information was available on the use of littoral areas by shorebirds in the Alaskan arctic, since prior work had concentrated on tundra breeding phenomena. Work in 1975-77 on this R.U. has documented normal dependencies of a wide variety of shorebirds on habitat features and prey items of Beaufort and Chukchi Sea littoral habitats. Year-to-year variability in abundance, timing, habitat use and diets of shorebirds has been outlined, and extreme variation between years in density of zooplankton prey has emerged. Temporal differences in movements and habitat use of the mobile shorebird populations between Chukchi and Beaufort areas are also emerging.

Work in FY 78 is programmed to focus on littoral zone use in artificially altered situations, such as the ARCO causeway in Prudhoe Bay and other disturbed sites in the Beaufort and Chukchi areas, and to expand the developing study of zooplankton occurrence and dynamics in relation to the critical use of this resource by migrating shorebirds, gulls and terns. These two areas of investigation emerged as critical informational needs at the OCSEAP Beaufort Synthesis Meeting in February 1977. The zooplankton study will be intended to gather one additional season's data at selected sites, laying the groundwork for a more intensive study in FY 79. Important migratory population dynamics information will derive from complementary work at field sites on both Chukchi and Beaufort coasts.

V. Objectives:

1. Determine seasonal use patterns of shorebirds, gulls and terns, by species and age class, in arctic littoral and nearshore habitats, with special emphasis on altered habitats, coastal structures, and disturbed sites of several kinds, bearing on questions of OCS development effects.

2. Assess foraging habitat preferences, by species and age class, within altered littoral zone areas as compared with undisturbed areas.

3. Determine prey species taken by shorebirds in disturbed littoral areas, as compared to natural situations evaluated previously.

4. From these information classes, assess the probable effects of disturbance and alterations associated with OCS development.

5. Expand the data base on variation in nearshore zooplankton densities and the relationship to migratory bird use, preparing for an intensive study in FY 79. Previous study has identified this highly variable biological system, in a zone potentially susceptible to several effects of OCS development, to be critical to many species.

6. Continue attempts to identify critical areas with respect to migratory bird use on the Beaufort and Chukchi coasts.

VI. General Strategy and Approach:

The general strategy will derive from the first three seasons of RU #172, combining intensive and extensive approaches (ref. Risebrough and Connors, OCSEAP annual reports, 1976 and 1977), but shifting the emphasis in site selection to areas with altered coastlines, coastal structures, and heavy levels of disturbance. At intensive study areas, regular sampling of established transects throughout the season will determine seasonal patterns of bird use in a variety of habitats, and habitat preferences and seasonal shifts by species, age and sex class. These data will be supplemented with collection of birds for stomach analysis, substrate sampling, and foraging observations to determine trophic relationships in disturbed and undisturbed areas. Emphasis will be given to measurement of nearshore zooplankton densities at selected study sites, following up on indications in 75-76 of extreme variation in this critical food source near Barrow. This is viewed as essential information in itself, as well as a base for a more profitable intensive study in FY 79.

Intensive site studies will be supplemented with brief visits to several other sites in Beaufort and Chukchi coasts, where distribution and habitat preference information will be collected for comparison to the intensive site data. All of this information will be synthesized to assess the dependence of shorebirds, gulls and terns on arctic littoral habitats and the probable effects on these species of coastal alterations which may arise from OCS development.

VII. Sampling Methods:

At intensive study sites (see below), we will continue the successful transect census procedure established during the first years of this program. Transects will be marked along shorelines, on mudflats, and on saltmarsh flats, including the full range of littoral habitats represented at each site, with emphasis given to disturbed or altered habitats. Transects consist of either a single row of adjacent 50 m square plots stretching along shorelines, usually for 1 km, or an equal length of a double row of 50 m square plots on saltmarsh or mudflats. These will be censused regularly and repeatedly at intervals of 5 days or less throughout the period of study, recording all sightings by species, age, and sex, whenever possible.

Habitats will be classified in general categories for each transect, permitting description of seasonal changes in bird habitat use. On a finer scale, a scheme of habitat classification parameters developed during 1976 will describe each 50 m plot, allowing comparison of habitat preferences between species and in disturbed versus undistrubed habitats.

At intensive sites, plankton sampling stations will be established (continued at Barrow) on ocean and lagoon shores, usually on bird census transects. At regular intervals during open water periods, plankton tows will be taken. During the first two seasons at Barrow we have developed a net design and a sampling method for quantitatively collecting zooplankton from surface waters (top 14 cm) very close to shore (within 2 m of the beach) since this is precisely the fraction of plankton most heavily used by phalaropes, gulls and terns. These collections will permit comparison of prey conditions between disturbed and undisturbed sites, between different shores at one study site, and between years at continued sites, and can be compared with bird density data. Comparison of food densities between disturbed and undisturbed sites is necessary to assess the effects of disturbance (or alteration) on bird use densities.

It is not possible to select all study sites before completion of the present field season and assessment of 1977 results. Prudhoe Bay will certainly figure as a site (or series of sites); the ARCO causeway and other shoreline modifications will serve as excellent models of alterations which may accompany OCS development in the Arctic. Reconnaissance trips in 1977 will aid in planning for 1978. Sites may be selected in conjunction with the ecologic process study intensive site (RU #467). Studies will continue at Barrow, with the advantage of three years comparative data and sites with different levels of human disturbance. Other sites will be chosen from among those occupied or identified as interesing in 1977 in Beaufort and Chukchi areas.

At other sites, subjected to brief visits principally during late summer when shoreline shorebird activity is greatest, the marked transect method is less useful. Density estimates, by species, will be made for linear distances of shoreline and for areas of mudflat for comparison to transect data. Habitat use data will also be collected.

Shorebirds foraging in disturbed littoral habitats will be collected for comparison of dietary information with that gathered in the first three seasons of this study, and plankton and substrate samples will be analyzed to compare selected prey with available potential prey. Replicate samples will be taken in most cases, but efforts here are limited by the time involved in sorting and identification of invertebrate samples.

VIII. Analytical Methods:

Transect census data will be used to construct seasonal frequency histograms of bird density by species, age, and sex in different habitats. Analysis of frequency of association of each species with different transect habitat types will define the habitat use characteristics of all species measured and to help to evaluate the dependence of shorebird species on particular littoral habitats. See annual reports for analysis of 1975 and 1976 data.

IX. Anticipated Problems:

Only logistics considerations, discussed in section XIV, present major difficulties.

X. Deliverable Products:

A. Digital Data

1. (a) For each transect: location, date, time, length, ice cover, temperature, wind direction and velocity, cloud cover, weather type, visibility.

   (b) For each bird sighting: species, age, sex, number, activity, transect plot.

   (c) For each bird stomach: species, age, sex, fat condition, weight, date, location, contents by species and material codes.

2. Date Products Schedule

(see page 7)

Data Products Schedule

Data Type (i.e. Intertidal, Benthic Organisms, etc.)	Media (Cards, coding sheets, tapes, disks)	Estimated Volume (Volume of processed data)	Processing and Formatting done by P.I. (Yes or No)	Collection Period (Month/Year to Month/Year)	Submission (Month/Year)
Bird Transect Census	tape	7500 cards	Yes — 084	June 78-Sept. 78	Jan. 79
Stomach contents	tape	200 cards	Yes	June 78-Sept. 78	Jan. 79

B. Narrative Reports

Periodic results and progress reporting, as prescribed. Specifically, this project will report on analysis of differences in shoreline habitat use between natural and artificially altered sites, temporal and spatial variability in prey densities and bird densities, and allocations of feeding and other activities within habitat types. Critical or high density use areas will be documented and placed in context.

C. Visual Data

Maps, overlays, charts, and diagrams as required to illustrate habitat dependency and use patterns to predict effects of OCS related events on littoral and nearshore zones.

D. Other Data

None anticipated.

E. Data Submission Schedule

See Data Products Schedule, page 7.

XI. Information from Other Investigators:

None required. However, the annual report from RU #3/4 will be helpful in planning site selection when it becomes available, and any plans for offshore zooplankton sampling which may be compared with our shoreline results will be useful. We have initiated contacts with Dr. Rita Horner concerning this. Results from RU #467 for 1977 and plans for 1978 will also be considered, as will RU # 356.

XII. Quality Assurance:

Almost all data will be direct counts, requiring no calibration. Periodically, census estimates of dense flocks of birds will be compared between observers.

XIII. Specimen Archival Plans:

Bird museum specimens will be submitted to the Museum of Vertebrate Zoology, University of California, Berkeley. Invertebrate samples will be stored at the Bodega Marine Laboratory, Bodega Bay, California.

XIV. Logistics Requirements:

Because final planning for the 1978 field season, especially with respect to study sites in the Prudhoe Bay area and the Kotzebue Sound region, must await the interpretation of 1977 field season results and reconnaissance trips, precise details concerning logistics for these operations cannot be specified at present. We have discussed these problems with Dr. David Norton and Mr. Ted Flesher of the Arctic Project Office and will follow their suggestions in this discussion.

In particular, the present cost of subsistence support at most Prudhoe Bay camps is at least $100 per person/day, and we will use this figure to establish a maximum cost. We are anxious to find a more efficient solution, however (as, for example, transport of a camper-trailer rented in Fairbanks) and will continue to investigate alternatives.

For the 1977 field season logistics budgets for NARL-Barrow and Wales-Kotzebue were handled separately to relieve the Arctic Project Office logistics coordinator of some of the burdens of field planning for Wales-Kotzebue. Since this arrangement has been successful, we separate here the costs for three areas of operation: NARL, Kotzebue, and Prudhoe Bay. Actual disposition of funds for these requirements can then be determined to maximize efficiency of logistics coordination by OCSEAP personnel.

A. Ship Support: None

B. Aircraft Support - Fixed Wing:

1. NARL: Approximately 26 hours of Cessna 180 flights between Barrow and Lonely, Oliktok, Peard Bay, Wainwright, and Icy Cape. To be scheduled during the field season, mainly during August. To carry 1 or 2 persons plus 150 lb camping and scientific gear. Cost: $2210 @ $85 per hour.

2. Kotzebue area: Principal source for charter flights will probably again be Baker Aviation. Flights from May 20 to September 20.

   Actual sites for field work will be determined after the 1977 season. We estimate needs for 1978 at approximately half the 1977 flights:

   a) Cessna 206, 50 hours @ $110 per hour;
   b) Commercial flights, Kotzebue to Barrow or Prudhoe Bay: 4 round trips, $1200.

   Total cost: $6700.

3. Prudhoe Bay area:

   a) Occasional short local flights: Cessna 180 or equivalent, 8 hours @ $100 per hour;

b) Commercial flights Prudhoe Bay to Barrow: 6 round trips, $800.

Total cost: $1600.

C. Aircraft Support - Helicopter: None

D. Quarters and Subsistence Support

1. Requirements:

Barrow: July 1-Sept. 15; 140 person days total; maximum 3 persons
Icy Cape, Wainwright, Peard Bay, Lonely, Oliktok: Aug. 1-Aug. 30; 30 person days total; maximum 2 persons
Kotzebue city: May 20-Sept. 21; 30 person days total; maximum 3 persons
Kotzebue area study sites: May 31-Sept. 20; 240 person days total; maximum 3 persons
Prudhoe Bay study sites: June 1-Sept. 15; 220 person days total; maximum 3 persons

2. Sources:

Barrow: NARL
Kotzebue study sites: tent camping
Prudhoe Bay, other sites: no recommendation

3. Cost:

Barrow: NARL proposed rate $79 per person day, total $11060
Kotzebue city, Wren Hotel: $40 per day, total $1200
Kotzebue study sites: estimated cost for food, $15 per person day, total $3600. Camp costs discussed in next section.
Prudhoe Bay: See note at beginning of logistics section. We use here the present commercial camp rate of $100 per day, but hope to find a less expensive alternative. Maximum total $22000.

E. Special Logistics Problems

1. NARL: Small laboratory, 80 days @ $5 per day = $400. Vehicle rental, shop, storeroom charges = $600. (We assume the OCS 3-wheelers will again be available for ourproject.)

2. Kotzebue area: Most necessary camp equipment was purchased for the 1977 season. Costs of replacement or repair of tents, furniture, tools, batteries is estimated at: $500.

Fuel for stove, heater, lamps, 3-wheeler = $600.
Purchase of CB radio, batteries, antenna, for communication = $250.

3. Prudhoe Bay: We will require regular use of a pickup truck and/or Honda 3-wheeler. In the hopes that OCS may have these vehicles available, we do not specifically budget for them. Rental of trucks in Prudhoe Bay in 1977 is exorbitant ($200 per day at one source).

   We will also need a boat, ideally a Zodiac, with motor. If not available, we would need to purchase one, which could also be used for FY 79 plankton studies. Estimate = $4000. Fuel for all vehicles, local supplies and repair = $1000.

Total logists costs:

NARL:	$14,270
Kotzebue area:	12,850
Prudhoe Bay area:	28,600 (maximum)
Total:	$55,720.

XV.

Management of this project for FY 1977 will proceed as it has for FY 1975 and 1976. Budgetary matters will be managed, in consultation with the principal investigator, by the business office and accounting staffs of U.C. Bodega Marine Laboratory and U.C. Berkeley. Expenditures will follow the activity/milestone chart on page 12, and a monthly financial accounting will allow any necessary adjustment of expenditure rate. Note that data coding, submission, analysis and report preparation will require extensive efforts after September 30, 1978, since the field season ends in late September. Anticipated expenditures for these tasks are included within the budget.

XVI. Outlook:

The effort planned for FY 78 with respect to zooplankton sampling and corresponding density measurements of birds depending on zooplankton is seen as laying the groundwork for a more focused investigation of this subject in FY 79. A better understanding of the Beaufort-Chukchi shoreline zooplankton resource and the relationship of several species of shorebirds, gulls and terns to this highly variable resource emerged as a critical need at the Beaufort Synthesis Meeting in February 1977. To understand this complex system, information for multiple seasons is required. 1978 will mark the fourth season of comparable data on Barrow transects. An intensive zooplankton-bird study utilizing this and other site data will provide information on:

1) range of between-year variability in zooplankton and birds;

2) variability between sites, over small and large scales;

3) plankton density relationship with depth, distance from shore, shoreline physical features;

4) potential causes of variation in plankton;

5) responses of birds to variability of plankton.

From these classes of information, an understanding of the population dynamics of nearshore zooplankton, the flexibility and degree of dependence of birds on this resource, and an assessment of the effects on bird populations of potential changes in zooplankton densities which may be associated with different OCS oil development disturbances.

It is hoped these results might be achieved in FY 79; however, it is the nature of these investigations that results are not wholly predictable.

Cost, if geographic extensiveness is not required by FY 78 results, should be under $60,000. Logistics requirements should be similar to FY 77 and FY 78.

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."

MILESTONE CHART

RU #: 172 PI: R. W. Risebrough

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

MAJOR MILESTONES (Data set equals one field season.)	1977			1978														
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D			
Coding and submission of 1977 data; preliminary analysis	—	—	—	△														
Final analysis; annual report preparation			—	—	—	△												
Planning 1978 season					—	—	—	—										
Field season								—	—	—	—	—						
Coding and submission of 1978 data; analysis													—	—	—	△		
Final analysis; annual report preparation															—	—	—	—
Quarterly Reports			△						△			△						

PUBLICATIONS

Robert W. Risebrough

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6. Risebrough, R. W., P. Reiche, D. B. Peakall, S. G. Herman, and M. N. Kirven. 1968. Polychlorinated biphenyls in the global ecosystem. Nature 220:1098-1102.

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9. Risebrough, R. W., P. Reiche, and H. S. Olcott. 1969. Current progress in the determination of the polychlorinated biphenyls. Bull. Environ. Contam. Toxicol. 4(4):192-201.

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Connors, P., and J. P. Myers. Site faithfulness in wintering shorebirds.

Connors, P., and C. Connors. Algae grazing by shorebirds.

Connors, P., and J. Standing. Gull predation on starfish: a population of specialists.

Studies in Progress:

Foraging and aggressive behavior of Sanderlings (Calidris alba) in California.

Territoriality in wintering shorebirds.

STUDY OF MICROBIAL ACTIVITY AND CRUDE OIL-MICROBIAL INTERATIONS IN THE WATERS AND SEDIMENTS OF COOK INLET AND THE BEAUFORT SEA

OCSEAP Research Unit #190

Co-principal Investigator: Robert P. Griffiths, Ph.D.

Co-principal Investigator: Richard Y. Morita, Professor of Microbiology and Oceanography

Total Cost: $104,000

Institution: Oregon State University
Department of Microbiology
Corvallis, OR 97331

Inclusive dates: October 1, 1977 to September 30, 1978

TECHNICAL PROPOSAL

I. Study of Microbial Activity and Crude Oil-Microbial Interactions in the Waters and Sediments of Cook Inlet and the Beaufort Sea.
Research Unit #190
Contract Number 03-5-022-68
Inclusive Dates: October 1, 1977 to September 30, 1978

II. Co-principal Investigator: Robert P. Griffiths, Ph.D., Research Associate
Co-principal Investigator: Richard Y. Morita, Professor of Microbiology and Oceanography

III. Cost of Proposal:

Total. Including approximately $7,000 for nutrient analysis of samples collected Dr. Atlas (RU #29) and ourselves	$104,000

Distribution by lease area:	Lower Cook Inlet	58%
	Beaufort Sea	42%

IV. Background:

During the recent OCSEAP sponsored synthesis meetings held in Barrow and Fairbanks, AK, it was recommended that microbial studies be continued to fill the gaps in the data that currently exist. In both geographical areas of study (Beaufort Sea and Cook Inlet) there is insufficient data on the rates of crude oil biodegradation in water, sediment, and in ice. Also lacking is information on the effects of crude oil on microbial functions throughout the environment. Gaps in the data were also shown to exist in relation to the levels of relative microbial activity and microbial distribution patterns from both temporal and spacial viewpoints. The coordinated research effort by Dr. Atlas and his associates (RU#29) and our group is designed to supply much of this information in the Beaufort Sea and Cook Inlet.

<u>Lower Cook Inlet</u>: The proposed study is a continuation of our current research efforts in this geographical area which was initiated during the current fiscal year (FY77). Todate, we have collected data on microbial activity and respiration (mineralization) characteristics in the sea water and sediment samples taken in the Lower Cook Inlet. The field studies were conducted during two cruises in this region (Ocrober, 1976 and April, 1977). We propose that collection of this type of data be expanded both seasonally and geographically.

During the last cruise in this region, we were able to show that the characteristic patterns of microbial activity, distribution, and respiration in the Lower Cook Inlet were greatly affected by forces originating outside of the region. The dynamics of microbial function in the Lower Cook Inlet would not have been revealed if we had only taken samples in that region. Sufficient stations outside the Lower Cook Inlet provided data so that we could interpret our data correctly.

Our data from this region indicate that there are two distinct water masses in the Cook Inlet; one to the north that is very turbid and of relatively low salinity and one to the south and southeast which is more typical of open ocean water. We have found that both of these water masses have characteristic patterns of microbial activity and respiration. Glutamic acid uptake studies in surface waters have shown that the relative microbial activity is very high and the respiration percentages are very low in the northern water mass. The reverse pattern is seen in the water mass to the south. Intermediate values were observed in regions where these two water masses meet in the area to the north and east of Augustine Island. This is the same region in which a gyre has been observed by other investigators. In general, the patterns of surface water microbial activity and respiration reflect the net surface circulation patterns reported by Miller and Allen (RU #436), Environmental Assessment of the Alaskan Continental Shelf, Oct.-Dec., 1976 Principal Investigators' Reports, Vol. 3, Page 782.

We also discovered that there was a good correlation between surface water turbidity and microbial activity. It is curious that the most active waters studied were in the north where very little primary productivity is taking place. This suggests that the primary energy source for heterotrophic bacteria in these waters comes from nutrients originating from the landmass.

We were curious as to where this highly active suspended matter found in the northern water mass settles. An analysis of microbial activity in the Cook Inlet sediments indicate that little of this material settles out into the sediments in this area but rather is deposited in the sediments of the Shelikof Strait. The high microbial activity in sediments of the Shelikof Strait undoubtedly is very important to the whole food chain in this region. If the studies of crude oil-suspended matter interactions currently being conducted by Drs. Joel Cline and Richard Feely (PMEL) show that significant quantities of crude oil can become associated with these particles, it is quite likely that crude oil would be introduced into these very active sediments of the Shelikof Strait.

These data suggest that microbial events in the Lower Cook Inlet may be affected by events taking place in the north end of Cook Inlet. Also to be considered are the effects of these events in the Lower Cook Inlet on areas well to the south of the Cook Inlet. Our data suggests that materials originating from the Cook Inlet may be deposited in the sediments of the Shelikof Strait. We are thus suggesting that our sampling area be officially expanded to include the area from East Foreland in the Cook Inlet to the Shelikof Strait and areas south and east of the Kennedy entrance. This would require that our usual cruise time at sea in this region be increased from about 10-13 days to about 20 days.

The data from these studies should be of interest to the benthic ecologists because levels of microbial activity in the sediments should indirectly indicate the amount of food available to organisms at higher trophic levels. If, in the case of sediments in the Shelikof Strait, the microbial activity is very high and there is a possibility of crude oil contamination in these sediments, the potential effects on benthic organisms could be profound. Microbial data from these areas should also be of interest to those studying the hydrography of this region as well. The levels of microbial activity and their functional characteristics could be an aid in identifying specific water masses in this region. A similar statement could be made for those studying sedimentation in this area.

The nitrogen budget in any marine system can play a key role in the function of all organisms in the area. Virtually nothing is known about the nitrogen cycle in the Lower Cook Inlet. During our last cruise in the Cook Inlet, rates of nitrogen fixation were measured in all sediment samples collected. The rates observed were low by terrestrial standards but could be significant in the marine environment. The estimated annual rate of nitrogen fixed in the sediments of Kachemak Bay, for example, was 2×10^4 kg. If all this fixed nitrogen was utilized by the bacteria in the sediments to generate biomass, this would represent roughly 400 tons of bacteria; a significant imput of biomass for utilization at higher trophic levels. Although it was not measured, it is quite likely that nitrogen fixation by bacteria in the guts of detritus feeders may contribute a much greater amount of fixed nitrogen to the overall system.

The entire nitrogen cycle is a very complex one as far as microbial involvement is concerned. An alteration to any one reaction could have profound effects on any number of processes. If the dynamics of the entire system is to be fully understood, it would take the full energies of both Dr. Atlas' group (RU #29) and ours. For practical reasons, the scope of the study must be restricted to the major imput and output portions of the nitrogen cycle and to the degree to which they are affected by crude oil. We propose that our group study the nitrogen fixation imput and that Dr. Atlas and his associates study the major dentrification output.

One of the major cuestions which went largely unanswered during the last series of synthesis meetings in Alaska was, what are the in situ rates of crude oil biodegradation in the waters and sediments of the regions studied? This is a very difficult rate to estimate for a number of reasons. At least four types of substrates would be involved to varying degrees; the seawater, the sea ice, the sediments and the beaches. A large number of factors are known to effect rates of biodegradation. The chemical composition of the menstruum, the temperature, crude oil composition and the degree of weathering it has undergone, the types of bacteria present, and the oxygen concentration are among the most important. Three basic approaches can be taken to make estimates of these rates: field studies in which a controlled oil spill is monitored over an extended period of time, field and laboratory experiments in which natural sample and crude oil interactions are observed in vitro under simulated in situ conditions, and laboratory studies using pure strains of bacteria isolated from the region being studied and their interactions with both crude oil and pure hydrocarbons.

Of the three approaches, the first would give the best information about crude oil degradation for a specific type of crude oil in a given location under specific environmental conditions. There are, however, two major drawbacks; there would be no information about how representative the rates would be for other conditions and it would require extensive field studies requiring input from investigators of various disciplines. A limited study of this nature will be recommended in this proposal for a sediment study in the Beaufort Sea. Due to the relative stability of sediments, this is one of the easiest substrates to study. In situ studies of crude oil degradation rates in water would best be accomplished by studying seawater contained in large plastic enclosures similar to that used in the CEPEX project. Such a project would require a massive support and is well beyond the scope of this proposal. Similar types of data might be obtained by studying accidental oil spills but current funding levels do not permit our involvement in such studies.

The second approach to studying microbial-crude oil interactions involves <u>in vitro</u> studies of natural samples under simulated <u>in situ</u> conditions. Such an approach has been taken by Dr. Atlas in his "crude oil biodegradation potential" experiments. We are attempting to find a means of measuring relative microbial activity using a specific substrate which would give a rapid estimation of the same parameter. If such a substrate could be found, estimates of crude oil biodegradation potentials could be made in a matter of hours rather than in the 4 to 6 weeks now required in the ^{14}C-spiked crude oil technique. As the system is better understood, these types of data could be a valuable supplement to Dr. Atlas' method.

The third approach involves measurements of crude oil and/or pure hydrocarbon degradation by pure strains of bacteria isolated from the area under study. This type of study provides the investigator the greatest control over the conditions of the experiment and has the greatest potential for producing the best basic information which can be applied to the greatest number of conditions. The greatest drawback to this approach is to determine if the conditions and bacterial strains used in the laboratory are the same as those found in the field. This is a difficult task at best when only one compound is involved but when the substance to be studied is as complex as crude oil, with many hundreds of compounds, the task is particularly difficult. This task is also difficult because many different microbial populations are probably involved in the natural biodegradation process. The problem is further complicated by the fact that the rates of growth on hydrocarbons and of hydrocarbon utilization by marine bacteria at the temperatures found in this region appear thus far to be very low. This means that experiments conducted on these organisms often take weeks. We have attempted to initiate experiments on the physiology of hydrocarbon utilizing bacteria which grow at low temperatures as it applies to crude oil degradation. Due in part to the slow growth of these organisms and due to the lack of funding to hire the required personnel, little progress has been made to date on these studies.

Regardless of the method used to study the rates of hydrocarbon biodegradation, the rates can only be estimates of what might occur in nature.

<u>Beaufort Sea</u>: During the summers of 1975 and 1976 and the winter of 1976, we were involved in a joint study of microbial function in the Beaufort Sea with Dr. Atlas and his associates. During this period, we studied relative microbial activity and bacterial concentrations in the inshore areas near Barrow and Prudhoe Bay, Alaska. We also participated in the August/September cruise of the Glacier during which we analyzed water, ice and sediment samples collected at stations located between Barrow and Purdhoe Bay. At present there is no similar data available for the area to the east of Prudhoe Bay. We are proposing that we participate in the August, 1978 Glacier cruise which is planned to cover stations in this region. As has been the case in the past, we will coordinate our studies with those of Dr. Atlas.

During the February, 1977 synthesis meeting in Barrow, AK, it was reported that buried pipelines might be used to transport crude oil from offshore platforms to pumping facilities on shore. If this mode of transport was utilized, the possibility exists for a pipeline break which would inject unweathered crude oil directly into the sediments. It was suggested that if such a break did occur, the crude oil might remain in the sediments for extended periods of time acting as a chronic source of pollutants. It was also suggested that a study be initiated to determine the microbial-crude oil interactions that might occur under these conditions. We are proposing that such a study be made with both groups working on various aspects of the problem.

V. Objectives:

A. Cook Inlet

1. To continue studies of relative microbial activity and respiration ratios in natural microbial populations found in water and sediment samples. The samples will be taken in such a way as to characterize these parameters both geographically and temporally. These studies will fill some of the data gaps which still exist from past studies in this region. Areas which are shown to have particularly high activity should be those in which crude oil will be degraded at higher rates. These areas probably support the highest overall biological activity and as such may be the areas which will be most affected by the presence of crude oil. These data may also be used in the future to estimate the degree of purturbation caused by chronic crude oil input.

Characterization of water masses using microbial parameters might also be useful in following net water mass flows within the inlet.

2. To evaluate the extent of nitrogen fixation in the sediments and gut contents of animals found in this region and to determine what, if any, effect crude oil might have on this process. Significant impact on function of any process in the nitrogen cycle could have a profound effect on all trophic levels in the Cook Inlet.

3. To evaluate techniques which might be used to determine crude oil degradation in sediments.

4. To provide nutrient data on all water and sediment samples taken by both microbiological groups. These data are important in evaluating other data collected by us; especially data on N_2 fixation and denitrification.

B. Beaufort Sea

1. To obtain information about the effects on the natural microflora of adding crude oil to sediments. These studies will include crude oil effects on microbial function as measured by uptake and respiration characteristics using several labeled compounds. They will also include the study of nitrogen fixation and the effects of crude oil on this parameter. These studies are designed to simulate the introduction of crude oil into the sediments by buried pipeline breaks similar to those discussed during the February synthesis meeting held in Barrow, AK.

2. To continue collecting data on relative microbial activity and respiration percentages in this region during the August-September, 1978 Glacier cruise in this region. Nitrogen fixation rates will also be estimated in sediment samples collected at the same time.

3. To provide nutrient data on all water and sediment samples collected by both Dr. Atlas and ourselves.

4. To estimate the effects of crude oil on natural microbial populations which undergo osmotic stress during freezing and thawing.

C. General

1. To coordinate our sampling efforts and experimentation with that of Dr. Atlas and his associates at the University of Louisville. This will minimize duplication of effort and maximize the usefulness of the resulting data.

2. To continue our laboratory studies at Oregon State University on the effects of crude oil on nitrogen fixation in marine sediments. We also plan to study crude oil degradation by bacteria isolated from the Beaufort Sea and the Cook Inlet.

VI. General strategy and approach

A. Cook Inlet

We will participate in two cruises in this area during FY78. The basic approach and experimental design used will be essentially the same as that used during our last two cruises. The major changes would be in the emphasis on nitrogen fixation in the sediments and animal gut contents and the expansion of geographical area studied. For the reasons mentioned in the "Background" section, we feel that the geographical area studied should be expanded from the current coverage.

B. Beaufort Sea

The effects of crude oil on the natural microflora in marine sediments will be made in conjunction with a series of experiments currently underway. The approach used is to remove marine sediment samples from Elson Lagoon near Barrow, AK and mix these samples with Prudhoe Bay crude oil. These samples are then placed into plexiglass trays which are then placed on the bottom of Elson Lagoon by divers. These trays are to be sampled at the start of the experiment and two other times during FY78. One of the sampling periods would be conducted just before or just after the Glacier cruise in August-September, 1978. The other sampling period will take place before the spring breakup in May.

Studies on the effects of crude oil on microorganisms undergoing osmotic shock during the freezing and thawing periods of seawater will be made during the above mentioned field trips.

Relative microbial activity and nitrogen fixation in the water and sediments of the Beaufort Sea will be made in the same way as we have done in the past. When possible, we will resample stations that we occupied during the September, 1976 Glacier cruise. Most of our sampling effort, however, will be directed in areas to the east of Prudhoe Bay that were not sampled during the last cruise in this region. As of now, we do not have any data on microbial functions, population, etc., in the area between Prudhoe Bay and Barter Island.

C. Laboratory studies

By analyzing the effects of crude oil on pure strains of marine Arctic nitrogen fixing bacteria, we will be able to estimate what potential effects crude oil might have on the growth of these organisms, the production of nitrogenase and the activity of nitrogenase present. These data will give use an idea of how the introduction of crude oil into the guts of animals and into sediments might effect this potentially critical microbial function in the Arctic and Subarctic marine systems.

We will continue our efforts to isolate crude oil oxidizing bacteria from sediments of the Cook Inlet and to continue physiological studies on these isolates. From these experiments, we will establish rates of hydrocarbon utilization which should give an estimate of crude oil degradation rates under in situ conditions.

VII. Sampling methods:

In general, the sampling techniques we will use are the same as those we have used in the past and are outlined in detail in our last annual report. The only new procedure to be used will be the introduction of sediment-crude oil mixtures in plexiglass trays into the sediments of Elson Lagoon near Pt. Barrow. A series of replicate samples will be removed for analysis at the times indicated under section VI.

VIII. Analytical methods:

In general, the same analytical methods will be used that we have used in the past; these are outlined in our last annual and quarterly reports.

IX. Anticipated Problems:

Judging from our past experience, there should be no difficulty in obtaining field data from the Cook Inlet area. Sampling offshore stations from some of the larger NOAA ships in these relatively protected waters has not been difficult except in areas which are shallow enough to require small boat operations. We have experienced some difficulty, however, in sampling shore stations from small boats mainly due to weather limitation.

Working in the Beaufort Sea is another situation entirely. Due to weather and ice conditions, this has traditionally been a very difficult area in which to conduct research. These problems coupled with the difficulty in finding a suitable sampling platform, have made working in this area difficult and frustrating. It must be understood that due to these problems, not all of our objectives in the region may be realized.

We have also encountered difficulties in our laboratory studies on crude oil and pure hydrocarbon degradation by bacterial isolates. These problems have been caused to a great degree by two factors. As a group, these organisms grow very slowly on media in which crude oil is the sole energy source; 6 to 8 weeks incubation time is usually required for visible colony formation to occur on crude oil agar plates. Also, to date, all pure strains that we have isolated utilize ^{14}C labeled crude oil at very low rates; often requiring 4 to 6 weeks to show high enough activities above background to be counted. These factors, along with the lack of sufficient personnel to conduct these studies, have resulted in dissapointing results to date. We have contacted the Juneau Project Office about this matter and they have made a request on our behalf to obtain funds to enable us to hire an additional technician. The salary for this individual has also been included in the budget of this proposal.

X. Deliberable products:

A. Digital data

1. We have made arrangements through the Juneau Project Office to incorporate our data into the data base at NIH through Dr. Krichevsky (RU #371). At the present time, Dr. Atlas (RU #29/30) has utilized this facility to analyze the data he has generated and has found this system satisfactory. This will insure that all microbiological data is located at the same place and will be available for future analytical work.

2. The format to be submitted will include the following information: station and sample numbers, time and date of sampling, station location, relative microbial activity as measured by uptake of both glutamic acid and glucose at one concentration, respiration percentages for both glutamic acid and glucose, nitrogen fixation rates in all sediments, depth of the water column at each station, the temperature and salinity at the surface and near the bottom at all stations, and all nutrient data.

B. Narrative reports

No special narrative reports are anticipated. We will continue including all data collected in the field and in the laboratory in our quarterly and annual reports. The format used in reporting these data will be approximately the same as that used in the past. In addition to the types of data that have been reported in the past, the following data will also be included in narrative reports: the effects of crude oil on nitrogen fixation and on relative microbial activity in sediments.

C. Visual data

Whenever data is best illustrated in graph or chart form, these will be used and included in our regular reports.

D. Other non-digital data

None anticipated

E. Data submission schedule

All data will be reported in our regular reports as soon as it is practical. In most cases, two months are required to complete our calculations after the end of a cruise.

XI. Information required from other investigators

It has become evident from some or our recent work that two types of data could be very helpful in interpreting our data. Our work in the Cook Inlet has shown that information about currents and water mass movement in the area of study can be very helpful. We have obtained some of this information on the Cook Inlet area through the quarterly reports but we could use more information about these processes particularly in the Beaufort Sea.

After meeting with the benthic ecologists at the NEGOA synthesis meeting this winter, it became evident that coordination between our groups could be helpful. As data on the benthic communities becomes available from the work of Dr. Howard Feder (Cook Inlet) and Dr. Andrew Carey (Beaufort Sea), will be using these data as a base for comparison with our data on relative microbial activity in the sediment.

Throughout this study, we have been working closely with Dr. Atlas and his associates and we will continue to do so in the future. We are continually comparing their data with ours and will continue to do so in the future. During all cruises, we will require salinity and temperature data, water depth, and position data for all stations taken.

XII. Quality assurance plans:

The techniques that we will be using will not require inter-comparison; however, we will use standard methods for calibrating our own equipment and we will run the necessary controls to insure the validity of our observations.

XIII. Special sample archival plans:

Does not apply to our study.

XIV. Logistics requirements:

See attached sheet.

XV. Management plan:

Dr. Morita will oversee the total project. Dr. Griffiths will be responsible for conducting all field and laboratory work. See data management chart for details on data completion goals.

XVI. Outlook:

The following ultimate goals should eventually be realized to insure that sufficient information about crude oil-microbial interactions are available as a data base from which informed managerial decisions can be made.

a. Data on the rates of key microbial reactions in water and sediments should be available for all areas within the major lease sites which have been identified as critical areas. These critical areas are those which have been identified as being unusually subject to impact by crude oil production. Examples of such areas that have already been identified are the areas to the west of Kayak Island in NEGOA and the region of the "null zone" in the center of the Lower Cook Inlet. Since the normal function of bacteria is critical either directly or indirectly to biological processes at all trophic levels, this information must be made available to management so that the long term impact on all organisms, including those of commerical value, can be properly assessed.

b. A better understanding of the effects of crude oil on specific microbial function should be obtained before the potential impact of crude oil perturbation can be fully understood. At the present time, we are looking at the potential effects of crude oil on the nitrogen fixation process. Other aspects of the nitrogen cycle should also be studied. We have looked at the short term effects of crude oil on the uptake and respiration of three compounds. These studies should also be expanded to include other heterotrophic functions.

c. At the present time, we have very little information on <u>in situ</u> rates of crude oil biodegradation in the Arctic marine environment. Work must continue on all three levels of investigation as outlined in section IV. Ultimately a major commitment will have to be made to establish a long term field study to measure actual <u>in situ</u> rates of crude oil degradation in the Gulf of Alaska-Bering Sea region.

This study would involve a continued monitoring of all relevant chemical, physical and biological parameters in a contained spill situation. This would involve establishing a field laboratory from which investigators from several different disciplines could make continuous measurements for up to a year or more. Once the experiment was initiated, routine measurements would be made by fulltime technicians living at the facility.

Goal "a" above could be achieved using the same approach that we are currently using in our field studies. The paramenters to be studied would be much the same as those currently being measured subject to change as we learn more about the microbial processes involved. These studies will not require any major new equipment. However, the same type of logistical support that we currently have would be required as well as the budget requested in this proposal. This effort should be continued for the life of the program with area emphasis shifting as other critical areas are identified and new lease sites are added to the schedule. The data generated from these studies would be about the same as are currently being produced.

Goal "b" above will be acheived in part by continuing our current studies. At the end of FY78, we should have a relatively good assessment as to how the presence of crude oil affects nitrogen fixation in sediments of the Beaufort Sea and Cook Inlet. In addition, we should have information on how crude oil affects the same process in the gut contents of several different organisms. During FY79, the effects of crude oil on other aspects of the nitrogen cycle should be initiated.

At the end of FY78, we will have some preliminary data on the effects of crude oil on chitinase activity in marine bacteria. These studies would be continued through FY79.

The acute effects of crude oil on glutamic acid uptake by natural microbial populations in Beaufort Sea and Cook Inlet sediments will be studied during FY78. These studies should be expanded to include different types of compounds in subsequent years. The long term effects of crude oil in sediments will be conducted during FY78 in the Beaufort Sea. If the results of these studies warrants it, these studies may be extended into FY79. This program should actually be expanded in FY79 to include a new series of experiments on a larger scale which would more closely simulate an actual buried pipeline release of crude oil directly into the sediments. The sediments in this experiment would be monitored into FY80. A similar type of project should be initiated in the Cook Inlet area during FY79. The resulting data from these studies would essentially be the same as those described for our crude oil-sediment study, to be initiated this year in the Beaufort Sea. As we learn more about crude oil-microbial interactions, other parameters would be measured as well. If such a study was initiated in the Cook Inlet area, we would need laboratory space at a permanent laboratory facility. If this work was conducted at the same time as the above mentioned studies, we would require an additional technician at a cost of about 15K per year and an additional 30K in other expenses. No new major equipment would be required.

Goal "c" above would be achieved by continuing our present studies and adding a significant program to the project. During FY78, both Dr. Atlas and our group will be continuing our efforts to measure *in situ* rates of crude oil degradation in the marine environment.

At this time, it is impossible to determine how fast we will be able to proceed with our study of crude oil degradation by pure bacterial isolates from the Beaufort Sea and Cook Inlet sediments. These basic physiological studies will proceed at a reasonable rate only if we are given the manpower we need to conduct them. At the end of FY78, we should be able to obtain some information on crude oil degradation rates with approximately 6 or more isolates. In FY79, we would continue these studies to other isolates and to crude oil degradation rates under a large number of environmental conditions.

Since there are so many factors which can affect crude oil degradation rates in the marine environment, the question of what rates of crude oil degradation should be anticipated in a given area will have to be answered by long term direct field observations. Between the current studies of both groups and those to be conducted during FY78, we should have sufficient background information to initiate such a large scale experiment during FY79 or FY80.

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., larve, 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 23-13).

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 by 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."

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)
Cruise data:				yes		
Time, date, location sample #, station # relative microbial activity, respiration percentages, sediment N_2 fixation rates, nutrient data	(disks at NIH)	?	special	coordinated with Drs. Atlas and Krichevsky	see milestone chart	
Effects of crude oil on N_2 fixation and hetrotrophic activity	regular reports					
Laboratory data:						
Physiological studies of N_2 fixation and biodegradation	regular reports					

COOK INLET

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 Oregon State University PRINCIPAL INVESTIGATOR Griffiths/Morita

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. Sampling grid in Cook Inlet used on previous operations. Also the standard PMEL sampling grid in the Shelikof Strait.

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. For shipboard sampling, water and sediments will be collected with Niskin sterile water and bottom grab samplers. We will want to collect various benthic organisms to analyze the gut contents for N_2 fixation rates.

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.)
Oct./Nov., 1977 and Feb., 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.)
20 working 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 will be working with Dr. Atlas' group on both cruises. We can coordinate with other group.
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. 1 hr. per station offshore
1½ to 3 hr on beach stations

6. What equipment and personnel would you expect the ship to provide?
Bottom grab and winch. STD casts. Ship's position on station. Tide information
Bottom trawl equipment to collect bethic organisms.

7. What is the approximate weight and volume of equipment you will bring?
500 lbs. 250 cu ft.

8. Will your data or equipment require special handling? yes If yes, please describe:
Fragile and samples require refrigeration and/or freezing

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. Six siphon type CO_2 cylinders for dry ice

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. NOAA ships Miller Freeman and Discoverer
These vessels are stable enough to allow us to conduct our work. They also have sufficient lab space and incubator facilities. Of these two, we have found the Miller Freeman to be the best for our purposes.

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
NA

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 persons

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 will require the same type of support that we have received from the OCSEAP office in Juneau in the past. These include the storage of equipment at the Gibson Cove facility and the handling of the CO_2 cylinders. We plan to purchase two more siphon type CO_2 cylinders so there will be a total of 6 to transport and fill.

BEAUFORT SEA

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 Oregon State University PRINCIPAL INVESTIGATOR Griffiths/Morita

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. *In situ* oil degradation exps. at Plover Pt. Transects east of Prudhoe Bay during Glacier cruise in Aug. 1978

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. Shipboard water samples will be taken with Niskin sterile bag samplers and sediment samples will be taken with bottom grab. When conditions permit, we would like to take shore samples from a small boat or helicopter. We will collect benthic organisms to collect gut contents for N_2 fixation rate studies.

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.)

   Summer when ice conditions permit

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.)

   10 working 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?

   Can coordinate with other

   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.

   1 hr per station (same time frame used by Dr. Atlas RU #29)

6. What equipment and personnel would you expect the ship to provide? Bottom sampling grab and winch. STD casts. Station position data. We will also require refrigerator and freezer space near the laboratories. Bottom trawl equipment.

7. What is the approximate weight and volume of equipment you will bring? 500 lbs. 100 cu ft

8. Will your data or equipment require special handling? yes If yes, please describe:

   Fragile

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. we will need 6 CO_2 cylinders on board (siphon type)

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. Glacier or equivalent 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

    NA

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 - Dr. Griffiths and one technician

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)

We will require helicopter support to transport personnel and equipment from the closest land base to the ship. This support has been provided by the Glacier in the past. We will also like to have the helicopter and/or small boat available for sampling shore stations when the opportunity becomes available.

2. Describe types of observations to be made.

Surfline samples of water and sediment will be taken at the shore stations. We will provide all of the equipment required for these stations.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

NA

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

Four shore stations are planned. Each station would require about one hour flight time and about ½ hr on the ground
Total flight hours? ?

5. How many people are required on board for each flight (exclusive of the pilot)?

2 persons

6. What are the weights and dimensions of equipment or supplies to be transported?

Three ice chests ; about 100 lbs.

7. What type of helicopter do you recommend for your operations and why?

Glacier helicopter

8. Do you recommend a particular source for the helicopter? If "yes" please name the source and the reason for your recommendation.

See above

9. What is the per hour charter cost of the helicopter?

NA

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

Glacier

11. Will special navigation and communications be required?

No

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)

We will require helicopter support to transport personnel and equipment from the closest land base to the ship. This support has been provided by the Glacier in the past. We will also like to have the helicopter and/or small boat available for sampling shore stations when the opportunity becomes available.

2. Describe types of observations to be made.

Surfline samples of water and sediment will be taken at the shore stations. We will provide all of the equipment required for these stations.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

NA

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

Four shore stations are planned. Each station would require about one hour flight time and about ½ hr on the ground
Total flight hours? ?

5. How many people are required on board for each flight (exclusive of the pilot)?

2 persons

6. What are the weights and dimensions of equipment or supplies to be transported?

Three ice chests ; about 100 lbs.

7. What type of helicopter do you recommend for your operations and why?

Glacier helicopter

8. Do you recommend a particular source for the helicopter? If "yes" please name the source and the reason for your recommendation.

See above

9. What is the per hour charter cost of the helicopter?

NA

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

Glacier

11. Will special navigation and communications be required?

No

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)

Barrow - NARL

1 person for 3 one week sampling periods = 30 man days

For preparation of ship cruise and transit to and from Glacier

2 persons for a total of about two weeks = 28 man days

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

NARL - require laboratory facilities

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

?

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?

Since we will be utilizing the same samples as Dr. Atlas' group, we will not require any additional support for sampling other than that outlined by him in his proposal for RU # 29. We will however, require laboratory space at NARL and on board ship.

MILESTONE CHART

RU #: 190 PI: Griffiths/Morita

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			X						X			X						
Annual report						X												
Ship cruise in Cook Inlet	X				X													
Ship cruise in Beaufort Sea											X							
Sampling of oiled sediments in the Beaufort Sea				X				X			X							
Deposit all FY75,76,& 77 data with NIH			X															
Complete data analysis of previous Cook Inlet cruise				X				X										
Complete data analysis of Glacier cruise															X			

Title of Dissertations

M.A. Thermal injury in the marine psychrophile *Vibrio marinus* MP-1.

Ph.D. Glucose uptake and catabolism in the marine psychrophilic bacterium, *Vibrio marinus*.

Publications

Haight, R. D. and R. P. Griffiths, 1968. Pseudolethal and other injury stages in *Vibrio marinus*. Bact. Proc. p. 27. (Abstract)

Griffiths, R. P. and R. Y. Morita. 1971. The effects of salinity on glucose uptake and catabolism in the marine psychrophile *Vibrio marinus*. Bact. Proc. p. 133. (Abstract)

Griffiths, R. P., P. Gillespie, L. P. Jones and R. Y. Morita. 1972. Heterotrophic activity of microorganisms in Antarctic waters. Bact. Proc. p. 70. (Abstract)

Morita, R. Y., R. P. Griffiths and S. S. Hayasaka. 1972. Heterotrophic potential of marine microorganisms in Antarctic waters. Antarctic J. U.S. 7:180-181.

Griffiths, R. P. and R. Y. Morita. 1973. Application of the reverse-flow filter technique to marine bacterial studies. Bact. Proc. p. 47. (Abstract)

Morita, R. Y., L. P. Jones, R. P. Griffiths and T. S. Staley. 1973. Salinity and temperature interactions and their relationship to the microbiology of the estuarine environment. In H. L. Stevenson and R. R. Colwell (ed.). Proc. Belle W. Baruch Symposium on Marine Science Estuarine Microbial Ecology. University of South Carolina Press. Columbia. Pages 221-242.

Griffiths, R. P. and R. D. Haight. 1973. Reversible heat injury in the marine psychrophilic bacterium *Vibrio marinus* MP-1. Can. J. Microbiol. 19:557-561.

Griffiths, R. P. and R. Y. Morita. 1973. Salinity effects on glucose catabolism in the obligately psychrophilic bacterium, *Vibrio marinus*. Marine Biol. 23:177-182.

Griffiths, R. P. and R. Y. Morita. 1973. The applicability of the reverse-flow technique to marine microbial studies. Appl. Microbiol. 26:687-691.

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Griffiths, R. P., F. J. Hanus and R. Y. Morita. 1974. The effects of various water sample treatments on the apparent uptake of glutamic acid by natural marine microbial populations. Can. J. Microbiol. 20:1261-1266.

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Baross, J. A., F. J. Hanus, R. P. Griffiths, and R. Y. Morita. 1975. Nature of incorporated ^{14}C-labeled material retained by sulfuric acid fixed bacteria in pure cultures and in natural aquatic populations. J. Fish. Res. Board Can. 32:1876-1879.

R. Y. Morita, R. P. Griffiths, and S. S. Hayasaka. 1976. Baseline study of microbial activity in the Beaufort Sea. Bact. Proc. (Abstract)

Morita, R. Y., R. P. Griffiths, and S. S. Hayasaka. 1976. Heterotrophic potential of microorganisms in Antarctic waters. Third Symposium on Antarctic Biology. National Academy of Sciences. (in press)

OCS 77-23
IAB 77-41
OCS 78-05

RESEARCH PROPOSAL

to

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado 80302

MORBIDITY AND MORTALITY OF MARINE MAMMALS
R.U. #194

TOTAL COST: $110,213

Institute of Arctic Biology
University of Alaska
Fairbanks, Alaska 99701

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August 23, 1977

I. Title

Morbidity and Mortality of Marine Mammals
Research Unit #194

II. Principal Investigator

Francis H. Fay

III. Cost of Proposal
(by federal fiscal year)

Total	$110,213
Distribution	
Bristol Bay	14%
Kodiak	20%
Lower Cook Inlet	7%
Norton Sound	10%
St. George Basin	24%
NE Gulf of Alaska	25%

IV. Background

The natural balance of marine mammal populations is a function of complementary birth and death rates. The productivity of Alaskan marine mammal poulations has been under study for more than 20 years, but the causes of illness and death have received little attention until now. This project has been concerned with investigation of the natural causes of morbidity and mortality in marine mammals of the eastern Bering Sea oil lease areas, with emphasis on determination of the kinds and incidences of pathological conditions, identification of the causative agents, and assessment of the potential relationships with future stresses brought to bear by offshore oil exploration and development. In the study proposed here, that work would be expanded geographically to include the Lower Cook Inlet, Kodiak, and Northeast Gulf of Alaska lease areas.

Field work will involve mainly necropsy of marine mammal specimens taken in connection with other OCSEAP projects (R.U. #229, 230, 232, 243) during cruises of NOAA ships and smaller chartered vessels. As opportunities permit, it will also include some post mortem examination of beached carcasses of marine mammals for cause of death.

V. Objectives

A. To identify and determine the frequency of occurrence of pathological conditions and identify the causative agents thereof in natural populations of marine mammals through necropsy of specimens taken nonselectively.

B. To determine major causes of morbidity through selective collection (as opportunities permit) of sick and moribund individuals.

C. To determine major causes of mortality through post mortem examination (as opportunities permit) of beached carcasses of marine mammals.

D. To compile and compare data obtained by this and other OCSEAP projects on numbers (by species) and location of beached carcasses along selected portions of the Alaskan coast.

E. To complete the analyses and interpretations of data collected in FY 77.

VI. General Strategy and Approach

Nonselective samples of animals from the living populations of marine mammals of eastern Bering Sea, (Kodiak, Cook Inlet), and eastern Gulf of Alaska are taken annually by other OCSEAP investigators in connection with R.U. #229 (Pitcher), 230 and 232 (Burns), and 243 (Calkins). A considerable number of those taken in the Bering Sea have already been examined by personnel of this project in FY 76 and FY 77, and it is proposed here to continue that work and to expand the geographical scope to utilization of those taken in the other areas as well. Investigation of the latter is especially timely, inasmuch as the apparent epizootic of leptospirosis and San Miguel Sea Lion Virus detected in California seems likely to have spread northward and to be affecting Alaskan sea lion populations in the lease areas at this time. As avilable and as time permits in the course of this work, moribund specimens also will be collected, and beached carcasses of dead mammals will be examined.

VII. Sampling Methods

The timing and locations for necropsy of collected specimens will be dictated largely by the collection schedules of R.U. #229, 230, 232, and 243, as will sample sizes.

VIII. Analytical Methods

Not applicable.

IX. Anticipated Problems

None.

X. Deliverable Products

A. A new Record Type for pathological information will be developed under File Type 025 (Marine Mammal Specimen), as an addendum to digital data provided by Burns, Calkins, and Pitcher. Coded parameters will include system and organ affected and kind of pathological condition detected on gross (visual) examination. A list of these is appended.

Data on distribution and numbers of beached carcasses, based on reports from this and other projects will be reported in digital form, as in the past.

B. Narrative Report

A full summary and analysis of findings for the duration of this project, including unpublished data acquired prior to this project and a review of published information, will be provided after the project field work is terminated. In the meantime, current findings will be summarized in the quarterly and annual reports.

C. Visual Data

1. Charts, showing location of beached marine mammal carcasses and their probable drift trajectory.

2. Tables, indicating the occurrence of pathological conditions and agents in relation to time, location, species, sex, and age, will be provided in the final narrative report. Preliminary, current findings will be tabulated in the quarterly and annual reports.

D. Other Non-Digital Data

Not Applicable.

E. Data Submission Schedule

First data collection - 10/77
Last data collection - 8/78

Data on beached carcasses will be submitted within 90 days after acquisition. Data on necropsies (gross pathology) also will be submitted within 90 days. Final analyses will be reported as completed (e.g., serological data may be delayed up to one year; histopathology and microbiology up to 8 to 10 months).

XI. Information Required from Other Investigators

Charts, showing location, date, and species of beached marine mammal carcasses sighted along the Bering Sea coast and in the Kodiak, Lower Cook Inlet, and NEGOA areas. Such data are currently being supplied by Arneson (R.U. #3) and have been provided in the past by Fiscus (R.U. #67 and 68) and by Faro (ADF&G, King Salmon). Other sources will be contacted.

XII. Quality Assurance Plans

All necropsies are conducted in accordance with procedures outlined in the project's manual. Microbiological isolates are identified by specialists in laboratories of the Alaska Department of Health and U.S. Department of Agriculture. Histopathology and parasitology are largely handled through specialists within the project team, with assistance and confirmation from various specialists in other institutions. Serological analyses are done at the Naval Biomedical Laboratory, Oakland, California.

XIII Sample Archival Plans

Pathological samples (preserved tissue blocks, prepared microsections), photos of gross pathological conditions, and replicate serum samples are stored in the Arctic Health Building, University of Alaska, Fairbanks, in areas under the control of the Principal Investigator.

XIV Logistics Requirements

No specific request for logistic support is feasible at this time, since the project will be dependent largely or entirely on the same logistic facilities used by projects R.U. #229, 230, 232, and 243. See logistic shcedules for same and add one person from this project to each field operation in the Norton, St. George, Bristol, Kodiak, Lower Cook and NEGOA lease areas. All studies under this project will be closely coordinated with projects R.U. #229, 230, 232, and 243.

XV Management Plan

The Principal Investigator will oversee all aspects of the project, will participate in ten percent of the field work, 20 percent of the laboratory work, and 80 percent of the office work. Associate Investigator Dieterich will participate in ten percent of the field work, 20 percent of the laboratory work, and ten percent of the office work. Technician Shults will cover 80 percent of the field work, 60 percent of the laboratory work, and ten percent of the office work. Field schedules will be closely coordinated to those of R.U. #229, 230, 232, and 243.

XVI. Outlook

Assuming that the present research and that proposed for FY 78 are successfully completed, samples adequate to describe the major pathological conditions and agents thereof in living populations of walruses, and of bearded, ribbon, and spotted seals of the eastern Bering Sea will be in hand. However, ringed and harbor seals, and Steller sea lions probably will require further sampling, as will the cetacean populations. Assuming that projects R.U. #229, 230, 232, and 243, which are the main sources of specimens at present, will continue at least through FY 79, then data acquisition from seals and sea lions will be continued by this project until such time as the samples are adequate or the collecting is terminated. Of the cetacea, it is probable that adequate samples can be obtained only from the white whale (belukha) population and it may be possible to do this through examination of animals taken by subsistence hunters at three or four locations on the western Alaskan coast.

Some further stranding surveys seem essential, since the FY 78 work at the indicated funding level cannot accommodate them. Stranded carcasses are the only source of information on natural causes of death, and at present the sample sizes for all species are inadequate for generalization. Strandings also are the only source at present of information on morbidity and mortality of large cetaceans in the Alaskan region. As indicated in the recent annual report (31 March 77) of this project, eventually at least one final effort on this aspect of the work is desirable in the eastern Bering Sea, in order to test the predictions of numbers and distributions, based on the earlier sampling, and to enlarge the samples by species of causes of death. This should be a single, one-time survey of the entire eastern shore of the Bering Sea from Unimak Pass to Bering Strait, with coverage ideally via helicopter or, alternatively, via small fixed-wing aircraft.

SUMMARY OF FUTURE ACTIVITIES

FY	Activity	Location	Cost
79	Complete pinniped sampling Begin belukha sampling	Bering, GOA Bering, Chukchi	100K
79	Final stranding survey	E. Bering	40K*
80	Complete Belukha sampling Complete data analyses and final report	Bering, Chukchi	100K

*Including logistics via fixed-wing, assuming availability of state aircraft 120 hrs. @ $80/hr, w/fuel.

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."

11. All data will be accompanied by a data documentation form (NOAA 24-13).

RECORD TYPE 9 - PATHOLOGY (New Record Type)

Suggested List of Parameters (affected areas)

I. Systems and Organs

A. Integumentary

general
hair
skin
blubber
mammaries

B. Muscular

general
head
Epaxial
hypaxial
thoracic
abdominal
forelimb
hindlimb
diaphragm

C. Skeletal

general
skull
axial
ribs
pectoral
pelvic

D. Nervous

general
brain
spinal cord
peripheral

E. Sensory

general
eyes
nose
ears

F. Digestive

general
dentition
mouth
salivary glands
esophagus
stomach
small gut
large gut
anus
liver
pancreas

G. Respiratory

general
nasal
larynx
trachea
bronchi
lungs

H. Circulatory

general
lymphatic
arterial
venous
heart

I. Reticuloendothebial

general
spleen
marrow
nodes
thymous

J. Endocrine

general
thyroid
adrenals
hypophysis

K. Urinary

general
kidneys
ureters
bladder
urethra

L. Genital

general
testes
epididymis
prostate
penis
ovaries
uterus
cerivx
vagina
clitoris

M. Peritoneal

pleural
abdominal

II. Kinds of Pathologic Conditions (lesions)

A. Helminthic
B. Bacterial
C. Fungal
D. Trauma
E. "Tumor"
F. Gunshot
G. Predation
H. Unknown

PUBLICATIONS: 1954. Quantitative experiments on the food consumption of *Parascalops breweri*. J. Mamm., 35:107-109.

1955. The geographical and ecological distribution of cottontail rabbits in Massachusetts. J. Mamm., 36:415-424 (with E. H. Chandler).

1957. History and present status of the Pacific walrus population. Trans. No. Amer. Wildl. Conf. 22:431-443.

1959. An ecological analysis of the avifauna of St. Lawrence Island, Alaska. Univ. Calif. Publ. Zool., 63:73-150 (with T. J. Cade).

1960. Technique for trapping small tundra mammals in winter. J. Mamm., 41:141-142.

1960. Carnivorous walrus and some arctic zoonoses. Arctic, 13:111-122.

1960. Structure and function of the pharyngeal pouches of the walrus (*Odobenus rosmarus* L.). Mammalia, 24:361-371.

1961. The distribution of waterfowl to St. Lawrence Island, Alaska. Ann. Rept. Wildfowl Trust, 12:70-80.

1962. Studies on the helminth fauna of Alaska. XXXIX. *Echinococcus multilocularis* Leuckart, 1863, and other helminths of foxes on the Pribilof Islands. Can. J. Zool., 40:767-772 (with F. S. L. Williamson).

1963. Unusual behavior of gray whales in summer. Psychol. Forsch., 27:175-176.

1966. The seasonal cycle of abundance of *Echinococcus multilocularis* in naturally infected arctic foxes. Proc. 1st Internat. Cong. Parasitol., 2:765-766 (Abstract) (with R. L. Rausch).

1966. Studies on the helminth fauna of Alaska. XLIV. Revision of *Ogmogaster* Jagerskiold, 1891, with a description of *O. pentalineatus* sp. n. (Trematoda:Notocotylidae). J. Parasit., 52:26-38 (with R. L. Rausch).

1967. The number of ribs and thoracic vertebrae in pinnipeds. J. Mamm., 48:144.

1967. Thermal requirements *in vitro* of epidermal cells from seals. Cryobiology, 3:261-264 (dated 1966) (with E. T. Feltz).

1967. Cytogenetic comparison of some pinnipeds (Mammalia: Eutheria). Can. J. Zool., 45:773-778 (with V. R. Rausch and E. T. Feltz).

1968. Influence of climate on the distribution of walruses, *Odobenus rosmarus* (Linnaeus). I. Evidence from thermoregulatory behavior. Zoologica, 53:1-18 (with C. Ray).

1968. Influence of climate on the distribution of walruses, *Odobenus rosmarus* (Linnaeus). II. Evidence from physiological characteristics. Zoologica, 53:19-32 (with C. Ray).

1968. Experimental transmission of *Trichinella spiralis* via marine amphipods. Can. J. Zool., 46:597-599.

1969. Parasitic organisms in the blood of arvicoline rodents in Alaska. J. Parasit., 55:1258-1265 (with R. L. Rausch).

1970. Comparative morphology of the skull of the ribbon seal, *Histriophoca fasciata* (Zimmermann), with remarks on systematics of Phocidae. J. Zool. (London), 161: 363-394 (with J. J. Burns).

1970. Development of larval *Echinococcus multilocularis* Leuckart in relation to maturation of the intermediate host. J. Parasit., 56(4, sec. II, pt. 1):97-98 (Abstract).

1971. On the ecology and distribution of *Echinococcus* spp. (Cestoda:Taeniidae), and characteristics of their development in the intermediate host. II. Comparative studies on the development of larval *E. multilocularis* Leuckart, 1863, in the intermediate host. Jap. J. Vet. Res., 19(suppl. 3):1-53 (with M. Ohbayashi and R. L. Rausch).

1971. Dental function in relation to feeding behavior of the Pacific walrus. Proc. Alaska Sci. Conf., 22: 137 (Abstract).

1971. New records and zoogeographical notes on the birds of St. Lawrence Island, Bering Sea. Condor, 73:322-336 (with S. G. Sealy, J. Bedard, and M. D. F. Udvardy).

1972. Adoption of a strange pup by the ice-inhabiting harbor seal, *Phoca vitulina largha*. J. Mamm., 53:594-598 (with J. J. Burns, G. C. Ray, and P. D. Shaughnessy).

1973. Comparative biology of Bering Sea harbor seal populations. Proc. Alaska Sci. Conf., 23:48 (Abstract) (w/J. J. Burns).

1973. The ecology of *Echinococcus multilocularis* Leuckart, 1863, (Cestoda: Taeniidae) on St. Lawrence Island, Alaska. I. Background and rationale. Ann. Parasit. Humaine et Compar., 48:523-542.

1974. The role of ice in the ecology of marine mammals of the Bering Sea. *In* D. W. Hood and E. J. Kelley (eds.), *Oceanography of the Bering Sea.* Univ. Alaska Inst. Marine Sci., Occas. Publ. No. 2, pp. 383-399.

1974. New Data on taxonomic relationships among North Pacific harbor seals, genus *Phoca* (*Sensu stricto*). Trans. 1st Internat. Theriol. Cong., Moscow, 1:99 (Abstract) (with J. J. Burns).

1974. Comparative and functional anatomy of the vascular system in the hind limbs of the Pinnipedia. Trans. 1st Internat. Theriol. Cong., Moscow, 1:166-167 (Abstract).

1975. Mammals and birds. In D. W. Hood and Y. Takenouti (eds.), Bering Sea Oceanography: An Update. Univ. Alaska, Inst. Marine Sci., Rept No. 75-2, pp. 133-138.

1976. Marine mammal distribution in relation to ice conditions in the Bering, Chukchi, and Beaufort Seas. Trans. Alaskan Sci. Conf., 25 (1976). (Abstract) (with J. J. Burns L. Shapiro).

1977. A review of the taxonomy and nomenclature of North Pacific harbour seals. J. Zool. (London), 182 (In press) (with P. D. Shaughnessy).

1977. The walrus. In R. J. Harrison and S. H. Ridgway (eds.), Handbook of Marine Mammals. London: Academic Press (In press).

Publications (Robert A. Dieterich):

Dieterich, R. A. 1967. Turtle diseases and their treatment. Int. Turtle and Tortoise Soc. J., March-April Issue, p. 20-21, 42.

Dieterich, R. A. 1969. Medial arterial sclerosis in captive beavers, Castor canadensis Kuhl. Bull. Wildlife Dis. 5:115-116.

Dieterich, R. A. 1970. Hematologic values of some arctic mammals. J. Am. Vet. Med. Assoc. 157:604-606.

Beckley, J. C. and R. A. Dieterich. 1970. Corynebacterial infection in the domesticated musk ox (Ovibos moschatus). Vet. Med./Small Anim. Clinician 65:1063-1067.

Dieterich, R. A. and J. R. Luick. 1971. The occurrence of setaria in reindeer. J. Wildlife Dis. 7:242-245.

Dieterich, R. A. and J. R. Luick. 1971. Reindeer in biomedical research. Lab. Anim. Sci. 21:817-824.

Dieterich, R. A. 1971. Hematologic values for five northern microtines. Lab. Anim. Sci. 22:390-392.

Van Pelt, R. W. and R. A. Dieterich. 1971. Mammary gland tumors in collared lemmings (Dicrostonyx groenlandicus). Lab. Anim. Sci. 22:433-439.

Dieterich, R. A. and R. W. Van Pelt. 1972. Juvenile osteomalacia in a coyote. J. Wildlife Dis. 8:146-148.

Van Pelt, R. W. and R. A. Dieterich. 1972. Toxoplasmosis in thirteen-lined ground squirrels. J. Am. Vet. Assoc. 161:643-647.

Dieterich, R. A. 1973. Hematologic values for six standardized wild rodent speices. Am. J. Vet. Res. 34:431-432.

Holleman, D. F. and R. A. Dieterich. 1973. Body water content and turnover in several species of rodents as evaluated by the tritiated water method. J. Mammal. 54:456-465.

Dieterich, R. A., R. W. Van Pelt and W. A. Galster. 1973. Diet induced cholesteremia and atherosclerosis in wild rodents. Atherosclerosis 17:345-352.

Van Pelt, R. W. and R. A. Dieterich. 1973. Staphylococcal infection and toxoplasmosis in a young Harbor seal. J. Wildlife Dis. 9:258-261.

Dieterich, R. A., P. R. Morrison and D. J. Preston. 1973. Comparative organ weights for eight standardized wild rodent species. Lab. Anim. Sci. 23:575-581.

Dieterich, R. A. and D. F. Holleman. 1973. Hematology, biochemistry, and physiology of environmentally stressed horses. Can. J. Zool. 51:867-873.

Dieterich, R. A. 1974. Northern exotic animals as models for human disease. J. Am. Vet. Assoc. 164:695-696.

Dieterich, R. A. 1975. The Collared lemming (Dicrostonyx stevensoni Nelson) in biomedical research. Lab. Anim. Sci. 25:48-54.

Dieterich, R. A., D. F. Holleman and J. R. Luick. 1975. An all-weather reindeer locator system. Can. J. Zool. 53:354-356.

Dieterich, R. A. 1975. Esophageal and ruminal fistulization of reindeer. In Proc. First Int'l. Reindeer and Caribou Symp. (J. R. Luick, P. C. Lent, D. R. Klein and R. G. White, eds.), p. 523-527, August 9-11, 1972, Univ. Alaska, Fairbanks. Biological Papers of Univ. Alaska, Special Report Number 1.

Dieterich, R. A., J. Grootenhuis, R. Olubayo and R. Paling. 1975. Wildlife Disease Research in Kenya. F.A.O. Official Publication. In press.

Dieterich, R. A. 1975. The influence of captivity on the hematologic values of the Snowshoe hare (Lepus americanus Merriam). Can. J. Zool. Submitted.

Dieterich, R. A. 1975. Cold injury (hypothermia, frostbite, freezing). 6th edition, Current Veterinary Therapy. Submitted.

Van Pelt, R. W. and R. A. Dieterich. Clinicopathologie course and management of Klossiella muris infection in a colony of feral Mus musculus from Peru. Lab. Anim. Sci. Submitted.

Holleman, D. F. and R. A. Dieterich. An evaluation of the tritiated water method for estimating body water in small rodents. Can. J. Zool. Submitted.

Morrison, P. R., R. A. Dieterich and D. Preston. Breeding and reproduction in 15 rodent taxa under standard conditions. Lab. Anim. Sci. Submitted.

Morrison, P. R., R. A. Dieterich and D. Preston. Mortality and survival in 15 rodent taxa under standard conditions. Manuscript.

Morrison, P. R., R. A. Dieterich and D. Preston. Body growth in 15 rodent taxa under standard conditions. Manuscript.

Van Pelt, R. W. and R. A. Dieterich. Spontaneous tumors in colony reared wild rodents. Manuscript.

MILESTONE CHART

RU #: 194 PI: Francis H. Fay

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		
NEGOA collection & necropsy (SURVEYOR)	△																
NGOA/PWS collection& necropsy (Pitcher charter)		△															
SE Bering collection & necropsy (CG Icebreaker)					△												
NEGOA collection & necropsy (Pitcher charter)						△											
Norton Sd. Collection & necropsy (shore-based)							△										
SE Bering collection & necropsy (SURVEYOR)									△								
NGOA collection & necropsy (SURVEYOR)										△							
Kodiak/Tugidak strandings (UH1H helo)								△		△		△					
Alaska Peninsula strandings (charter & UH1H?)										△							
Kodiak collection & necropsy (Pitcher charter)										△							
St. Lawrence/Norton strandings (charter)											△						
Kodiak collection & necropsy (SURVEYOR)												△					
LCI strandings (charter)												△					

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: RK-8-0069

4. BUREAU CONTROL NO.

5. PURCHASE ORDER NO.

6. ISSUED TO:

University of Alaska
Fairbanks, AK 99701

7. DESTINATION

SHIP TO

OCS Program Office
NOAA/ERL, Rx4
Boulder, CO 80302

8. ACCOUNTING CODE: RK0000 R7120815

9. QUOTATION REF. OR CONTRACT NO.: 03-5-022-56

10. DISCOUNT TERMS

11. DELIVERY F.O.B.

12. GOVT. B/L NO.

13. DELIVERY DATE

14. FUNDS AVAILABLE *(Budget Office)*

14a. STATION

15. LINE NO.	16. DO NOT USE	17. DESCRIPTION	18. QUANTITY	19. UNIT	20. ESTIMATED TOTAL COST	21. ACTUAL UNIT PRICE	ACTUAL TOTAL COST
		Additional funds for contract 03-5-022-56, T. O. #8, RU#194 for ice breaker cruise, as per attached					
		Total funded to date: $296,721					
		AMOUNT OF THIS ACTION: $ 3,830			3,830		
		Total funded to date: $300,551					
	Approved:						
	Director, ERL						

22. SIGNATURE OF REQUISITIONER

TITLE

DATE

23. SIGNATURE APPROVING OFFICER

TITLE Director, OCSEAP

DATE 3-13-78

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: →

OCS 78-16

WORK STATEMENT MODIFICATION

TO: Outer Continental Shelf Energy Program
National Oceanic and Atmospheric Administration
Environmental Research Laboratory
Boulder, Colorado 80302

FROM: University of Alaska
Fairbanks, Alaska 99701

CONTRACT: 03-5-022-56

TASK ORDER: #8 R.U. #194

TOTAL INCREASE REQUESTED $3,830

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Marine Mammal Pathology/Beaufort-Chukchi Seas:
An amendment to RU# 194, Natural Morbidity and Mortality of Marine Mammals; to be coordinated with RU#s 230 & 232 (ADF&G) for expanded Trophic studies in the Beaufort/Chukchi Seas.

Principal Investigator:
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This an amendment complementary to proposals for extension of ongoing research efforts on marine mammals of the Beaufort and Chukchi seas. American and Canadian studies of seals in the Beaufort-Chukchi region over the past two decades have documented a drastic decline in numbers and productivity of seals, beginning in 1974. The secondary causes of that decline are unknown but are presumed to be either nutritive (i.e. lowered secondary productivity of the marine environment), physical (e.g. unfavorable ice conditions), pathological (parasites and diseases) or a combination of these. Conceivably, the primary cause is related to the recent activities associated with petroleum development in the region. A thorough investigation of potential secondary causes and their effects seems essential, in order to develop a focus on the primary cause. We propose to investigate the pathological aspect, in conjunction with ongoing studies of the trophic relations and other biological and ecological characteristics of those seals, utilizing the same logistic support and collected materials.

This is a continuation of efforts begun in FY77 as an adjunct to RU#230 and 232. In FY77, we participated in the OCSEAP multidisciplinary cruise of the CGC GLACIER in the Beaufort Sea and began our analysis of the materials collected. This was completed in the first quarter of FY78, and analyses of a large quantity of additional materials obtained subsequently by personnel of RU# 230, 232 in the Beaufort-Chukchi region were begun. We propose here to continue that work in the last quarter of FY78, by participation in the prospective cruise of a CGC icebreaker in the Beaufort Sea in August . Continuing into FY79, we would participate in at least one shore-based operation in the Beaufort-Chukchi region, complete the analysis of all materials collected there in FY77 and 78, and begin analysis of the FY79 materials.

Our activities during field operations will include:

1) Necropsy of all marine mammals collected and identification of gross pathological conditions.

2) Collection of blood sera for subsequent analysis.

3) Isolation of microbiological and parasitological agents of disease.

4) Collection of tissues for histopathological examination, and

5) Collection of tissue samples for assessment of petroleum hydrocarbon and heavy metals analysis.

Laboratory analysis of the materials collected during our field operations and collected for us in other field operations by personnel of RU#230, 232, will be conducted with facilities of the Institutes of Marine Science and Arctic Biology of the University of Alaska-Fairbanks and with diagnostic services of the Department of Pathology, Johns Hopkins University, Baltimore, the U.S. Department of Agriculture Laboratories, Ames and Plum Island, and the Division of Public Health, Alaska Department of Health and Welfare, Fairbanks. The kinds of information to be obtained from these analyses will include:

1) Serological screening for evidence (antibodies) of previous exposure to pathological agents,

2) Identification of microbiological and parasitological agents of disease,

3) Identification of histopathological conditions, and

4) Correlation of each of the above with gross pathology and with the physical indices of physiological condition of each animal.

Tissues for assessment of petroleum hydrocarbon and heavy metal burdens will be provided to investigators (e.g. D. Burrell, D. Shaw) concerned with that aspect of environmental study.

We anticipate that the information obtained, in combination with that from other, related projects, will allow us to estimate the rates of occurrence of pathogens and pathological conditions in seals of the Beaufort Sea and to compare these with rates in like hosts over a wide area of the Alaskan continental shelf. We expect further that our findings will shed some light on answers to the question of the recent decline in numbers of seals in the Beaufort Sea, and the apparently related decline there of polar bears.

RESEARCH PROPOSAL

R. U. 196. The distribution, abundance and feeding ecology of birds associated with the Beaufort, Chukchi and Bering Sea pack ice.

Principal Investigator: George J. Divoky

Total Cost: $66,279

Research Institution: Point Reyes Bird Observatory

Date of Proposal: 27 June 1977

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Technical Proposal

I. Title: The distribution, abundance and feeding ecology of birds associated with the Beaufort, Chukchi and Bering Sea pack ice.

Research Unit Number: 196

Contract Number: 03-7-022-35140

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

II. Principal Investigator: George J. Divoky

III. Cost of Proposal

C. Total: $66,279

D. Distribution by lease area:

St. George	40%
Chukchi	15%
Norton	15%
Beaufort	30%

IV. Background

During its annual formation and retreat the Arctic pack ice covers a major part of the outer continental shelf being considered for development as part of the OCS program. The annual cycle of the pack ice has a profound effect on the marine birds in the Beaufort, Chukchi and Bering Seas. The proposed research is part of a continuing project aimed at obtaining predictive understanding of the distribution, abundance and biology of bird species associated with the ice environment. Because aerial censusing over ice has been shown to provide unreliable data, this project is dependent on the availability of ships that operate in and next to the ice. Thus seasonal and year to year patterns emerge slowly through repetitive observations. Major emphasis in 1977 (and probably 1978) will be placed on trophic studies through collection of birds and subsequent stomach analysis. Ice edge habitats are sites of major concentrations of marine birds under certain circumstances and at the same time can be expected to be subject to buildup of any marine contaminants.

The proposed research identifies the prey items that are being consumed by birds and relates the information to oceanographic and productivity data being gathered concurrently. In this way the proximate factors determining seabird distribution at the ice edge can be determined.

V. Objectives:

This research unit fulfills in part sub-task E-3 with special reference to distribution, abundance and feeding ecology of marine birds with ice and ice edge habitats and E-17.

1) Sample bird occurrence in relation to all major seasonal ice events (formation, maximum extent, decomposition, minimum extent) in each lease area (Norton, Chukchi, Beaufort).

2) Develop predictive understanding of repetitive ice features on the distributions of birds.

3) Develop predictive understanding of anomalous ice features in year to year variations of occurrence and abundance of pagophilic species.

4) Use all appropriate techniques to identify and follow ice and water mass dynamics seasonally to learn what influence events such as river overflow, variable shear zones and major lead systems have on the avian community.

5) Amplify the understanding of trophic ecology of pagophilic species to the point that major prey items can be identified as requiring additional understanding/experimentation in view of offshore development.

VI. General Strategy and Approach

The majority of information gathered by this project is obtained through shipboard observations and collections. Shipboard work allows this project to be conducted concurrently with physical oceanographic and biological studies that provide information needed to interpret bird distribution and feeding data. Aerial censusing over ice habitats has been shown to provide poor information on seabird numbers due to the lack of a uniform background to observe birds on. Aerial censusing also provides information with no oceanographic information for use in data interpretation.

Since this project is so dependent on cruises in and next to the ice and since the availability of such cruises is limited the project must progress slowly over a number of years. We are slowly building up a data base that will allow the objectives of this project to be reached. Advances in data processing should allow speeding up of data interpretation.

VII. Sampling Methods

The overall sampling scheme for this project is dependent on OCSEAP scheduling of ice edge cruises. On a given cruise an attempt is made to conduct observations south of the ice, at the ice edge and at varying distances within the ice. Observations are usually made continuously as the ship steams during daylight hours so that gradients north and south of the ice are discernible. Observations are divided into 15-minute periods with all birds seen in a 300-meter transect on one side of the ship being counted. Birds seen in this transect are used to compute birds per km^2. This is done for all birds seen and by species. Ship followers are counted once every 15 minutes but are not included in density computations. Information gathered on birds includes age, sex, activity, and direction of flight. For each observation period, information on ice cover, type and a number of other ice parameters is taken. Oceanographic information and distance to land and shelfbreak are obtained for each 15-minute transect. All observations are coded in OCSEAP data format 035.

Bird specimens are collected from a small boat with a shotgun. On returning to the ship all specimens are weighed, sexed, analyzed for fat, and the stomach removed. Stomach contents analysis is done immediately. The weight, number and size of each prey organism is recorded. All bird specimen and stomach contents data will be entered into an OCSEAP data format as soon as the format is approved by NODC.

Limited land-based field work will be conducted during those periods when cruises are not taking place.

VIII. Analytical Methods

Bird densities will be analyzed in relation to ice cover, distance to ice edge, distance to shelfbreak, distance to land and a number of oceanographic parameters. In this way the principal factors determining bird distribution in and next to the ice can be ascertained.

Stomach contents will be analyzed by determining frequency of occurrence for all prey items and percent of total volume. Frequency of prey species in stomachs will be compared with the frequency of the species in otter and Tucker trawls.

IX. Anticipated Problems

The major anticipated problem is the lack of ice edge cruises to provide information for this project. Ice edge cruises in the Bering Sea in March and April of 1976 and 1977 have provided good information on those birds associated with ice at maximum ice extent. Icebreaker cruises in August and September have provided information from the period of minimum ice cover. There is a need for cruises at other times of the year. If OCSEAP is given a month of icebreaker time in 1978 they should think seriously of asking for something other than an August cruise in the Beaufort. A cruise in the decomposing ice in the Chukchi in July would prove more worthwhile than repeating an August-Beaufort cruise for a third year.

X. Deliverable products

A. Digital data - All of the parameters included in data format 033 are recorded during observations. In the past, coded sheets similar to the one included in this report (see Section E. Other Information) have been sent to Michael Crane of the AEIDC in Anchorage. The AEIDC then keypunched the data, proofed them for errors, put them on magnetic tape and sent them to the Juneau Project Office. In F Y 1978 an attempt is being made to enter all data on magnetic tape while at sea. This will remove the coded sheets and keypunching from the data processing, thus resulting in a savings for this project and OCSEAP. Funds for the hardware and software to accomplish this task are included in the budget.

B. Narrative Reports - All narrative data will be included in quarterly and annual reports and in papers published in scientific journals. This will include word-schematic models of ice features, deformations, anomalies, illustrating the dynamics of bird/ice relationships in average and extreme cases for all lease areas.

C. Visual Data - Maps of the occurrence and densities of each species for each cruise in relation to ice features will be prepared. Figures showing bird densities in relation to oceanographic and other parameters will also be submitted.

D. Other Non-Digital Data - none

E. Data Submission Schedule - See next page.

XI. Information Required from Other Investigators

Information being gathered by Alexander (R.U. 427) on primary productivity and Cooney (R.U. 426) on secondary productivity allow meaningful analysis of bird density information. Stringer's information on ice dynamics (R.U. 257) provides information on ice features of importance to birds. The Remote Sensing Library at the Geophysical Institute of the University of Alaska provides NOAA and Landsat imagery that allows large scale ice features to be mapped.

XII. Quality Assurance Plans

The Principal Investigator will participate in all cruises and oversee all data gathering methods in order to assure standardization of technique. In addition all personnel hired as field assistants in this project have conducted similar observations as part of this project and R.U. 3/4. The techniques used in this project allow data to be compared with other pelagic distribution and feeding data.

XIII. Special sample and voucher specimen archival plans.

Voucher specimens of all prey items found in bird stomachs are kept as a reference for later comparison with specimens at the University of Alaska's Marine Science Sorting Center.

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)
Pelagic Bird Obs.	Tapes	20,000 lines	033	Yes	10/77 to 9/78	As Below *
Bird Stomach Contents	Coded Sheets	200 sheets	-	As Below **	10/77 to 9/78	As Below *

* Data will be submitted after each cruise. Once the new data entry system is functional, data will be submitted on magnetic tapes for 033 formats; on coded sheets for stomach contents. Data will be submitted one month after the completion of a cruise whenever possible, and within the 120 day contract requirement.

** Coded sheets will be submitted to AEIDC (OCSEAP/EDS Technical Representative) for checking and assignment of keypunching. Keypunching will be contracted out through the AEIDC/EDS Research Unit, or the UA/IMS Research Unit.

In addition, the following data may be collected and submitted as time and information is available:

Bird Colony	Coded Sheets	(small amt.)	035	As Above**	10/77 to 9/78	As Above *
Zooplankton	Coded Sheets	(small amt.)	024	As Below**	10/77 to 9/78	As Above *

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 Pt. Reyes Bird Observatory PRINCIPAL INVESTIGATOR George J. Divoky

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 attached sheet.

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.
   Observations of birds are made when ship is steaming in daylight. Birds collected from small boat when ship on station.

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.) **Bering Sea cruises in January through June. Chukchi cruises July through October. Beaufort cruises July through September. At least one cruise per sea.**

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.)
   28 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?
   I 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. **One day a week needed for running specific bird transects. Bird collections need to be done three times a day on all day stations.**

6. What equipment and personnel would you expect the ship to provide?
   Small boats and crew for collecting

7. What is the approximate weight and volume of equipment you will bring?
   200 lb. 18 cu. feet

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. **While NOAA ships can be used for ice edge work icebreakers will allow more freedom of movement.**

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.
    Minimum of two. Maximum of three.

B. Aircraft Support - Fixed Wing

1. Proposed flight lines.

   Flights out of Barrow needed to supplement shoreline and shipboard bird and ice observations. Time and location of flights dependent on location of ice. No more than four 3-hour flights needed.

   Two flights needed in late June to establish Cooper Island field camp.

2. Types of observations to be made.

   Mapping and photography of ice with some bird observations being made to supplement coastal and shipboard observations.

3. Optimum time chronology for flights.

   Two flights in June and two in September of October for ice observations.

   Two flights needed in late June to establish Cooper Island field camp.

4. Days of flight operations.

   6 days.

   Total flight hours: 15

5. I can piggyback with some whale flights.

6. No special equipment required.

7. Recommended aircraft.

   Twin Otter.

8. Recommended source of aircraft.

   NARL.

9. Charter cost.

   $350 per hour.

10. People on board.

    Two.

11. Recommended area that flights be staged from.

    Barrow.

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)

Helicopter operations needed on cruises on ships that have helo pads.

2. Describe types of observations to be made.

Observations of ice types and limited bird censusing. Photographs of ice types.

3. What is the optimum time chronology of observations on a seasonal basis and what is the maximum allowable departure from these optimum times?

At least one flight a week on appropiate cruises.

4. How many days of helicopter operations are required and how many flight hours per day? **Two hours each week.**

Total flight hours? **Depends on number and length of cruises.**

5. How many people are required on board for each flight (exclusive of the pilot)?

One

6. What are the weights and dimensions of equipment or supplies to be transported?

None.

7. What type of helicopter do you recommend for your operations and why?

Any helicopter capable of flying off of ships.

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?

N/A

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

N/A

11. Will special navigation and communications be required?

No.

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)

Borrow - 100 man days needed for personnel in transit to and from icebreakers and Cooper Island. Quarters also needed for personnel observing fall migration of pagophilic species at Barrow.
Cooper Island - 75 man days to study breeding in July and August.

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

Yes.
NARL.
No other support available in Barrow

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

Barrow - $79 per day
Cooper Island - $15 per 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?

The above figures are based on information obtained from NARL

XV. Management Plan

The principal investigator will oversee all operations in the field, laboratory and office. He will participate in all cruises and be responsible for the preparation of all digital and narrative data. Should the proposed shipboard data entry system prove to be unworkable, data will be channeled through the AEIDC in Anchorage for keypunching and being put on magnetic tape.

Information on chronology of data gathering is given on the attached Milestone chart.

XVI. Outlook

At the completion of F Y 1978 this project will have obtained an overview of bird species and densities associated with the pack ice during times of maximum and minimum ice cover. Three years of information will have been obtained thus showing year to year variation in distribution and abundance. Predictive models can then be completed using 1975-78 data.

The increased emphasis being given to trophic relations by OCSEAP has already provided much new information on feeding habits. If this emphasis is continued in 1978 by the start of F Y 1979 a large collection of stomach samples from ice inhabiting birds will have been collected. This will allow the primary and secondary prey species of birds at the ice edge to be identified.

Work to be carried out after F Y 1978 would include cruises similar to those planned for F Y 1978. The annual variation in ice cover and features demands that birds in and next to the ice be censused annually when possible. Future field work should be aimed at replicating observations and collections done in preceding years as well as conducting cruises in lease areas that have not yet had ice edge cruises.

Funding for research after F Y 1978 should not exceed $50K per year. If data processing advances are realized there will be little need for assistants to be employed when cruises are not being conducted.

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."

MILESTONE CHART

RU #: 196 PI: George J. Divoky

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
Observations of pagophilic species at Barrow	X														
Ananlysis of stomach contents and data from summer and fall 1977		X	X												
Preparation of maps and figures showing bird distributions				X	X	X									
Ice edge cruises in Bering Sea						X	X	X	X						
Cooper Island field camp									X	X	X				
Icebreaker cruises in Chukchi or Beaufort											X	X	X		
Quarterly or Annual Reports submitted			X			X			X			X			

Papers Published:

Watson, G. E. and G. J. Divoky. 1971. Identification of _Diomedea leptorhyncha_ Coues 1866, an albatross with remarkably small salt glands. Condor 73:487-489.

Divoky, G. J. 1972. The pelagic birds and mammals of the Chukchi Sea in fall. M.S. thesis. Michigan State University, E. Lansing, Michigan.

Watson, G. E. and G. J. Divoky. 1972. Pelagic bird and mammal observations in the eastern Chukchi Sea, early fall 1970. U.S. Coast Guard Oceanographic Report 50:111-172.

Divoky, G. J., G. E. Watson and J. C. Bartonek. Breeding of the Black Guillemot in northern Alaska. Condor 76:339-343.

Watson, G. E. and G. J. Divoky. 1975. Marine birds of the western Beaufort Sea. Pages 681-695 in J. C. Reed and J. E. Sater, eds. The coast and shelf of the Beaufort Sea. Arctic Institute of North America, Washington, D. C.

Divoky, G. J. 1976. The pelagic feeding habits of Ivory and Ross' Gulls. Condor 78:85-90.

☆U.S. Government Printing Office: 1978-777-067/1252 Region 8

SHIP--AIRCRAFT CENSUS

HEADER

File type			File Ident.					
1	2	3	4	5	6	7	8	9

LOCATION

RT	Station number	Start Latitude Deg.	Min.	Sec.	H.	Start Longitude Deg.	Min.	Sec.	H.	GMT year	mon.	day	hour	min.	Stop Latitude Deg.	Min.	Sec.	H.	Stop Longitude Deg.	Min.	Sec.	H.	Elap. Time	Time Zone	Time Zone 01-12	Speed Made Good	Course made good	height above sea	Platf. Type	Sample Tech.	Ship activ.	Photos
10	11 12 13 14 15	16 17	18 19	20 21	22	23 24 25	26 27	28 29	30	31 32	33 34	35 36	37 38	39 40	41 42	43 44	45 46	47	48 49 50	51 52	53 54	55	56 57	58	59 60	61 62 63	64 65	66 67 68	69	70	71	72
1					N					76	10																					

ENVIRONMENTAL

RT	Depth to bottom in m.	Depth of Thermocline	Sea Surface Temp.	surface salinity	Dry Bulb Temp.	Wet Bulb Temp.	Rel. Hum.	Bar. Pressure	Bar. Trend	Wind Dir.	Wind Speed	Sea St.	Swell Dir.	Swell Ht.	Weather	Cloud Type	Cloud Amt.	Vis.
10	15 17 18 19	20 21 22	23 24 25 26	27 28 29	30 31 32 33	34 35 36 37	38 39	40 41 42 43	44	45 46	47 48	49	50 51	52 53 54	55 56	57	58	61
2																		

ICE

RT	Ice Cover	pattern code	Type code	form code	relief code	thickness	melt	coverage	pattern	type	form	relief	thickness	melt	Open Water Type	Dir.	Dis.	Lead	Visible Ice Form	Cov.	Dir.	Dist.	Ship in H_2O	width of lead	dist. to edge	Arctic			Ice algae	Mammal trace	other feature		Time of ice	
10	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
3																																		

DATA

RT	Time (min.)	Taxonomic Code	Sub-Spec.	Spec. group	Age	Sex	Color Ph.	Plum.	Mat	No. Individuals	Count Meth.	Rel. Code	Dist.	Dist. From Obs.	Dir. Flight	Assoc. Code	Linkage multi-species	No. Spec. Partic.	Behavior	Special marks	Bird Cond.	Food Source	Taxonomic Code - Food Sp.	Debris	Oil	Oil	Substrate	Cover	Habitat
10	15 17	18 19 20 21 22 23 24 25 26 27	28 29	30 31	32	33	34	35	36	37 38 39 40 41	42	43	44 45	46 47	48 49	50	51 52 53	54 55	56 57	58	59	60	61 62 63 64 65 66 67 68 69 70	71	72	73	74	75	76 77
5 ↓																													