UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

RPWG

NATIONAL MARINE FISHERIES SERVICE
OFFICE OF OIL SPILL DAMAGE ASSESSMENT AND RESTORATION

P.O. 210029
11305 GLACIER HWY
AUKE BAY, ALASKA 99821

TELEPHONE: (907) 789-6600
FAX: (907) 789-6608

RAPIDFAX TRANSMISSION: 1 PAGES TO FOLLOW

DATE: 06/25/93

FROM: JOHN A. STRAND

TO: RT MEMBERS: ~~BRODERSEN~~, ~~BERGMANN~~, ~~RUTHERFORD~~, ~~MONTAGUE~~, RICE, GIBBONS & RPWG

FAX NUMBER: CACI

SUBJECT: RESTORATION MONITORING PLANNING UPDATE

please Distribute to members

COMMENTS -

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

June 25, 1993

MEMORANDUM FOR: Restoration Team

FROM: John Strand
Co-Chair, Restoration Planning
Planning Work Group

SUBJECT: Restoration Monitoring Planning Update

REFERENCE: (1) Monitoring Recovery Following the *Exxon Valdez* Oil Spill: A Conceptual Monitoring Plan (Draft Final)

(2) 1993 Draft Work Plan (Project 93041, page 166) - Comprehensive Restoration Monitoring Plan Phase 2

(3) Draft Request For Proposals - Develop Detailed Design Specifications for Comprehensive and Integrated Monitoring Plan

On June 29th, we again will discuss the progress of monitoring planning. As a means of focusing discussion on future monitoring planning needs, the RPWG will provide an overview of the planning document being finalized by Parametrix Inc., highlighting salient results and recommendations. Before the meeting, you might again review the Draft Final Conceptual Plan (Reference 1) which was forwarded to you on May 18th, noting that this was an early draft and that the final version will have undergone re-organization and extensive editing following peer review. From a technical perspective, however, I think the draft is still useful to introduce technical concepts. I should have a copy of the final Parametrix document for distribution on the 29th.

I would expect that we also will discuss Project 93041 (Reference 2) and the Draft RFP for Phase 2 (Reference 3). Please call if you need an another copy of the RFP. The RFP was sent to David Gibbons March 24th for subsequent distribution and review by the Restoration Team. Thank you.

Distribution: RT
RPWG

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

July 23, 1993

MEMORANDUM FOR: Bob Spies

FROM: John Strand

SUBJECT: Use of Conceptual Monitoring Plan Prepared by Parametrix, Inc.

By separate letter (my July 20th memo), you should have received a final copy of the subject document. We are also sending copies to Pete Peterson, Don Boesch, Jim Richardson and Phil Mundy (each provided comment on either the preliminary draft or draft final document).

The Restoration Planning Work Group would like to use the Conceptual Plan as an attachment to the RFP for Phase 2 monitoring planning (Develop Detailed Design Specifications). It was always the intent that the results of Phase 1 would provide conceptual guidance to develop a more detailed, technical monitoring plan in Phase 2. You will receive a copy of the revised Phase 2 RFP dated July 21, 1993 from Bruce Wright or David Gibbons in the next day or so. We also eventually would like to see a copy of the Conceptual Plan available at Oil Spill Public Information Center.

We hope that you will find that the final document is significantly improved when compared with the draft final document that was forwarded to you for peer review in mid-May. We also hope that you will agree that the comments offered by Pete Peterson, Don Boesch, Jim Richardson and the Planning Group (Chris Swenson, Karen Klinge, and myself) were appropriately used in the preparation of the final document. You may not have received copies of all the comments; let me know which set of comments you don't have.

When we discussed our intended use of the subject document with the Restoration Team (RT) on June 29th, we were instructed to seek your concurrence. While the RT could agree with and accept many of Parametrix's recommendations (e.g., use of a conceptual framework and conceptual models, etc.), the RT also noted that other recommendations (options) (e.g., how monitoring will be managed; who will perform the monitoring, etc.) would deserve much further discussion. However, the RT believed that we clearly had to move ahead with Phase 2 as quickly as possible. They also viewed the document as one providing broad guidance for future planning, and agreed to hold future discussions on which of the recommendations and options to implement.

Perhaps you would give the document a final review and let us know what you think. Thank you.

cc: Byron Morris
Bruce Wright
RPWG

(Y)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

July 2, 1993

MEMORANDUM FOR: Mary Sue Brancato

FROM: John Strand

SUBJECT: Conceptual Monitoring Plan

I have just completed my review of your final Conceptual Monitoring Plan. I also asked Barbara Iseah to proof read the text. While I found that technically the plan is sound, both Barbara and I found a significant number of typographical errors. While the errors (misspellings, words left out, inconsistencies, etc.) are relatively minor and none alter the context of the document, I will need a "clean" copy of the report for final distribution. I have made the suggested corrections in pen and ink in the text of the enclosed copy. If any comment is not understood, please don't hesitate to call. I will call from Anchorage next week to determine when I could expect replacement pages. Have a good holiday. Thank you.

Enclosure

cc: Byron Morris
RPWG

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

June 15, 1993

Dr. John Armstrong
U.S. Environmental Protection Agency
Office of Coastal Waters
Water Division, WD-139
1200 Sixth Avenue
Seattle, WA 98101

Dear John:

RE: Interagency Agreement DW13957045-01-1
Coordinate Development of a Comprehensive and Integrated Monitoring Plan for the Exxon Valdez Oil Spill (Revision 1), Progress Report 3.

A. Progress to Date May 1 through May 31, 1993

Task 1. Obtain Services of Qualified Consultant to Provide Technical Assistance in the Development of a Conceptual Design for Monitoring.

On 18 May, Parametrix submitted a draft of their final product entitled, **"Monitoring Recovery Following the *Exxon Valdez* Oil Spill: A Conceptual Monitoring Plan."** Copies for review and comment were distributed to the Restoration Planning Work Group, the Restoration Team, the Chief Scientist, and three members of the Peer Review Team (Donald Boesch, Charles Peterson, James Richardson). To date, seven reviews have been received and forwarded to Parametrix for their use in developing a final document.

All the reviews indicated that the draft plan provided excellent guidance to the *Exxon Valdez* Oil Spill Trustee Council, although some technical concepts were still fuzzy and needed to be brought into sharper focus. From an editorial perspective, however, the document was in need of much work. Some measure of re-organization was required, redundancies had to be addressed, and some sections needed to be rewritten. It was still obvious that the plan was written by multiple authors, and that Parametrix was best advised to obtain the services of a professional editor.

Task 2. Design and Conduct Workshop to Develop Conceptual Design for a Restoration Monitoring Plan

This task was essentially completed at the time the workshop was held, April 14, 1993.

B. Problems Encountered

Because of the extensive number of comments received during the peer review of the Draft Conceptual Monitoring Plan, and the need to undertake a significant editorial revision, we (NOAA) have recommended and granted a no-cost, time-extension to the above contract, extending the period of performance from June 11 to June 30, 1993. This will benefit NOAA, the *Exxon Valdez* Oil Spill Trustee Council, and USEPA by providing a better quality final plan.

C. Funds Expended to Date (May 31, 1993)

There has been no change since the last progress report (May 17, 1993). Three invoices totaling $49,671.96 have been received and authorized for payment since the beginning of the contract. Pursuant to the provisions of the USEPA/NOAA IAG, $40,671.96 of this total was charged to USEPA; the remainder $9,000 was charged to NOAA.

D. Anticipated Progress (June 1 through June 30, 1993)

It is expected that the final Conceptual Monitoring Plan will be submitted prior to the end of the contract. I have asked to again review and approve/disapprove several of the key sections prior to submission of the final document.

Yours very truly,

John A. Strand, Ph.D.
Restoration Manager

Attachments

cc: Mark Brodersen
Byron Morris
Stephen Pennoyer
Bruce Wright
RPWG Files

RPWG
Y

RESTORATION PLANNING WORK GROUP
EXXON VALDEZ OIL SPILL OFFICE
645 "G" STREET
ANCHORAGE, ALASKA 99501

TO: Heidi Sickles
Contracting Officer
NOAA, WASC
Procurement Division
7600 Sand Point Way NE, BIN C15700
Seattle, WA 98115

DATE: May 13, 1993

FROM: John Strand
Contracting Officer's
Technical Representative
(Contract No. 50ABNF300041)

SUBJECT: Parametrix Invoice No. 009549 for March 1993

I recommend approval of the attached invoice. The Contractor's costs are consistent with the negotiated price, and progress is satisfactory and commensurate with the rate of expenditure. I suggest that the costs to the program be allocated as follows:

	Account No.	Amount
1)	FS 1300/RL1ABW4K/2517	$21,902.29
2)	FS 1300/EL1AO24K/2517	3,000.00
		$24,902.29

Thank you.

Attachment

cc: Lynne Lewis
Byron Morris

Parametrix, Inc. Consultants in Engineering and Environmental Sciences

5808 Lake Washington Blvd. N.E. Kirkland, WA 98033
206-822-8880 • Fax: 206-889-8808

Dr. John Strand
US Dept. of Commerce, NOAA,WASC
PO Box 2010029
Auke Bay, AK 99821-0029

April 28, 1993
55-2417-01 (1)

SUBJECT: PARAMETRIX INVOICE NO. 009549 FOR MARCH 1993 CONSULTING SERVICES FOR: EXXON VALDEZ CONCEPTUAL MONITORING

Dear John:

Enclosed is our invoice for services rendered in March 1993. The attached invoice requests payment for $24,902.29.

The majority of the work performed on Task 1 during March consisted of conducting telephone interviews with approximately 50 peer reviewers, principal investigators, and Restoration Team members; and revising the preliminary draft conceptual plan to reflect the input received.

Mary Sue Brancato

As project manager, Ms. Brancato managed overall project activities including review of materials submitted by project team members for inclusion in the draft report. Additionally, she facilitated approximately half of the telephone interviews, and synthesized the information obtained into the draft conceptual monitoring plan document.

Tracey McKenzie

Ms. McKenzie was responsible for conducting approximately half of the telephone interviews and assisted in synthesizing the information obtained into the draft conceptual monitoring plan document.

Ronald Shimek

Dr. Shimek provided the initial draft of the sampling plan for marine benthos of intertidal and subtidal communities. He also assisted in the review of earlier drafts of the conceptual monitoring plan and participated in telephone interviews.

Margaret Spence

Ms. Spence assisted in the preparation of the draft conceptual monitoring plan, including reviewing elements of other monitoring programs and preparing the section on general guidance for sampling design.

Thomas Strong

Dr. Strong provided additional input on goals, strategies, and criteria for the conceptual monitoring plan as well as drafting the section of the plan dealing with mammals and avifauna.

Don E. Weitkamp

Dr. Weitkamp prepared Chapter 1 material for preliminary draft of the Conceptual Monitoring Plan.

Rick Cardwell

Dr. Cardwell reviewed portions of the draft monitoring plan with Ms. McKenzie.

Alf Shepherd

Mr. Shepherd participated in the drafting and review of materials prepared for criteria development.

Dolores Lehtinen\Kim Naughten\Shanon Harris\Caz Anderson\Michael Ehelebe\Sabina Renn\Mary Haff

The above people were involved in administrative duties, including providing support to Dr. Weitkamp, Mary Sue Brancato and Tracey McKenzie. Their work included correspondence, library research, faxing, copying, arranging telephone interviews and general clerical duties.

If you have any questions, please contact Tracey McKenzie or Mary Sue Brancato at 206-822-8880.

Sincerely,

Don Weitkamp, Ph.D.
Principal

DW:sh
Encl.

Parametrix, Inc.

P.O. Box 460
Sumner, Washington 98390
206-863-5128 • 206-838-9810

INVOICE:

Invoice #: 009549
04/19/93
Page #: 1

55-2417-01 EXXON VALDEZ CONCEPTUAL MONITORING
Contract #50ABNF300041

US Dept of Commerce,NOAA,WASC
Dr. John Strand
P.O. Box 2010029
Auke Bay, AK 99821-0029

Billing Period Ending 03/31/93

01:Conceptual Plan		
	Direct Labor	22,819.05
	Direct Expenses	2,083.24
Task Total		24,902.29
Invoice Total		24,902.29

TOTAL AMOUNT DUE THIS INVOICE 24,902.29

PARAMETRIX, INC.

Mary Sue Brancato

Mary Sue Brancato

TERMS: NET 30 DAYS--PAST DUE SUBJECT TO 1-1/2 % CHARGE.

STATEMENT

Previously Billed	24,769.67	Contract Amount	129,258.00
Total This Invoice	24,902.29	Billed To Date	49,671.96
Billed To Date	49,671.96	Contract Balance	79,586.04
Paid To Date	8,343.31		

Parametrix, Inc.

P.O. Box 460
Sumner, Washington 98390
206-863-5128 • 206-838-9810

INVOICE:

55-2417-01 EXXON VALDEZ CONCEPTUAL MONITORING

S A L A R Y & E X P E N S E D E T A I L

01:Conceptual Plan

SALARIES ON A MULTIPLIER BASIS

	HOURS	RATE	COST	
Caz Anderson	2.00	14.1500	28.30	
Mary Sue Brancato	55.50	32.8100	1,820.96	
Rick D. Cardwell	1.50	42.8100	64.22	
Michael E. Ehelebe	1.00	8.6000	8.60	
Mary E Haff	3.50	12.6400	44.24	
Shanon L. Harris	29.75	12.9000	383.78	
Dolores Lehtinen	18.00	12.6200	227.16	
Tracey McKenzie	70.00	25.9600	1,817.20	
Kim T. Naughten	.50	12.3000	6.15	
Sabina J. Renn	6.50	14.0400	91.26	
Alf D. Shepherd	1.50	20.4400	30.66	
Ronald L. Shimek	35.50	24.1100	855.91	
Margaret E. Spence	35.00	20.5200	718.20	
Thomas R. Strong	25.50	20.0500	511.28	
Donald E. Weitkamp	24.00	41.6700	1,000.08	
	309.75		7,608.00	
Overhead @ 169%			12,857.52	
			20,465.52	
Professional Fee			2,353.53	
				22,819.05

Fixed Fee Budget	8,642.00
Billed To Date	4,871.26
Balance Fee Amt.	3,770.74

OTHER DIRECT CHARGES

	COST/QTY	RATE	AMOUNT
Airline Fares			
Bankcard Center	1,602.72	1.1500	1,843.13
Courier Services			
Federal Express Corp.	57.60	1.1500	66.24
Documents, Maps			
State of Alaska	15.92	1.1500	18.31

Parametrix, Inc.

P.O. Box 460
Sumner, Washington 98390
206-863-5128 • 206-838-9810

INVOICE:

55-2417-01 EXXON VALDEZ CONCEPTUAL MONITORING

S A L A R Y & E X P E N S E D E T A I L

01:Conceptual Plan (CON'T)

	COST/QTY	RATE	AMOUNT
Rental Car Budget Rent-A-Car	72.00	1.1500	82.80
Mileage Employee mileage	133.00 mile(s)	.2800	37.24
Parking Sabina J. Renn	17.50	1.0000	17.50
Supplies Sabina J. Renn	4.00	1.0000	4.00
Per Diem Donald E. Weitkamp	14.02	1.0000	14.02
			2,083.24
** Total Project 55-2417-01			24,902.29

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

RPWG
Y

May 17, 1993

Dr. John Armstrong
Office of Coastal Waters
Water Division, WD-139
1200 Sixth Avenue
Seattle, WA 98101

Dear John:

RE: Interagency Agreement DW13957045-01-1
Coordinate Development of a Comprehensive and Integrated Monitoring Plan for the Exxon Valdez Oil Spill (Revision 1), Progress Report 2.

A. Progress to Date (January 1 through April 30, 1993)

Task 1. Obtain Services of Qualified Consultant to Provide Technical Assistance in the Development of a Conceptual Design for Monitoring.

As indicated in Progress Report 1, NOAA, NMFS hired Parametrix, Inc. to assist the Exxon Valdez Oil Spill Trustee Council in developing a conceptual monitoring design.

On January 27th, the Restoration Planning Work Group met with Parametrix to discuss in detail the approach to be used in addressing each of the issues listed in the Request for Proposals (RFP included in Progress Report 1). An outline (see ATTACHMENT 1) for the Draft Conceptual Monitoring Plan was also presented and adopted.

At the heart of the Parametrix approach is a conceptual framework that could be used by the Trustee Council as a tool for developing and refining effective monitoring, and as a guide for decisions on what to monitor, where, when and how. It also establishes the relationships among those who require and those who produce monitoring information, as well as establishing how monitoring could be integrated and coordinated among the various activities. This approach borrows heavily from the National Research Council's conceptual methodology for developing a more effective and useful monitoring programs (National Research Council, Managing Troubled Waters- The Role of Marine Environmental Monitoring, National Academy Press, Washington, D.C., 1990).

Use of conceptual models is the central feature of this framework. In application, conceptual models can be used to identify the links among resources at risk; the physical, chemical and biological processes of the affected ecosystem, and; the human and natural causes of change. Conceptual models begin as qualitative descriptions of the causal links within the ecosystem to be monitored. Then based on technical knowledge (rates of important processes), they can be expanded to include quantitative elements, such as mathematical or numerical models to better understand the dynamics of the ecosystem to be studied. Essentially, conceptual models help define cause-and-effect relationships and permit testable questions (hypotheses) to be formulated and evaluated.

Task 2. Design and Conduct Workshop to Develop Conceptual Design for a Restoration Monitoring Plan

The design of a April 1993 workshop also was discussed at the January 27th meeting. The workshop was scheduled to be held in Anchorage April 14th to review preliminary materials for potential inclusion in the Draft Conceptual Monitoring Plan. These preliminary materials would largely address the objectives, strategies, and criteria to establish monitoring priorities and reflect the input of the Principal Investigators, the Restoration Planning Work Group, Restoration Team, peer reviewers as well as Parametrix. An agenda was developed (see ATTACHMENT 2) and considerable thought was given to a prospective list of participants. Agreement was reached that at least one peer reviewer representing each major category of injured resource or service in addition to the Chief Scientist should attend the workshop.

The Conceptual Monitoring Planning Workshop was held as scheduled. Nine members of the Peer Review Team as well as the Chief Scientist attended. Some 25 other individuals representing Principal Investigators, the Restoration Planning Work Group, Restoration Team, and the two Regional Citizen's Advisory Committees (RCAC) also attended. The RCACs were organized as a result of the Oil Pollution Act of 1990 and currently conduct monitoring in Cook Inlet and Prince William Sound.

The workshop was well organized and made good use of the participants. Parametrix was willing to modify their draft materials in accordance with the views of the attending resource experts.

B. Problems Encountered

None.

C. Funds Expended To Date (April 30, 1993)

Three invoices totaling $49,671.96 were received and approved for payment during the reporting period. Pursuant to provisions of the EPA/NOAA IAG, $40,671.96 of this total was charged to EPA; the remainder $9,000.00 was charged to NOAA.

D. <u>Anticipated Progress (May 1 through June 11, 1993)</u>

1) On May 18th, Parametrix will submit for review and comment a draft of the conceptual monitoring design. It is anticipated that this document will be reviewed by the Restoration Planning Work Group, Restoration Team and the Chief Scientist. A two-week review period is envisioned, after which Parametrix will have until June 11th to make the required changes. June 11th is the termination date for the existing contract.

Yours very truly,

John A. Strand, Ph.D
Restoration Manager

Attachments

cc: Mark Brodersen
Byron Morris
Steven Pennoyer
Bruce Wright
RPWG Files

DRAFT

Conceptual Monitoring Plan

1.0 Introduction
- 1.1 Background (Purpose and intent of project)
- 1.2 What is a Coneptual Monitoring Plan?
- 1.3 Approach to Coneptual Plan
- 1.4 Plan Content

2.0 Why Restoration Monitoring?
- 2.1 Value and Use of Restoration Monitoring

3.0 Definition of Restoration

4.0 Goals, Objectives, and Strategies of Conceptual Monitoring Plan
- 4.1 Restoration
  - 4.1.1 Ecosystem Level
  - 4.1.2 Priorities
  - 4.1.3 Standardized Methods for Studies
  - 4.1.4 Standardized Protocols for Reporting
  - 4.1.5 Restoration Alternatives
  - 4.1.6 Evaluation of Recovery
- 4.2 Reference/Baseline Data
  - 4.2.1 Guidance on Database Requirements
  - 4.2.2 Data Base Management including QA/QC
  - 4.2.3 Comparability with Existing Monitoring Data Bases
- 4.3 Institutional
  - 4.3.1 Peer Review Panel
  - 4.3.2 Data Dissemination
  - 4.3.3 Avoiding Duplication of Effort

5.0 Resources and Services to be Monitored
- 5.1 Monitoring Services (or elements of services)
- 5.2 Criteria for Evaluating Restoration Monitoring Activities
- 5.3 Value of Criteria
- 5.4 Guidance on Use of Criteria

DRAFT

ATTACHMENT 2

RESTORATION MONITORING WORKSHOP

14 April 1993

Exxon Valdez Oil Spill Office
645 "G" Street
Anchorage, AK 99501

8:00 AM - NOON

Introduction	John Strand Restoration Planning Working Group
Review of Conceptual Plan Process	Parametrix Team

- RPWG Meeting
- Telephone Interviews
- Key Informant Interviews
- Workshop
- Finalizaton of Conceptual Plan
- Phase II of Monitoring Plan

Review of Workshop Process and Goals	Parametrix Team
Summary of Results to Date	Parametrix Team

- Prioritization of Objectives
- Criteria for Monitoring Plan Selection

1:00 - 5:00 PM

Discussion of Objectives and Criteria

Test Application of Criteria

- Written and Verbal Exercise

Closing Summary	Parametrix Team
Adjourn	John Strand Restoration Planning Working Group

RPWG
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RESTORATION PLANNING WORK GROUP
EXXON VALDEZ OIL SPILL OFFICE
645 "G" STREET
ANCHORAGE, ALASKA 99501

TO: Mary Sue Brancato **DATE:** June 1, 1993

FROM: John Strand

SUBJECT: Comments on Draft Conceptual Monitoring Plan

Thank you for the Draft Final copy of the Conceptual Monitoring Plan. While I am now forwarding to you my specific comments, I fear that others asked to comment may take several more days to complete their reviews. I still have not received comment from Bob Spies or from the other peer reviewers. Karen Klinge also has some comments specific to "end points" and "criteria" that she will FAX by separate letter. Once you have had time to digest the comments that you have received, let's plan to make contact and discuss a mutual course of action.

General Comments:

1) From a technical perspective, the document provides excellent guidance to the Trustee Council, although there are at least two places where key technical concepts still are fuzzy. This may not altogether be your fault, and we may need to provide some better clarification. These include:

a) definition of recovery and what constitutes each monitoring component (recovery monitoring, restoration or project monitoring, ecosystem or long-term monitoring); and

b) the difference between conceptual methodology (framework or strategy) and conceptual models.

2) From an editorial perspective, the document is in need of much work. I believe some re-organization is required (see attached revised Table of Contents), some redundancies need to be addressed, and some sections are very rough. It is still obvious that the report (plan) was written by multiple authors. I also would ask you to consider some minor format changes. Clearly, a professional editor will need to spend some time with the plan.

Specific comments:

<u>Re-organization</u>

1) While I generally like what you have presented in Section 1.3

What is a Conceptual Monitoring Plan, I would opt to move Sections 1.3.4 through 1.3.8 to a new section in the plan, perhaps this becomes Section 5.0 **Conceptual Approach/Conceptual Framework** (see attached revised Table of Contents). In my opinion, what is described in your Figures 2 and 3 answers one of our original questions, "What process or mechanism would best assist the Trustee Council in determining monitoring priorities?" In devising this question, we were looking for an overall design methodology that we could use in developing our monitoring program. I am not being critical of what you presented (you have given us excellent guidance for how we should organize our thinking); rather, I would like to see it presented somewhat differently. In other words, what is embodied in Figures 2 and 3 should be presented as part of the Conceptual Plan.

It is a minor technical point, but I do not consider Figure 2 or 3 to be conceptual models in the same sense as Figure 8 (Section 5.8) is a conceptual model. I would rather use the term "framework" or strategy to describe what is presented in Figures 2 and 3. These "wiring diagrams" are also "decision trees." Clearly, use of conceptual models is a central feature in this framework or strategy. Please refer to my April 30th memo regarding your preliminary draft for additional comment on this topic. I also would be inclined to include your Section 5.8 in the new Section 5.0.

2) I also would take each of the issues that were included in the Request For Proposals (these are embodied in the questions on pages 13-21) and address them, where possible, in their own section of the plan. In part, you have already done this. This would avoid presenting some of the key information up front (on pages 13-21) in response to the questions, and the rest of the key information in the specific sections (5.0, 6.0, and 7.0) of the plan that further address the questions on pages 13-21. Perhaps you include the list of issues/questions in Section 1.0 **Introduction.**

3) I am inclined to include your Sections 5.4 **Value and Use of Criteria** and 5.5 **Criteria for Selecting and Evaluating Monitoring Activities** in a new Section 6.0. These materials are important enough to demand their own section in the plan.

4) Your Section 6.0 **Guidance on Sampling Design,** which becomes 7.0, should also be slightly re-organized. I would take all the up front statistical analyses information (Greens' Ten Principles and what is found in Sections 6.1.1, 6.1.2) and move it further back in the section and include it in a new subsection along with what you presented in your Section 6.1.7 **Statistical Analyses.** I would like you to first present the information on what to sample, where to sample for resources and services, then present guidance on statistical design, e.g., Greens' Ten Principles and formulation of hypotheses, etc. Actually, I am still inclined to include this information in an appendix.

5) As you re-organize and edit your document, try to make it read as much like a plan as possible. In parts, your document takes on the "flavor" of a report.

Technical Comments

1) I think there is still some confusion regarding the definitions used to describe the two or three monitoring components that the Trustee Council will consider for inclusion in their Monitoring
Program. I would suggest that you go back to my April 17th memo on this topic. I envision that we will need to discuss this point in some detail before we settle on a consistent set of definitions.

2) In Section 1.3.7 **Data Conversion to Information,** you indicate that it is essential to establish a computer-assisted data management system, yet at the recent workshop, I thought that we were best advised to avoid building a large, centralized data management and retrieval system. Please reconcile.

3) Your definition (concept) of recovery in Section 3.0 **Definitions of Recovery and Long-Term Monitoring** is not consistent with the definition (concept) of recovery used in the Restoration Framework (see page 41).

4) I have difficulty understanding what is meant by the first sentence in Section 4.2.2 **Needs Specific to Monitoring the Effectiveness of Restoration Activities.** Also, do these needs, objectives, and strategies adequately address "effectiveness" (project) monitoring? This again deals with how we define "monitoring." Do we opt for a three component (Recovery Monitoring, Effectiveness (project) Monitoring, Long-Term Monitoring) program; or do we opt for a two-component (Recovery Monitoring and Long-Term Monitoring) program? We again recognize the need to help reconcile this issue.

5) In Section 5.0 **Resources and Services To Be Monitored,** how do we handle the "ecosystem" component? Is there a recommended strategy?

6) In Section 5.3 **Recovery Endpoints** at the end of the first paragraph, you refer us to Section 8 **Recommendations** to learn what your recommendation will be. I would prefer that you include your recommendation in its entirety in this section. Section 8, then could become a summary of recommendations. Does this comment apply to other sections?

7) Table 1 in Section 5.3 **Recovery Endpoints** needs further explanation, particularly the use of the several symbols. Where is the symbol for "long-term?" Is long-term the same as "trend?" What is "achievement of compensatory action mean?" You might go back through the text in Section 5.3 to see if you have adequately

explained the concept of "end points."

8) Section 5.4 **Value and Use of Criteria** should be included in Section 5.5 **Criteria for Selecting and Evaluating Monitoring Activities.** Perhaps this becomes Section 5.1, actually 6.1 (see my earlier comments on re-organization).

9) Section 5.6 **Development of Conceptual Models** should be included in the new section of the report/plan entitled Conceptual Approach/Framework (whatever). See my earlier comments under "Re-organization."

10) In Section 6.2.5.3 **Commercial Tourism** on page 95, I do not see the relevance of the paragraph dealing with commercial fisheries. Is this meant for inclusion in Section 6.2.5.4 **Commercial Fishing?**

11) Why isn't Section 6.3 **Relationship of the *Exxon Valdez* Spill Monitoring Plan to Other Monitoring Programs** a stand-alone section? Do we need to be concerned with monitoring programs where there is no geographic overlap? I think not. I also would like more information on each of the relevant programs, that is, those with overlap. At minimum, I would like to see the full title of the program, the responsible agency, an address, and a one- or two-sentence scope description.

12) In Section 8.0 **Recommendations**, I think that in the context of this report/plan, consensus building applies to the monitoring planning process, not the restoration/recovery process.

<u>Other Editorial Comments</u>

1) I would like for you to use an "Executive Summary." Your **Summary** also is relatively (too) thin. At minimum, you should summarize what is contained in each section of the plan (see page *vi*). It is not enough to simply state what is presented in each of the major sections of the plan.

2) In your final copy of the plan, I would give some thought to better separation of the sections of the report/plan. Perhaps "dividers" and "tabs" could be used; at minimum you should use color dividers.

3) You should consider inclusion of an "acknowledgement" section where the names of contributing authors are given, or other contributions are acknowledged.

4) Throughout your document, you refer to "injured resources and <u>damaged</u> services." I would rather you say "injured resources and services."

5) The second major paragraph in Section 1.1 is in part redundant to that presented in the first major paragraph in Section 1.1.

6) Some of what is presented in Section 2.0 **Why Monitor?** is already presented in Section 1.2 **Why Monitor Recovery?** Please address any redundancy.

7) Your Section 1.4 **Monitoring Plan Approach and Design** appears to be redundant to your Section 1.3.4. **Study Strategy.**

8) Your Section **Conceptual Model Development** under question 2 (page 15) is redundant with what is described in Section 1.3.4 **Study Strategy** on page 8.

Attachment

cc: Byron Morris
Mark Brodersen
Bob Spies
RPWG

TABLE OF CONTENTS
(Strand Revision)

This becomes a much shorter section; it provides a brief description of what is a conceptual plan and its utility. It includes a brief statement of how this concept is embraced by the National Research Council.

This section includes our (your) approach as you have done, but it simply lists the key issues (questions) to be addressed. It may clarify what is meant by the issue or question to be addressed, but it should not include the answers or recommendations. Rather, these materials are better included in the subsequent following sections of the plan.

This section guides the reader through the plan, as you have done.

This section and section 1.2 (Why Monitor Recovery?) are redundant. This will need to be reconciled. Perhaps one is best advised to combine the two sections presenting this material in Section 1.2.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

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June 9, 1993

Dr. Eli Reinharz
Damage Assessment
Regulations Team
Office of General Council
United States Department of Commerce
National Oceanic and Atmospheric Administration
Washington D.C 20230

Dear Eli:

Thank you for the opportunity to review a copy of the Restoration Guidance Document. This was a long overdue undertaking and will result in a significant contribution. I regret that I was unable to comment earlier; I have been consumed with the task of preparing a restoration plan for the *Exxon Valdez* Oil Spill Trustees. Hopefully my comments are not too late and will be of some help.

In my review, I have necessarily focused on elements of the Restoration Guidance Document dealing with the *Exxon Valdez* oil spill, or elements where I have experience and interest (damage assessment, restoration science, environmental planning).

Enclosed, also please find two copies of our latest product: Summary of Alternatives for Public Comment. Perhaps Debbie French could have one of the copies. We are now in a public comment period, after which the Trustees will select a "preferred alternative." We then will prepare the Draft Restoration Plan and issue simultaneously the Draft Environmental Impact Statement. We are still hopeful of issuing the Final Restoration Plan in February 1994.

General Comments:

This is a generally well-written, carefully worded, well conceived and complete review of the state-of-the-art of restoration for injured natural resources. My only concern is that the document does not address restoration of reduced or lost human uses (services) in any degree of detail. It is the position of the *Exxon Valdez* Oil Spill Trustees that settlement funds also be used to restore reduced or lost services provided by such natural resources. Accordingly, we have spend a significant amount of time developing restoration options for reduced or lost subsistence use, commercial fishing, recreation (including sport fishing, sport hunting, camping and boating) and commercial tourism opportunities. It was the Trustee's assumption that you could not always restore reduced or lost services by only addressing restoration of the resource upon which the service depends. Subsistence is a particularly relevant example; you need to restore confidence (of the subsistence user) in the safety of subsistence resources as well as restoring the subsistence resource itself. In this case, we have attempted to increase confidence by testing subsistence resources for residual hydrocarbon content.

From a purely editorial perspective, there is some need for cleanup, but I am generally pleased with how the information is organized and presented. You might give some thought to including a reference list at the end of each major section, rather then opting to place the cited literature at the end of the document.

Specific Comments:

1) **Table of Contents**

The **Table of Contents** is inaccurate. For example, according to **Section 2.3.5** should start on page 2-168. It does not; it begins on page 2-188.

2) **Section 2.3.4.3.4. Option D - Modification to Management Practices (Birds).**

Perhaps you also could consider modification of fishing gear (gill nets) or fishing times to better protect diving sea birds such as marbled murrelets. This could be voluntary. A significant number of marine birds are killed each year in fishing nets.

3) **Section 2.3.5.3.4. Option D - Modification to Management Practices (Mammals).**

We are also considering a voluntary use of different fishing gear for black cod and possibly other species (Pacific cod, halibut) in Prince William Sound where the injured AB pod of killer whales are found. Perhaps using pot gear (pot gear used in British Columbia and Washington waters) in lieu of long-line will decrease the number of fishery interactions with AB pod. The AB pod has historically raided long-lines in Prince William Sound.

4) **Section 3.2.6.3.1. Case Histories.**

Regarding the *Arco Anchorage*, I seem to remember that longer term monitoring at Port Angeles Harbor was undertaken by Blaylock and Houghton. Perhaps they did not estimate recovery times for intertidal communities.

5) **Section 3.3.2.1. Natural Recovery.**

Regarding the Baker et al (1990), the article also fails to mention that herring can be affected by oil spills that occur in near coastal habitat, particularly during spawning. Herring spawn both in the intertidal and in the shallow subtidal zone. In the case of the *Exxon Valdez* oil spill, although none of the herring spawning areas were heavily oiled, over 40% of areas used by herring to stage, spawn or deposit eggs, and 90% of the areas used for summer rearing were lightly to moderately oiled. Oiled spawning areas included portions of Naked and Montague Islands. While the impact on herring in Prince William Sound is still being assessed, herring are clearly vulnerable to the affects of spills in near-coastal areas.

6) **Section 3.3.2.8 Evaluation of Options.**

Regarding the checklist and specifically Number 6 that indicates that "genetic damage to salmon eggs and fry was detected during the *Exxon Valdez* oil spill and could reduce productivity and fitness for many years." The suggestion that there is evidence of genetic damage is highly speculative. To date, there is no documentation of this type of injury attributable to the oil spill. It is true, however, that hatchery pink salmon wander into and spawn in wild pink salmon streams. While this has the potential to alter genetic diversity, the implications for survival of wild pink salmon in Prince William Sound are not known.

7) **Section 3.2.10 Monitoring of Habitat Recovery**

You might review the concepts for design and implementation of monitoring programs presented in the National Research Council's (NRC) recent publication <u>Managing Troubled Waters: The Role of Maine Environmental Monitoring</u>. This is a 1990 publication and can be obtained from the National Academy Press. We are generally following their approach in the design of the Trustee's recovery monitoring program. You might consider recognizing the NRC approach in your document.

8) **Section 3.3.5.1.5. Effects of Oil Spills on Marine Mammal Populations.**

Regarding injury to harbor seals following the *Exxon Valdez* oil spill, many seals were directly oiled and an estimated 345 were killed. There was a greater decline in population indices in oiled areas compared to unoiled areas in Prince William Sound in 1989 and 1990. This population was declining prior to the spill and no recovery was evident in 1992. Oil residues found in seal bile were five to six times higher in oiled areas to compared with unoiled areas.

For killer whales, 13 adult whales of 36 in AB pod are missing and presumed dead. The AB pod has grown by two individuals since 1990. Some experts believe that circumstantial evidence links the loss of 13 whales to the oil spill; other experts think the deaths are unrelated to the oil spill.

An estimated 3500 to 5500 sea otters were killed by the oil spill. Post-spill surveys showed measurable differences in populations and survival between oiled and unoiled areas in 1989, 1990, and 1991. Survey data have not established a significant recovery trend. Dead prime-age animals were still found on beaches in 1990 and 1991 suggesting continuing effects.

9) **Section 5.1.1 Quantification of Recovery.**

While I like this approach (particularly for concentrations of residual oil in the environment), will there always be enough data to establish rates of natural recovery for habitat and resource populations? I think not; this was the problem encountered in the *Exxon Valdez* oil spill. My only point is that the calculations are only as good as the input data. In practice, the input data can be very sparse as was the case in the *Exxon Valdez* oil spill, and there is significant uncertainty associated with our estimates of recovery, both for natural and assisted recovery. Perhaps you need to address uncertainty in the description of your approach.

10) **Section 6.1.1 Oil Spills.**

Your summary of the *Exxon Valdez* spill history and restoration planning process is an accurate representation. I have enclosed a copy of the "next step" for your potential use; you might review this material for possible use in updating this case history.

11) **Section 7.0 References.**

There is a need to verify the reference list. For example, you have included two citations for the *Exxon Valdez* Oil Spill Restoration Volume I. Restoration Framework. You also do not always use a consistent format for each citation. For example, you have not included the title for Foster's 1990 article on the impacts of cleanup on intertidal communities appearing in Northwest Environmental Journal 6: 105-120. While you should consult the relevant "style manual," I don't believe you should include personal communications in the reference list; rather, they are dealt with in the text either in parentheses or by a footnote.

Again, thank you for the opportunity to offer comment. Best of luck.

Yours very truly,

John A. Strand, Ph.D.
Restoration Manager

Enclosure

cc: Byron Morris
RPWG

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

RPWG
Y

National Marine Fisheries Service
Office of Oil Spill Damage Assessment and Restoration
P.O. Box 210029
or
11305 Glacier Hwy
Auke Bay, Alaska 99821

Telephone: (907) 789-6600
Fax: *(907) 789-6608*

RAPIDFAX TRANSMISSION: 4 **PAGES TO FOLLOW**

DATE: 4/30/93

FROM: John Strand

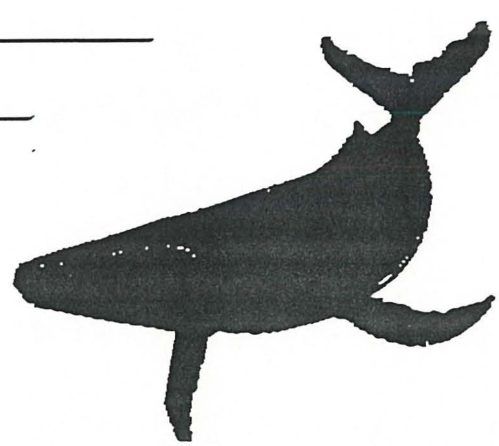
TO: Barbara Iseah

FAX NO: CACI

SUBJECT: Comments to Parametrix re: Preliminary Draft of Conceptual Monitoring Plan

COMMENTS:

Please distribute to RPWG. Thanks



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

April 30, 1993

MEMORANDUM FOR: Mary Sue Brancato

FROM: John Strand

SUBJECT: Review of Preliminary Draft of Conceptual Monitoring Plan (April 5th Version)

Thank you for the opportunity to review an early version of the subject report. The Conceptual Plan is beginning to take shape and I am pleased with your progress. I regret that I have not had time to collate and reconcile comments received by individual members of the Restoration Planning Work Group. As you know, we all have been consumed by the round of public meetings that began on April 12th; actually I will not complete my public meeting commitment until May 5th. Before I forget, I also wanted to thank you for the very productive workshop that you designed and implemented on April 13th and 14th. I believe it achieved its intended goal; it stimulated much needed discussion among many of the interested parties. I also have received positive feedback from many of the attendees.

My individual comments on the preliminary draft are necessarily organized by the nine issues listed in the RFP. I have added a 10th issue regarding Section 6 as it is presented in your preliminary draft. I hope my comments are of some help; they are:

1) **What process or mechanism would best assist the Trustee Council in determining monitoring priorities?**

What we are after here is use of conceptual models to prioritize what to monitor. You describe this approach on page 7 of your draft and illustrate this concept in Figure 3, but I think that perhaps you do not fully understand the concept. Your Figure 3 seems to further refine the conceptual methodology that is embodied in Figure 2, and does not, for example, describe the links among resources that are at risk, or the physical, chemical and biological components of the affected ecosystem, or the human and natural causes of change in the system to be studied (monitored).

The use of conceptual models also is introduced in the National Research Council's Managing Troubled Waters - The Role of Marine Environmental Monitoring (MTW) on page 62. Given the magnitude and complexity of impacts and the geographic scope of the *Exxon Valdez* oil spill, I envision many such models will be required to decide what to monitor and how. For example, a conceptual model of the fate of oil in mussel beds or other intertidal habitats, showing how vulnerable resources can be exposed to oil, and at what exposure levels, could permit important questions (hypotheses) regarding the magnitude of effects to be formulated and tested. The NRC's MTW gives another example on page 65 (San Onofre kelp bed) to illustrate what is meant by conceptual model. Let me know if I have not been clear; this is a very important point.

2) **What are realistic goals and objectives of monitoring?**

I really have no substantive criticism; I think that you have done a good job here.

3) **What resources and services should be monitored and why, given the goals and objectives in (2);**

Do we necessarily have to prioritize which resources and services to monitor? With the assumption that not every resource or service has to be monitored each year, and perhaps some resources and services would not have to be monitored for five years, do we still have to adopt and implement a process of prioritization? I am not saying that we do not have to prioritize, but I would like some further discussion on the subject. Let me know what you think.

I don't know if this will be of much help, but the Planning Group did create injury criteria to determine which natural resources and human uses (services) warrant restoration. Perhaps you could review our approach in the context of developing criteria to decide which resources and services should be monitored. You will find a description of this concept on page 39 in Volume 1 Restoration Framework (Exxon Valdez Oil Spill Trustees 1992).

4) **Which clean-up, damage assessment and restoration science studies contain elements that would best serve the purpose of the intended monitoring program, and what are these elements?**

I think that you have begun to address this issue in Section 6.2. Although I think that you have gone further (by including statistical approaches) than what was asked of you, was this your intent? If this assumption is correct, should you not make that connection on page of 15 of your preliminary draft. Also, while you addressed avian, mammalian, intertidal and subtidal fauna, will you also address fish in this context in the next draft of your report? You will also want to review my comments dealing with the whole of Section 6 as it is now presented (see Issue 10 below).

5) **Which surveys of services provided by natural resources contain elements that would best serve the purposes of the intended monitoring program, and what are these elements?**

Please see my comments to Issue 4 above. I believe they equally apply to human uses (services).

6) **What consideration should be given to the relationships among different monitoring (ecosystem) components, and how should they be integrated?**

While I agree that understanding the linkages among resources will be useful to us in our effort to better integrate our monitoring design, isn't this information also obtained through development and validation of conceptual models as described in Issue 1 above. Do you think the matrix approach as described in Section 5 is a superior way to go? Clearly, it may be superior for human uses (services), although even the linkages among resources and human uses can be identified and even quantified in a conceptual model. Again, let me know your response to this particular insight.

7) **What relationships need to be established with other monitoring programs within the spill area and how should they be integrated?**

I like your approach here. First, I would ask that you include in your listing of Alaskan Monitoring Programs a possible future program that will be designed and implemented by the Oil Spill Response Institute (OSRI) which was created by the Oil Spill Pollution Act of 1990. The OSRI is housed within the Prince William Sound Science Center located in Cordova, Alaska. It is chaired by Dr. Gary Thomas formerly of the University of Washington. Gary usually can be reached on (907) 424-5800. I don't know much about his intended program except that it will focus on long-term issues. I do know that he is asking for funds from the Trustee Council and will attend the Council's next meeting on May 13th. I obviously will know more in the next few days, but you also should make contact.

Second, you need to address what periodic surveys of human uses are conducted in the spill area. For example, I believe that the U.S. Forest Service routinely conducts recreational-use surveys of Forest Service lands throughout Alaska. I also seem to remember hearing about a recent Minerals Management Service or Bureau of Land Management survey of subsistence use in coastal Alaska.

8) **What process (including infrastructure) should be considered to guide implementation and management of monitoring?**

I generally like this section although I feel that perhaps you should include other options for how the intended monitoring should be managed. While I agree that the Trustee Council could ask a contractor to manage the monitoring program, management of the Trustee Council's monitoring program also could become the responsibility of a Monitoring Management Committee (MMC). This body, not to exceed 15-20 members, could include representation from the Trustee agencies, university scientists, peer reviewers, and other regional monitoring programs. As you know, this essentially is the model being used in Puget Sound.

Other than perhaps providing a choice of management models, I think that Section 7 (pages 75-80) makes some excellent recommendations for how the program should be implemented.

10) **Section 6.0: Guidance on Sampling Design.**

After a quick review of this Section, I believe most of this information is relevant to what we hope to address in Phase 2 of our planning efforts. For the most part, this information may be too technical for inclusion in the Conceptual Plan. It is not that I disagree with what was said (it is some excellent work), rather it goes beyond the intent of the Phase 1 planning effort. As I indicated above (see Issue 4), some of the information (Sections 6.2 and 6.3) is germane to Phase 1 and should stay. However, this information best addresses Issues 3 and 4 in the RFP and should be presented in that context. This suggests that editing also will be needed. What do you think?

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

RPWG
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NATIONAL MARINE FISHERIES SERVICE
OFFICE OF OIL SPILL DAMAGE ASSESSMENT AND RESTORATION

P.O. 210029
11305 GLACIER HWY
AUKE BAY, ALASKA 99821

TELEPHONE: (907) 789-6600
FAX: (907) 789-6608

RAPIDFAX TRANSMISSION: 9 PAGES TO FOLLOW

DATE: 4/28/93

FROM: John Strand

TO: RPWG

FAX NUMBER: CACI

SUBJECT: Section of Draft Restoration Plan on Comprehensive Restoration Monitoring Program

COMMENTS -

For review/comment, please find attached first pass at preparing this section.

Barbara or Bob, please distribute to RPWG.
thanks

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VII. COMPREHENSIVE RESTORATION MONITORING PROGRAM

A. BACKGROUND

The *Exxon Valdez* Oil Spill Trustee Council has developed initial (conceptual) design requirements for a comprehensive restoration monitoring program for resources and human uses (services) injured by the *Exxon Valdez* oil spill. With an approved conceptual design, the Trustees will next develop detailed technical specifications for monitoring that will be implemented in April 1994, coincident with implementation of the Restoration Plan.

B. CONCEPTUAL DESIGN

A conceptual design or plan is used as a tool for developing and refining monitoring systems, a means for identifying and prioritizing elements to be considered for an effective monitoring plan, and a guide for decisions on what to monitor, where, when and how (National Research Council 1990). It also establishes the relationships among those who require monitoring information and those who produce monitoring information, as well as establishing how monitoring is integrated and coordinated among the various activities.

As with any tool, it is both how well the tool is constructed and how well the tool is used that determines it's effectiveness. The Trustee's approach has been to construct a conceptual design with the contributions of as many interested parties as possible. Through telephone interviews, analysis of case histories, a technical workshop, and review of previously prepared materials, the Trustee's have obtained the participation of a large number of individuals representing the Trustee agencies, universities, consultants, and peer reviewers.

Key elements of the conceptual design for the Trustee's proposed Monitoring Program include:

1) Goals

Monitoring is essential to understand if the proposed restoration activities have been successful at restoring, rehabilitating, replacing, enhancing, or acquiring the equivalent of natural resources and human uses injured by the oil spill. The goal is to develop a comprehensive and integrated monitoring program to follow the progress of recovery, evaluate the effectiveness of proposed restoration activities, and improve the information base from which future disturbances can be evaluated.

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2) **Objectives**

Monitoring is necessary to assess the rate and adequacy of recovery. Resources and associated services that are found to be recovering at an unacceptable rate may have to be considered as candidates for restoration action. Likewise, resources that are found to be recovering faster than anticipated may allow for earlier completion of a restoration action. Monitoring of important physical, chemical, biological, cultural and economic properties will establish an environmental baseline for the affected ecosystem and associated human uses. This baseline then can be used to assess the anticipated effects of human development and to improve our ability to manage affected resources and services over the long-term.

Monitoring will be conducted to fulfill the following specific objectives:

a) to assess the rate of recovery of injured resources and human uses, identifying where additional restoration activities may be appropriate, and determining when injury is delayed;

b) to evaluate the effectiveness of individual restoration activities, particularly where the endpoint of "effectiveness" for an individual project is different than the endpoint (full recovery) of the injured resource or human use. It may not always be possible to detect the contribution of individual restoration projects if several or more restoration projects target the same resource or human use, or if uncontrolled factors such as climatic conditions mediate recovery, and;

c) to follow the long-term trends in distribution and abundance of injured resources and the quality and quantity of human uses. Monitoring of this type also could detect residual oil spill effects and provide ecological, cultural, and economic baseline information useful in assessing the impacts of future disturbances.

3. **Strategy/Conceptual Methodology**

Figure 1 shows the main elements of a conceptual methodology presently under consideration for implementation by the Trustees. Figure 2 provides the detail of defining a monitoring strategy and developing specific questions to be addressed by monitoring. As indicated above, this conceptual approach borrows significantly from the National Research Council's model for developing more effective and useful marine monitoring programs.

Working from the bottom up in Figure 1 helps in understanding the relationships among the steps in the proposed methodology. Information is disseminated to decision makers (step 7) only after it has been produced (step 6). Information is developed when the results of carefully designed monitoring studies are implemented

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and the results are analyzed and evaluated (step 5). For a monitoring study to be implemented, it must be designed (step 4) to effectively address important questions (step 2). The focused questions that serve as the basis for the monitoring studies, in turn, rely on clear management objectives (step 1). Finally preliminary studies may be required to better define the questions and technical aspects of the monitoring (step 3). There also are three feedback loops that allow the designers to reframe the program's underlying questions, review and modify monitoring objectives, and finally use the results of monitoring to refine sampling design.

Figure 2 shows how a monitoring program can begin with general monitoring objectives and develop specific questions to be answered that are the basis for developing detailed sampling protocols. This process includes: identifying the resources at risk, establishing the linkages (direct and indirect) among ecosystem components (particularly the resources at risk and the sources of change, both natural and human), establishing boundaries for spatial, temporal, biological, physical, chemical, cultural or economic aspects of the system (including defining scales for spatial and temporal changes), and projecting either quantitatively or qualitatively, changes in natural resources and human uses and the interactions among them.

This approach will help define the cause and effect relationships that determine potential responses of the resources and human uses affected by the oil spill. As in Figure 1, sufficient feedback is incorporated so that the questions being asked are refined to reflect the best information available including new information as it is produced.

A conceptual model is the central feature of this methodology. In application, a conceptual model will describe the links among the resources at risk; the physical, chemical and biological components of the affected ecosystem; and human and natural causes of change. Conceptual models begin as a qualitative description of the causal links in the system to be monitored. Then, based on technical knowledge, they can be expanded to include quantitative elements such as mathematical or numerical models to better understand the the dynamics of the system to be monitored.

For example, a conceptual model of the fate of spilled oil in Prince William Sound showing how vulnerable resources are exposed to oil in the environment, and at what exposure levels, will permit important questions (hypotheses) regarding the effects of oil to be formulated and tested. By providing a framework for organizing existing scientific understanding, a conceptual model also identifies important sources of uncertainty.

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4. Resources and Services to be Monitored

The Memorandum of Agreement and Consent Decree (Civil Action A91-081, United States v. State of Alaska approved August 28, 1991) requires that use of restoration funds be linked to injured resources and human uses (services) resulting from the *Exxon Valdez* oil spill. The injuries summarized in Volume 1 Restoration Framework (Exxon Valdez Oil Spill Trustees 1992) and in the more recent Draft *Exxon Valdez* Oil Spill Restoration Plan Summary of Alternatives for Public Comment (Exxon Valdez Oil Spill Trustees 1993) were used to prepare a list of injured resources and services shown in Table 1.

The list of injured resources is divided into those whose populations measurably declined, and those that were killed or otherwise injured, but where the injury did not result in a measurably lower population. By measurable decline, we mean a detectable decline in abundance that will persist for more than one generation. Some species such as common murres, marbled murrelets, pigeon guillemots, and harbor seals were declining before the spill. Their rate of decline was accelerated by the spill, but other factors such as variation in climatic conditions, habitat loss, or increased competition for food may also be influencing long-term trends in the health and populations of these and other species.

The spill also directly affected human uses of the spill area including commercial fishing, commercial tourism, recreation, passive use, and subsistence. The nature and extent of the injury varied by user group and by area.

5. Management Structure

Implementation of this multifacted program requires central coordination and management. In order to successfully implement an ambitious and wide-ranging program as contemplated, a high degree of organization is needed to create the final design, to analyze, interpret and disseminate the data generated, and to ensure that all aspects of the program are carried out as designed.

Management of the Trustee's monitoring program could become the responsibility of a Monitoring Management Committee (MMC) consisting of representatives of the Trustee Agencies, university scientists, and the peer reviewers. Representation could also be invited from the Regional Citizens Advisory Councils (Prince William Sound and Cook Inlet), other monitoring programs in the region, and the public at large, however, membership should not exceed 15 to 20. Alternatively, a single contractor could manage implementation of the monitoring program.

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Management of the program consists of coordinating not only implementation but also evaluation of program results. The most certain way to ensure that the best monitoring approaches will be implemented is to employ a competitive bid process whenever possible. A panel of peer-reviewers could be selected to review and grade all proposals submitted in response to an open solicitation for monitoring services. Proposals submitted by the Trustee agencies would also be subjected to the same level of review. A similar peer-review process should be used for review of all project renewals and for review of draft and final reports.

Finally, peer-review will determine if plans and projects and related activities have been implemented as designed and in compliance with the Restoration Plan, Restoration Monitoring Plan an the National Environmental Policy Act.

It is expected that the Trustee Council will make a final decision on the type of management structure to implement once the public has opportunity to comment.

6. Data Dissemination

All of the monitoring results (interim and final reports) will be kept in a central repository or library where, at minimum, titles and abstracts will be accessible by a computerized system. Responsibility for archival of raw data will reside with the agency or contractor performing the monitoring. The final configuration of the data management system, and how and who can use the system will be decided by the Trustees. Oversight of the repository and computer system will be the responsibility of the MMC or a contractor. It is the intent that this information be accessible and in a format that can be readily utilized by scientists, resource managers and the public.

7. Avoiding Duplication of Effort

Integration and coordination with other monitoring programs in the spill area is essential to avoid duplication of effort, but also could result in a benefit to each program where there is potential overlap. As discussed above, both the Prince William Sound and Cook Inlet Regional Citizens Advisory Councils presently conduct monitoring in Prince William Sound and the Gulf of Alaska. A third major program with potential geographic as well as technical overlap will soon be implemented by the Oil Spill Recovery Institute. While often the specific goals and objectives of these programs (including the Trustee's proposed program) are different, each program could benefit from conducting monitoring at common stations, agreeing to follow standardized sampling protocols, and sharing logistics as well as data, etc.

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C. DETAILED DESIGN

With an approved conceptual design, the Trustees next will develop detailed design specifications. This planning effort focuses on the technical requirements of an integrated monitoring plan and again assumes a close working relationship among the Trustee Agencies. It also is the intent of the Trustees that the Final Restoration Plan, to be published in November 1993, will include at least a summary of the technical design for each monitoring component, both resource and human use.

The final phase of planning will establish:

1) the locations where monitoring should be conducted;

2) a technical design for each monitoring component (e, g., sediments, invertebrates, fish, birds, mammals, and services [commercial fishing, tourism, recreation, subsistence] that specifies how, when data will be collected, analyzed, interpreted, and reported;

3) a design for a data management system to support the needs of the Trustees and other decision makers, planners, researchers and the general public.

4) a rigorous quality assurance program to ensure that monitoring data produces defensible answers to management questions and will be accepted by scientific researchers and the public;

5) cost estimates for each monitoring component; and

6) a strategy for review and update to ensure that the most appropriate and cost-effective monitoring methods are applied.

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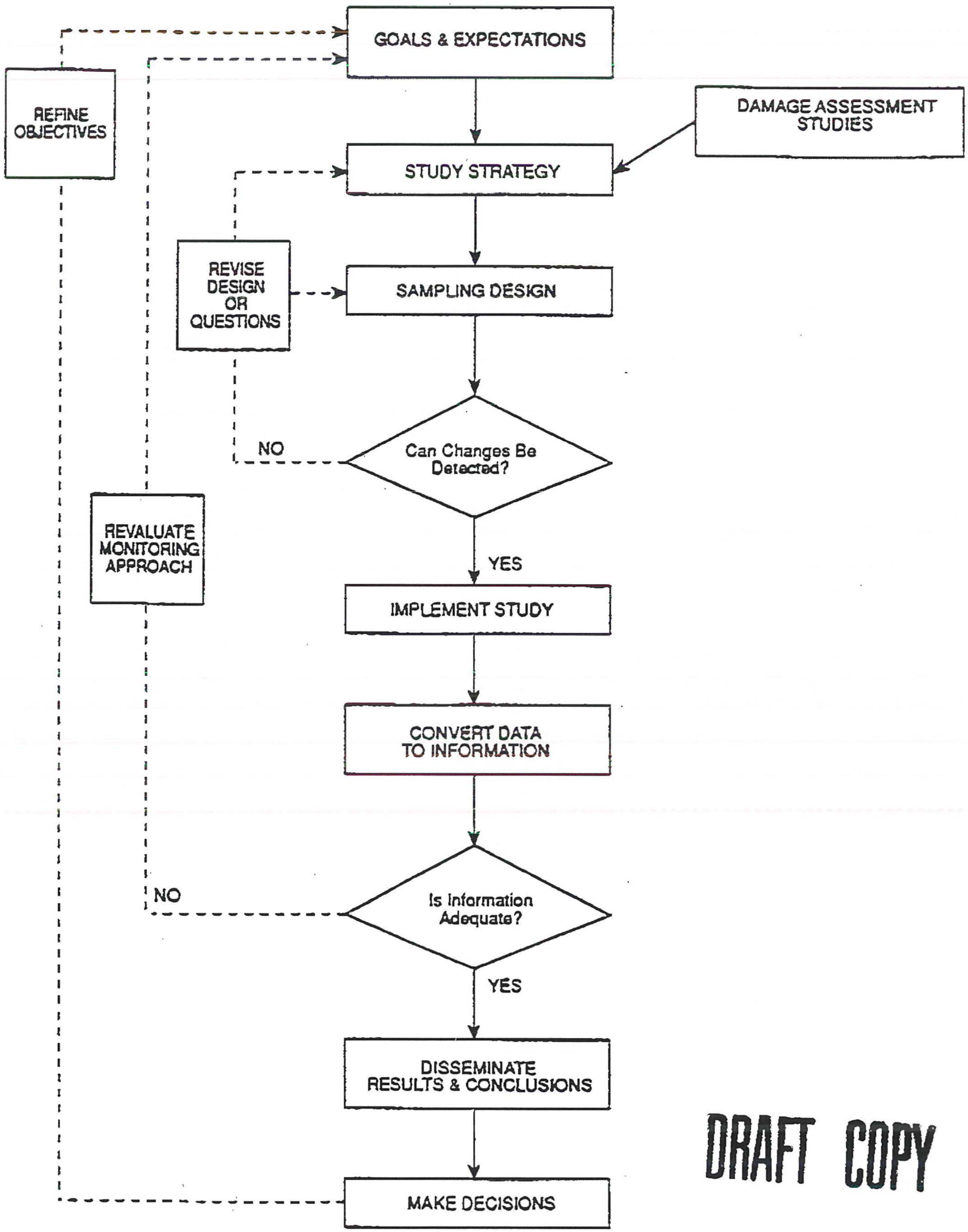

Figure 1. Design and implementation elements of proposed restoration monitoring program (National Research Council 1990).

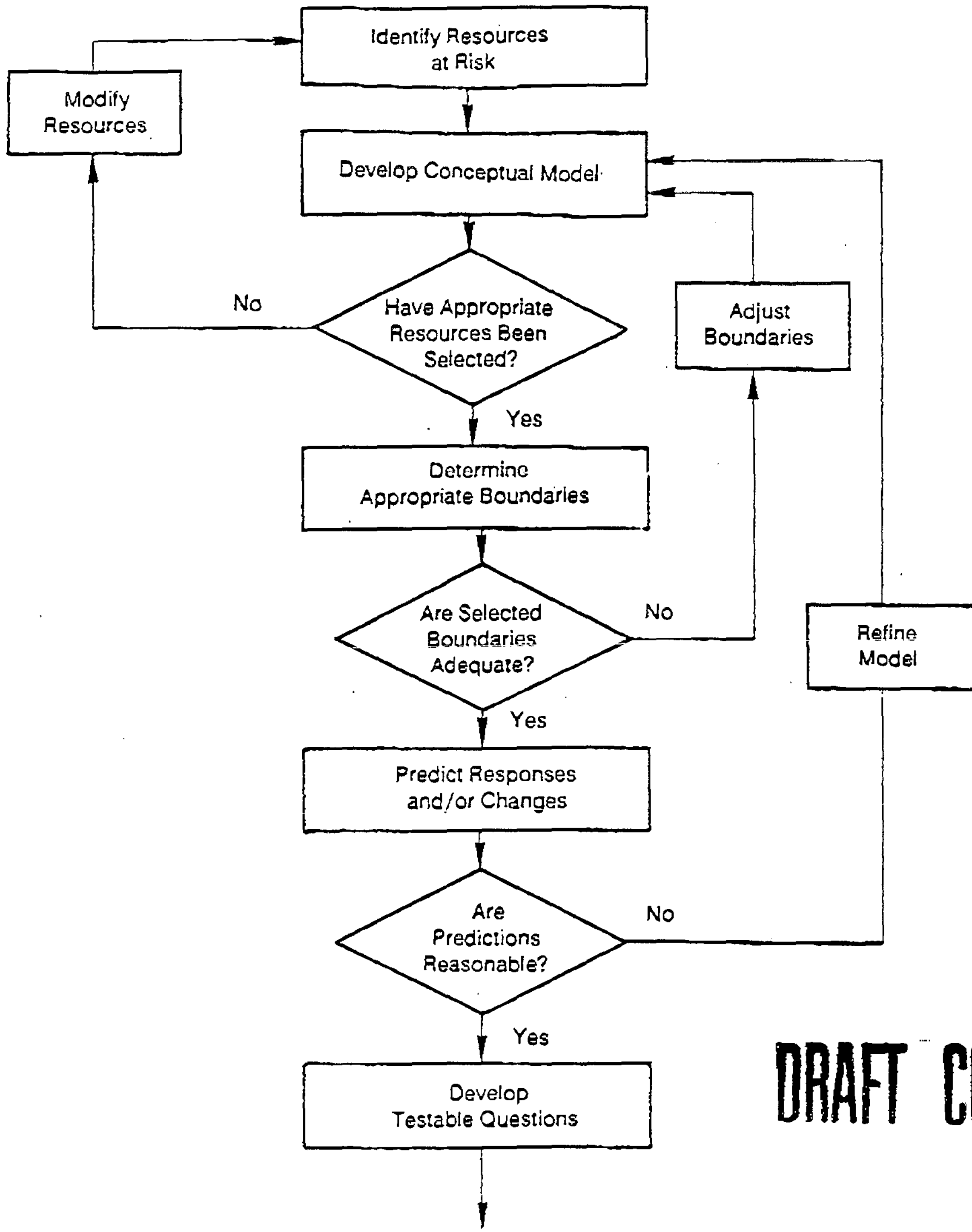

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Figure 2. Elements for defining a monitoring strategy and developing specific questions to answer (National Research Council 1990).

Table 1. Resources and Human Uses (Services) Injured by the Spill.

RESOURCES			SERVICES (Human Uses)
Population Decline	Injured, but No Population Decline	Other	
Black oystercatcher Common murre Harbor seal Harlequin duck Intertidal organisms Marbled murrelet Pigeon guillemot Sea otter Sockeye salmon Subtidal organisms	Bald eagle * Cutthroat trout * Dolly Varden * Killer whale Pacific herring * Pink salmon River otter Rockfish	Air, water, and sediments Archaeological resources Designated wilderness areas	Commercial fishing Commercial tourism Passive use Recreation including sport fishing, sport hunting, and other recreation use Subsistence

* For these species, the Trustees' scientists have considerable disagreement over the conclusions to be drawn from the results of the damage assessment studies.

DRAFT COPY

KVYG

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

March 12, 1993

Dr. John Armstrong
Office of Coastal Waters
Water Division, WD-139
1200 Sixth Avenue
Seattle, WA 98101

Dear John:

RE: Interagency Agreement DW13957045-01-1
Coordinate Development of a Comprehensive and Integrated Monitoring Plan for the Exxon Valdez Oil Spill (Revision 1), Progress Report 1.

A. Progress to Date (October 1 through December 30, 1992)

Task 1. Obtain Services of Qualified Consultant to Provide Technical Assistance in the Development of a Conceptual Design for Monitoring

The Request for Proposals (RFP) that NOAA issued August 15, 1992 is Attachment 1. A copy of this document was forwarded to your offices in late August when we processed Amendment 1 to our Interagency Agreement that extended the contract period to September 30, 1993.

A Source Evaluation Board (SEB) was formed in mid-September to evaluate proposals received from this solicitation. The evaluation process followed the provisions of the Federal Procurement Policy Act. Each proposal was evaluated and scored following a numerical scoring system that included a provision to check previous and past clients of each prospective contractor. Evaluation factors included technical approach, project management, contractor and investigator experience, and costs.

The SEB completed their evaluation on November 9th and unanimously gave the proposal from Parametrix, Inc., the highest score. Parametrix, Inc., as you know, is a Pacific Northwest based environmental consulting company with 22 years of experience. They have a strong background in monitoring program design and implementation, and have recent relevant Alaskan experience. Their proposed staff includes benthic ecologists, fisheries biologists, avian scientists, GIS specialists, statisticians and toxicologists. They have teamed with Moss Landing Marine Laboratory who will add expertise in intertidal and marine mammal ecology. Goldstream Consulting is also a team member and will contribute in the area of archaeology and cultural resources. A resources economist who has conducted fisheries and other resource economics assessments (including contingent valuation) rounds out the proposed study team. On a check of recent clients (USEPA, City of Tacoma, ASARCO, Inc.), we determined that Parametrix genuinely enjoys an excellent reputation. They have been responsive to their clients' needs and have provided quality work within the time and cost estimates.

A best-and-final bid of $129,258 was accepted and a six-month contract between NOAA and Parametrix, Inc., was signed December 15, 1992. The contract amount is considerably more than the $70,400 that was provided by EPA and NOAA, but the difference is clearly associated with the need to develop a monitoring strategy for injured natural resource services in addition to injured natural resources. Our proposed monitoring program initially did not include the provision to monitor recovery of injured resource services. The EPA/NOAA IAG signed September 9, 1991 also did not include this provision. Amendment 1 to the EPA/NOAA IAG signed August 27, 1992, however, includes language indicating that we will develop a monitoring strategy for both injured resources and injured resource services.

The contact between NOAA and Parametrix, Inc., will be incrementally funded. Start-up was funded with the $70,400 provided by EPA and NOAA and covers the period of performance from December 15, 1992 through March 15, 1993. An additional $58,858 recently obtained from the Exxon Valdez Oil Spill Court Registry Account via the Alaska Department of Environmental Conservation will be used to supplement the contract and support planning from March 15, 1993 through June 15, 1993. The need for additional funds was foreseen as the Restoration Planning Work Group's FY-1993 budget was developed in June 1992.

In summary, we have hired a suitable contractor and we are moving ahead with the development of a recovery monitoring strategy that addresses both injured natural resources and natural resource services.

<u>Task 2.</u> <u>Design and Conduct Workshop to Develop Conceptual Design for a Restoration Monitoring Plan</u>

The dates of the Monitoring Planning Workshop will be April 13-15, 1993. Meetings to discuss the design of the workshop were scheduled for January 8 and 27, 1993.

B. <u>Problems Encountered</u>

None.

C. <u>Funds Expended (October 1 through December 30, 1992)</u>

While Parametrix, Inc., began work on December 15, 1992, it is not likely an invoice will be received and processed before mid-March 1993. Accordingly, for the reporting period, there were no expenditures.

D. <u>Anticipated Progress (January 1 through March 30, 1993)</u>

1) We will complete design requirements for the Monitoring Planning Workshop to be held in April 1993. This will include goals and objectives, format and strategy, the list of participants, logistics, and the preparation of materials that will be mailed out to participants in advance of the Workshop.

2) We also will develop a draft outline for the "conceptual" monitoring plan.

3) Transmittal of Progress Report 2 will occur before April 30, 1993.

Yours very truly,

John A. Strand, Ph.D.
Restoration Manager

Attachment

cc: Byron Morris
Steve Pennoyer
Bruce Wright
RPWG Files

ATTACHMENT 1

REQUEST FOR PROPOSALS FOR:

COORDINATION AND DEVELOPMENT OF A COMPREHENSIVE AND INTEGRATED MONITORING PLAN FOR THE *EXXON VALDEZ* OIL SPILL AREA

I. BACKGROUND

The *Exxon Valdez* Oil Spill Trustee Council has initiated a planning effort to develop a comprehensive and integrated monitoring program for resources and services injured by the *Exxon Valdez* oil spill. A monitoring program will be implemented to follow the progress of recovery, evaluate the effectiveness of restoration activities, and document long-term trends in the condition of resources and services affected by the spill. Resulting information will not only guide restoration activities during the recovery phase of the spill, but also will provide information useful to long-term management of resources and services in the oil spill area. As described in EXXON Valdez Oil Spill Restoration Volume 1: Restoration Framework (*Exxon Valdez* Oil Spill Trustee Council, 1992), implementation of a monitoring program is one option being considered during the development of a Restoration Plan.

Because of the complexities of both institutional and technical issues associated with developing a meaningful monitoring program for the spill area, a phased approach will be undertaken. In Phase 1, a contractor will develop a conceptual design for a monitoring program. This will guide more detailed, technical planning in Phase 2. This REQUEST FOR PROPOSALS addresses only Phase 1.

II. OBJECTIVE

The objective of this REQUEST FOR PROPOSALS is to invite the services of a qualified contractor to develop a conceptual monitoring plan (Phase 1). It is the intent that this document, or elements thereof, be included in a first draft of a restoration plan now scheduled for completion on November 15, 1992.

III. STATEMENT OF WORK

TASK 1 - DEVELOPMENT OF CONCEPTUAL DESIGN FOR MONITORING

It is expected that the contractor will, at a minimum, draw on information derived from the Trustees' damage assessment and restoration science programs; the U.S. Coast Guards' clean-up program; other relevant monitoring programs (e.g., Puget Sound Ambient Monitoring Plan, Prince William Sound Regional Citizens'

Advisory Council Ecological Monitoring Project, etc.); and a monitoring workshop conducted to develop ideas for a conceptual plan. The conceptual plan will address, but will not be limited to, the following issues:

1) what process or mechanism would best assist the Trustee Council in determining monitoring, damage assessment, restoration science, and related project priorities;

2) what are realistic goals and objectives for monitoring;

3) what resources and services should be monitored and why, given the goals and objectives developed in (2);

4) which clean-up, damage assessment and restoration science studies contain elements that would best serve the purposes of the intended monitoring program, and what are these elements;

5) which surveys of services (e.g., recreation, subsistence, aesthetics, etc.) provided by natural resources contain elements that would best serve the purposes of the intended monitoring program, and what are these elements;

6) what consideration should be given to the relationships among different monitoring components (e.g., sediments, shellfish, fish, mammals, birds, etc.) and how should they be integrated;

7) what relationships need to be established with other monitoring programs within the spill area and how should they be integrated; and

8) what process (including infrastructure) should be considered to guide implementation and management of monitoring.

<u>TASK 2</u> - <u>CONDUCT MONITORING WORKSHOP</u>

The contractor also will be expected to design and conduct a two- or three-day monitoring planning workshop in Anchorage, Alaska. The first day will deal with the purpose, need and scope of the intended monitoring program and will provide a forum for presentations reviewing other relevant monitoring programs (e.g. Beaufort Environmental Monitoring Project, NOAA's National Status and Trends Program). The focus of such presentations will be on "lessons learned," particularly as they relate to issues of strategy and design. The second and possibly third day will be devoted to development of a framework for the conceptual plan.

It is anticipated that the workshop will include five participants with monitoring experience in regions outside Alaska and up to ten participants with experience gained from the *Exxon Valdez* oil spill. Prospective contractors should budget for

travel, subsistence, and honoraria for the five participants from outside Alaska.

IV. RESPONSIBILITIES

The contractor will be required to work closely with the Trustee Councils' staff and other appropriate agency and university scientists to accomplish the specific objectives of this work. The contractor will be provided access to the results of all relevant clean-up, damage assessment, restoration science and natural resource service monitoring information.

V. DELIVERABLES

A summary document from the monitoring planning workshop and a conceptual monitoring plan (including input from workshop) will be required to fulfill the proposed scope of work. Additionally, letter reports will be submitted monthly covering project status, costs to date and any problems or delays encountered or anticipated.

VI. SCHEDULE

The contract period will be six months. The monitoring workshop should be held during the second or third month of the contract period. It also is anticipated that there will be a need for at least three meetings in Anchorage, Alaska. The first meeting will be held at the beginning of the contract period to develop a working outline of the conceptual plan and to design the monitoring planning workshop. A second meeting will be held two or three months after project award to review progress on developing a conceptual design, but could occur while the contractor is in Anchorage to conduct the monitoring workshop. A third meeting will be held at the end of five months to review the draft conceptual plan. The draft conceptual plan will be submitted at least two weeks prior to the date of the third meeting. The final copy of the conceptual plan will be due one month after return of review comments. A draft summary document for the monitoring planning workshop will be submitted one month after the date of the workshop. The final monitoring workshop summary will be due one month after review and return of comments.

VII. BUDGET

Cost estimates should be developed by task. Also, costs associated with developing input to the conceptual plan for monitoring of injured natural resources should be separated from the costs associated with developing input to the conceptual plan for monitoring injured services.

VIII. PROPOSAL EVALUATION FACTORS

Proposals will be evaluated based on the qualifications and demonstrated experience of the proposed contractor (including prior experience in the design and conduct of environmental monitoring programs in northern or far southern latitudes), and the responsiveness of the proposal to the Trustee Councils' objectives and schedule. Cost is also a consideration.

It is expected that proposals will include:

1) statement of objectives,

2) proposed study plan and approach,

3) project organization, including a designated leader/liaison to the Trustee Councils' staff,

4) personnel experience,

5) deliverables, and

6) budget.

VIII. PROPOSAL SUBMISSION

Proposals should be submitted to:

Ms. Heidi Sickles, Contract Administrator
National Oceanic and Atmospheric Administration
Western Administrative Support Center
7600 Sand Point Way NE
Seattle, WA 98115

Telephone inquiries pertaining to contractual matters may be directed to Ms. Heidi Sickles on (206) 526-6028. Inquiries pertaining to technical matters may be addressed to John Strand, Restoration Planning Working Group on (907) 789-6601.

RPWG
Y

RESTORATION PLANNING WORK GROUP
EXXON VALDEZ OIL SPILL OFFICE
645 G STREET
ANCHORAGE, ALASKA 99501

MEMORANDUM FOR: Distribution **DATE:** March 5, 1993

FROM: John Strand, Co-Chair
Restoration Planning Work Group

SUBJECT: Review and Comment on:

1) Draft Outline for Conceptual Monitoring Plan
2) Draft Request For Proposals (RFP) for Phase 2 - Monitoring Plan Development

I would greatly appreciate your review and comment of the attached outline for the conceptual monitoring plan (Phase 1) and the RFP for Phase 2 monitoring plan design. On March 2nd, I forwarded for your use a copy of the RFP that we used in hiring Parametrix who is conducting the Phase 1 planning. I also included in that transmittal a description of the future Phase 2 planning. Phase 2 should begin in mid-June after the scheduled completion of Phase 1. We need to issue the RFP for Phase 2 later this month if we are to maintain our schedule. Please provide your comments by COB March 12th. I will then collate comments on the draft outline and forward these to Parametrix. I also will revise as necessary the RFP and forward this document to the RT for further review and comment.

Attachments (2)

Distribution: Byron Morris
Bob Spies
Bruce Wright
P. Peterson
RPWG

ATTACHMENT 1

DRAFT

Conceptual Monitoring Plan

1.0 Introduction
- 1.1 Background (Purpose and intent of project)
- 1.2 What is a Coneptual Monitoring Plan?
- 1.3 Approach to Coneptual Plan
- 1.4 Plan Content

2.0 Why Restoration Monitoring?
- 2.1 Value and Use of Restoration Monitoring

3.0 Definition of Restoration

4.0 Goals, Objectives, and Strategies of Conceptual Monitoring Plan
- 4.1 Restoration
  - 4.1.1 Ecosystem Level
  - 4.1.2 Priorities
  - 4.1.3 Standardized Methods for Studies
  - 4.1.4 Standardized Protocols for Reporting
  - 4.1.5 Restoration Alternatives
  - 4.1.6 Evaluation of Recovery
- 4.2 Reference/Baseline Data
  - 4.2.1 Guidance on Database Requirements
  - 4.2.2 Data Base Management including QA/QC
  - 4.2.3 Comparability with Existing Monitoring Data Bases
- 4.3 Institutional
  - 4.3.1 Peer Review Panel
  - 4.3.2 Data Dissemination
  - 4.3.3 Avoiding Duplication of Effort

5.0 Resources and Services to be Monitored
- 5.1 Monitoring Services (or elements of services)
- 5.2 Criteria for Evaluating Restoration Monitoring Activities
- 5.3 Value of Criteria
- 5.4 Guidance on Use of Criteria

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6.0 Guidance on Sampling Design
- 6.1 Considerations for what to Measure
- 6.2 Considerations for where to Measure
- 6.3 Considerations for how to Measure
- 6.4 Considerations for when to Measure
- 6.5 Considerations for how to Analyse
- 6.6 Considerations for how to Interpret
- 6.7 Considerations of Relationship of Monitoring Components to Other Monitoring Programs

7.0 Processes to Guide Implementation and Management of Restoration Monitoring
- 7.1 Implementation
- 7.2 Management
  - 7.2.1 Contractual Considerations

8.0 Recommndations

DRAFT

DRAFT

REQUEST FOR PROPOSALS FOR:

COORDINATION AND DEVELOPMENT OF A COMPREHENSIVE AND INTEGRATED MONITORING PLAN FOR THE *EXXON VALDEZ* OIL SPILL AREA

PHASE 2 - DEVELOP DETAILED DESIGN SPECIFICATIONS

I. BACKGROUND

The *Exxon Valdez* Oil Spill Trustee Council has initiated a planning effort to develop a comprehensive and integrated monitoring program for resources and services injured by the *Exxon Valdez* oil spill. A monitoring program will be implemented to follow the progress of recovery, evaluate the effectiveness of restoration activities, and document long-term trends in the conditions of resources and services affected by the spill. Resulting information will guide restoration activities during the recovery phase of the spill, provide information useful to the long-term management of resources and services in the spill area, and improve upon the environmental baseline from which the impacts of future oil spills and other disturbances are assessed.

Because of the complexities of both institutional and technical issues associated with developing a meaningful monitoring program for the spill area, a phased approach was undertaken. In Phase 1, a contractor developed a conceptual design for the monitoring program. The conceptual planning in Phase 1 addressed goals and objectives, what resources and services to monitor, what process was required to determine monitoring priorities, what relationships needed to be established with other monitoring programs within the spill zone, and what process was required to guide implementation and management of monitoring. It was the intent of this effort to guide more detailed, technical planning in Phase 2.

II. OBJECTIVE

The objective of this Request For Proposals is to invite the services of a qualified contractor to develop detailed monitoring design specifications. It is the intent for this document, or elements thereof, to be included in the Final Restoration Plan, now scheduled for completion in December 1993.

III. STATEMENT OF WORK

Task 1 - DEVELOPMENT OF DETAILED DESIGN FOR MONITORING PLAN

It is expected that the contractor will, at a minimum, draw on the Trustees' approved conceptual monitoring plan, and will be familiar with the provisions of the National Research Councils' recent publication, Managing Troubled Waters - The Role of Environmental

Monitoring. The contractor also will be expected to incorporate the results of a workshop to review the draft detailed monitoring design specifications. The detailed monitoring design will address, but will not be limited to, the following provisions:

1. the locations (fixed and rotating) where monitoring should be conducted for each resource or service of interest;

2. a technical design for each monitoring component that specifies how and when data will be collected, analyzed, interpreted, and reported;

4. a data management system to support the needs of the Trustees and other decision makers, planners, researchers and the public. This assumes a system that facilitates a variety of retrieval and analysis functions and is flexible and expandable to meet new and changing needs;

5. a rigorous quality assurance program to ensure that monitoring data produces defensible answers to management questions and will be accepted by scientific researchers and the public;

6. cost estimates for each monitoring component;

7. a design for coordination of this monitoring plan with other monitoring programs in the oil spill area that may exist or be proposed; and

8. a design for review and update to ensure that the most appropriate and cost-effective monitoring methods are applied.

Task 2 - CONDUCT MONITORING PLAN REVIEW WORKSHOP

The contractor also will be expected to design and conduct a two or three day monitoring planning workshop in Anchorage, Alaska to review the draft detailed monitoring plan design. It is anticipated that the workshop will include five experts with monitoring experience in regions outside Alaska and up to ten experts with experience gained from the *Exxon Valdez* oil spill. Key members of the Trustees' organization also will be invited. Prospective contractors should budget for travel, subsistence, and honoraria for the five participants from outside Alaska.

IV. RESPONSIBILITIES

The contractor will be required to work closely with the Trustee Council's staff and other appropriate agency and university scientists to accomplish the specific objectives of this work. For example, the contractor will be expected to work directly with the Trustee agencies and peer reviewers to produce definitive sampling protocols that specify how and when data are collected, analyzed, interpreted and reported. The contractor will be provided the results of Phase 1 planning efforts which were to develop a conceptual design for the required monitoring plan. The contractor also will be provided access to the results of all relevant clean-up, damage assessment, restoration science and natural resource monitoring information.

V. DELIVERABLES

A comprehensive and integrated (detailed) monitoring plan for resources and services injured by the *Exxon Valdez* oil spill will be required to fulfill the proposed scope of work. The draft of this document will be presented as a "straw dog" for review by technical experts at the monitoring planning workshop. Additionally, letter reports will be submitted monthly covering project status, costs to date and any problems or delays encountered or anticipated.

VI. SCHEDULE

The contract period will be six months. The workshop to review the draft plan will be held during the fourth month of the contract. It also is anticipated that there will be a need for at least three meetings (two in Anchorage, one in Seattle). The first meeting will be held in Anchorage at the beginning of the contract period to develop a working outline of the detailed monitoring plan and to design the monitoring planning workshop. A second meeting will be held in Seattle two or three months into the contract to review progress to develop a detailed plan. A third and final meeting will be held in Anchorage to present the detailed plan to the Trustee organization.

VII. BUDGET

Cost estimates should be developed by task.

VIII. PROPOSAL EVALUATION FACTORS

Proposals will be evaluated based on the qualifications and demonstrated experience of the proposed contractor (including prior experience in the design and conduct of environmental monitoring programs in northern or far southern latitudes), and the responsiveness of the proposal to the Trustee Council's objectives and schedule. Cost is also a consideration.

It is expected that the proposals will include:

1) statement of objectives,

2) proposed study plan and approach,

DRAFT

3) project organization, including a designated liaison to the Trustee Council's staff,

4) personnel experience,

5) deliverables, and

6) budget.

IX. PROPOSAL SUBMISSION

Proposals should be submitted to:

Ms. Heidi Sickles, Contract Administrator
National Oceanic and Atmospheric Administration
Western Administrative Support Center
7600 Sand Point Way NE
Seattle, WA 98115

Exxon Valdez Oil Spill Trustee Council

Restoration Office
645 "G" Street, Anchorage, AK 99501
Phone: (907) 278-8012 Fax: (907) 276-7178

FAX COVER SHEET

RPWG
Y

To: Distribution

Number:

From: J. Strand

Date: 3/5/93

Comments:

Total Pages: 13

RESTORATION PLANNING WORK GROUP
EXXON VALDEZ OIL SPILL OFFICE
645 "G" STREET
ANCHORAGE, ALASKA 99501

MEMORANDUM FOR: Distribution **DATE:** March 2, 1993

FROM: John Strand, Co-Chair
Restoration Planning Work Group

SUBJECT: Development of a Comprehensive and Integrated Monitoring Plan for the *Exxon Valdez* Oil Spill

By way of an update on the above planning effort, I am enclosing for your information two enclosures. Enclosure 1 is a copy of a Request For Proposals (RFP) that we used to invite the services of a qualified consultant to develop a conceptual design for a monitoring program. The effort described in this RFP constitutes Phase 1. of our monitoring planning activities. This was initiated December 15, 1992, and is intended to guide more detailed, technical planning in Phase 2, which is described in Enclosure 2. Enclosure 2 is found in the 1993 Draft Work Plan and was recently approved by the Trustee Council for implementation in Spring (June) 1993.

Parametrix Inc. of Kirkland, Washington is the consultant who has been contracted to work with the Planning Group to develop the requisite recovery monitoring program, at least Phase 1 (Conceptual Design). They will be convening a workshop in mid-April (April 13-15 timeframe) to develop firsthand input to the conceptual plan. Please note that the key issues to be addressed in the conceptual plan are listed on page 2 of the RFP. The April workshop will be limited to no more than 30 attendees, consisting primarily of the Chief Scientist, Peer Reviewers, some of the Principal Investigators, the Restoration Team, and the Restoration Planning Work Group.

As a precursor to the April workshop, Parametrix also will conduct "key-informant" interviews with a wider spectrum (50-60) of experts (additional Principal Investigators and Peer Reviewers as well as the attendees of the workshop) from the Trustee organization. The FAX or mailer that you already have or soon will receive from Parametrix is intended to guide these telephone interviews. This is preliminary (draft) material that ultimately may be included in the conceptual plan, although not necessarily in this format. This material also will likely guide the agenda for the April workshop.

I would hope that each of you will find the time to help us in this vital restoration planning activity. If there are any questions that you may have or I can be of help in any way, please do not hesitate to call me in Juneau on (907) 789-6601, or in Anchorage on (907) 278-8012. Additional information on the development of the monitoring planning process may be obtained through your Restoration Team or Restoration Planning Work Group member. I also will try to provide you periodic updates of our progress. Thank you for your cooperation.

Enclosures

Distribution:

Bob Spies
Don Boesch
Pete Peterson
Gail Irvine
Bruce Wright
Doug Wolfe
Gary Mayer/Peter Hill
Stan Rice
Ray Highsmith
Steven Jewett
Al Mearns
Don Siniff
John Ford
Jim Bodkin
Jim Faro
Vern Byrd
Marilyn Dahlheim
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John Piatt
Sam Patten
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Michael Fry
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Jon Isaacs
Jim Fall
Maurie Cohen
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Art Weiner
Richard Podalsky
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Doug Robson
Dave Bowden
Lee Eberhardt
Ken Reckhow
James Ruttenber
Joan Braddock
Jeffrey Short
James Bauer
Martin McAllister
Tracey MacKenzie
Restoration Team
RPWG

REQUEST FOR PROPOSALS FOR:

COORDINATION AND DEVELOPMENT OF A COMPREHENSIVE AND INTEGRATED MONITORING PLAN FOR THE *EXXON VALDEZ* OIL SPILL AREA

I. BACKGROUND

The *Exxon Valdez* Oil Spill Trustee Council has initiated a planning effort to develop a comprehensive and integrated monitoring program for resources and services injured by the *Exxon Valdez* oil spill. A monitoring program will be implemented to follow the progress of recovery, evaluate the effectiveness of restoration activities, and document long-term trends in the condition of resources and services affected by the spill. Resulting information will not only guide restoration activities during the recovery phase of the spill, but also will provide information useful to long-term management of resources and services in the oil spill area. As described in EXXON Valdez Oil Spill Restoration Volume 1: Restoration Framework (*Exxon Valdez* Oil Spill Trustee Council, 1992), implementation of a monitoring program is one option being considered during the development of a Restoration Plan.

Because of the complexities of both institutional and technical issues associated with developing a meaningful monitoring program for the spill area, a phased approach will be undertaken. In Phase 1, a contractor will develop a conceptual design for a monitoring program. This will guide more detailed, technical planning in Phase 2. This REQUEST FOR PROPOSALS addresses only Phase 1.

II. OBJECTIVE

The objective of this REQUEST FOR PROPOSALS is to invite the services of a qualified contractor to develop a conceptual monitoring plan (Phase 1). It is the intent that this document, or elements thereof, be included in a first draft of a restoration plan now scheduled for completion on November 15, 1992.

III. STATEMENT OF WORK

TASK 1 - DEVELOPMENT OF CONCEPTUAL DESIGN FOR MONITORING

It is expected that the contractor will, at a minimum, draw on information derived from the Trustees' damage assessment and restoration science programs; the U.S. Coast Guards' clean-up program; other relevant monitoring programs (e.g., Puget Sound Ambient Monitoring Plan, Prince William Sound Regional Citizens'

Advisory Council Ecological Monitoring Project, etc.); and a monitoring workshop conducted to develop ideas for a conceptual plan. The conceptual plan will address, but will not be limited to, the following issues:

1) what process or mechanism would best assist the Trustee Council in determining monitoring, damage assessment, restoration science, and related project priorities;

2) what are realistic goals and objectives for monitoring;

3) what resources and services should be monitored and why, given the goals and objectives developed in (2);

4) which clean-up, damage assessment and restoration science studies contain elements that would best serve the purposes of the intended monitoring program, and what are these elements;

5) which surveys of services (e.g., recreation, subsistence, aesthetics, etc.) provided by natural resources contain elements that would best serve the purposes of the intended monitoring program, and what are these elements;

6) what consideration should be given to the relationships among different monitoring components (e.g., sediments, shellfish, fish, mammals, birds, etc.) and how should they be integrated;

7) what relationships need to be established with other monitoring programs within the spill area and how should they be integrated; and

8) what process (including infrastructure) should be considered to guide implementation and management of monitoring.

TASK 2 - CONDUCT MONITORING WORKSHOP

The contractor also will be expected to design and conduct a two- or three-day monitoring planning workshop in Anchorage, Alaska. The first day will deal with the purpose, need and scope of the intended monitoring program and will provide a forum for presentations reviewing other relevant monitoring programs (e.g. Beaufort Environmental Monitoring Project, NOAA's National Status and Trends Program). The focus of such presentations will be on "lessons learned," particularly as they relate to issues of strategy and design. The second and possibly third day will be devoted to development of a framework for the conceptual plan.

It is anticipated that the workshop will include five participants with monitoring experience in regions outside Alaska and up to ten participants with experience gained from the *Exxon Valdez* oil spill. Prospective contractors should budget for

travel, subsistence, and honoraria for the five participants from outside Alaska.

IV. RESPONSIBILITIES

The contractor will be required to work closely with the Trustee Councils' staff and other appropriate agency and university scientists to accomplish the specific objectives of this work. The contractor will be provided access to the results of all relevant clean-up, damage assessment, restoration science and natural resource service monitoring information.

V. DELIVERABLES

A summary document from the monitoring planning workshop and a conceptual monitoring plan (including input from workshop) will be required to fulfill the proposed scope of work. Additionally, letter reports will be submitted monthly covering project status, costs to date and any problems or delays encountered or anticipated.

VI. SCHEDULE

The contract period will be six months. The monitoring workshop should be held during the second or third month of the contract period. It also is anticipated that there will be a need for at least three meetings in Anchorage, Alaska. The first meeting will be held at the beginning of the contract period to develop a working outline of the conceptual plan and to design the monitoring planning workshop. A second meeting will be held two or three months after project award to review progress on developing a conceptual design, but could occur while the contractor is in Anchorage to conduct the monitoring workshop. A third meeting will be held at the end of five months to review the draft conceptual plan. The draft conceptual plan will be submitted at least two weeks prior to the date of the third meeting. The final copy of the conceptual plan will be due one month after return of review comments. A draft summary document for the monitoring planning workshop will be submitted one month after the date of the workshop. The final monitoring workshop summary will be due one month after review and return of comments.

VII. BUDGET

Cost estimates should be developed by task. Also, costs associated with developing input to the conceptual plan for monitoring of injured natural resources should be separated from the costs associated with developing input to the conceptual plan for monitoring injured services.

VIII. PROPOSAL EVALUATION FACTORS

Proposals will be evaluated based on the qualifications and demonstrated experience of the proposed contractor (including prior experience in the design and conduct of environmental monitoring programs in northern or far southern latitudes), and the responsiveness of the proposal to the Trustee Councils' objectives and schedule. Cost is also a consideration.

It is expected that proposals will include:

1) statement of objectives,

2) proposed study plan and approach,

3) project organization, including a designated leader/liaison to the Trustee Councils' staff,

4) personnel experience,

5) deliverables, and

6) budget.

VIII. PROPOSAL SUBMISSION

Proposals should be submitted to:

Ms. Heidi Sickles, Contract Administrator
National Oceanic and Atmospheric Administration
Western Administrative Support Center
7600 Sand Point Way NE
Seattle, WA 98115

Telephone inquiries pertaining to contractual matters may be directed to Ms. Heidi Sickles on (206) 526-6028. Inquiries pertaining to technical matters may be addressed to John Strand, Restoration Planning Working Group on (907) 789-6601.

EXXON VALDEZ OIL SPILL PROJECT DESCRIPTION

Project Number: 93041

Project Title: Comprehensive Restoration Monitoring Program Phase 2: Monitoring Plan Development

Project Category: Restoration Monitoring

Project Type: Monitoring

Lead Agency: National Oceanic and Atmospheric Administration

Cooperating Agencies: Alaska Department of Fish and Game; Alaska Department of Environmental Conservation; Alaska Department of Natural Resources; U.S. Department of Agriculture, Forest Service; U.S. Department of Interior, Fish and Wildlife Service; U.S. Department of Interior, National Park Service

Project Term: January 1, 1993 to September 30, 1993

INTRODUCTION

A. Background on the Resource

Resources to be monitored include affected floral and faunal assemblages as well as impacted substrates upon which they depend. Services arising from injured natural resources will also be monitored inclusive of, but not limited to, recreation, subsistence, and wilderness and intrinsic values. Finally, injured archaeological resources will be monitored.

B. Summary of Injury

The *Exxon Valdez* oil spill occurred just prior to the most biologically active season of the year. During the four-month period following the spill, critical life stages of algae, invertebrates, fish, birds, and mammals encountered the most concentrated, volatile, and potentially toxic forms of the spilled oil. While different species demonstrated varying levels of injury, sea otters and marine birds (common and thick-billed murres, sea ducks) were particularly hard-hit. Portions of 1200 miles of coastline were oiled resulting in impacts to intertidal and shallow subtidal resources. Oil reached shorelines nearly 800 miles from Bligh Reef, the site of the spill. Of continuing concern, resources are exposed to oil remaining in the intertidal zone or transported to the subtidal zone. Following the spill, recreational use of public lands and waters declined and archaeological resources along the shoreline also were injured. For a more detailed account of injuries to individual species, habitats and services, see Chapter IV of the *Exxon Valdez* Oil Spill Restoration Volume 1: Restoration Framework.

C. Location

Monitoring will be conducted on and in surface waters, on tidelands, and on adjacent uplands including their watersheds in Prince William Sound and the Gulf of Alaska.

WHAT

A. Goal

This project will establish the design of the monitoring component of the Restoration Plan. The goal is to develop a comprehensive and integrated restoration monitoring program that will follow the progress of natural recovery, evaluate the effectiveness of restoration activities, and establish an ecological baseline from which future disturbances can be evaluated.

Implementation of this multifaceted program requires central coordination and management. To successfully implement an ambitious and wide-ranging program as contemplated, a high degree of organization is needed to create the design, to analyze, interpret and disseminate the data generated, and to assure that all aspects of the program are carried out as designed.

B. Objectives

This program will assist the Trustees in various organizational and coordination activities in support of developing a comprehensive, interdisciplinary and integrated program of restoration monitoring aimed at:

1. assessing the rate of natural (unassisted) recovery of injured resources and services;

2. evaluating the effectiveness of restoration activities, identifying where additional restoration activities may be appropriate, and determining when injury is delayed, and;

3. following the dynamics of other ecological components (those important in the food webs of injured species) to document long-term trends in the environmental health of the affected ecosystem.

To fulfill these objectives, a three-phase program is planned. Phase 1 is being conducted in early FY-93 and focuses on the development of a "conceptual" plan for monitoring[1]. Phase 2, which is the focus of this proposal, will be conducted over essentially the second-half of FY-93 and deals with developing the technical plans for monitoring. Phase 3 provides for management of the monitoring program following full implementation (FY-94 thru FY-2203).

WHY

Monitoring is necessary to assess the adequacy of natural recovery. Resources and associated services that are found to be recovering at an unacceptable rate may have to be reconsidered as candidates for restoration action. Likewise, resources and services that are found to be

[1] Environmental Protection Agency pass-through money in 1991.

recovering faster than anticipated may allow for an earlier completion of a restoration endpoint. Monitoring of important physical, chemical and biological properties will establish an environmental baseline for the affected ecosystem. This baseline then can be used to assess the anticipated effects of human activities and to improve our ability to manage affected resources and services over the long-term.

HOW

Phase 1:

In Phase 1, which is being conducted this year (1 September 1992 thru 31 January 1993), a consultant will be asked to assist the Trustees in developing a "conceptual" design for the required monitoring plan. This will provide for more technical planning in Phase 2, which is the focus of this proposal. The conceptual planning in Phase 1 will address but will not be limited to such issues as goals and objectives, what resources and services to monitor, what process is required for management, what relationships need be established with other monitoring programs in the spill zone, and how can monitoring be funded over the long-term. Phase 1 planning also addresses the need to identify which current cleanup, damage assessment and restoration science studies would best serve the purpose of the intended restoration monitoring program.

Phase 2:

In Phase 2 (1 January 93 thru 30 September 93), a consultant will again be asked to assist the Trustees. With an approved "conceptual" plan, the consultant will develop a "detailed" monitoring plan that will be presented as a "strawman" plan for review by technical experts at a workshop. This phase focuses on the technical requirements of an integrated monitoring plan and assumes a close working relationship with the Trustee agencies and contracted peer reviewers. It is further assumed that the Trustee agencies will implement monitoring once this phase of planning is completed and a Final Restoration Monitoring Plan is approved. Phase 2 will establish:

1. what the bounds (magnitude) of the monitoring effort will be;

2. the locations (fixed and rotating) where monitoring should be conducted;

3. a technical design for each monitoring component (e.g., sediments, invertebrates, fish, birds, mammals, and services [recreation, subsistence, aesthetics, etc.]) that specifies how and when data will be collected, analyzed, interpreted, and reported;

4. a data management system to support the needs of the Trustees and other decision makers, planners, researchers and the public. This assumes a system that facilitates a variety of retrieval and analysis functions and is flexible and expandable to meet new and changing needs;

5. a rigorous quality assurance program to ensure that monitoring data produces defensible answers to management questions and will be accepted by scientific researchers and the public;

6. cost estimates for each monitoring component;

7. coordination of this monitoring plan with other monitoring programs that may exist or be proposed; and

8. a strategy for review and update to ensure that the most appropriate and cost-effective monitoring methods are applied.

A workshop approach will be used to establish a model for specific technical requirements. The consultant will then work directly with representatives of the Trustee agencies and peer reviewers to produce definitive monitoring protocols. After completion of a Draft Restoration Monitoring Plan, a program of peer review will be organized and implemented. Subsequently, the draft plan will be issued for public review and comment.

It is proposed in Phase 2 that NOAA/NMFS will assist the Trustees in various organizational and coordination activities pursuant to developing the Draft Final Restoration Monitoring Plan. NOAA/NMFS will design and prepare the RFP to solicit services of a consultant to provide technical expertise. NOAA/NMFS also will design procedures for evaluating the resulting technical proposals and chair a proposal review committee to select a consultant. NOAA/NMFS with the assistance of the consultant also will design and implement a workshop to develop a framework for detailed monitoring protocols, a data management system, a QA/QC program, costs, and a review strategy, etc.

The Trustee agencies will be expected to attend the workshop and to work with NOAA/NMFS and the consultant to provide detailed input to the comprehensive monitoring plan.

Phase 3:

Following development of the Restoration Monitoring Plan, 1994 and beyond will be devoted to Phase 3 - monitoring and management, including audits, annual reviews, data management, and reports.

ENVIRONMENTAL COMPLIANCE

This activity should fall under a categorical exclusion within NEPA because this proposed project is essentially a planning exercise. This does not, however, obviate the responsibility for each Trustee agency to conduct additional NEPA reviews as various components of the comprehensive and integrated monitoring plan are implemented in Phase 3.

WHEN

Phase 1 planning begins 1 September 1992 and will essentially be complete 1 February 1993. Phase 2 planning which is the focus of this proposal will begin 1 February 1993 and essentially be complete 30 September 1993. Phase 3, a fully expanded and integrated monitoring program, will be implemented in the 1994 field season and will continue for the life of the Restoration Monitoring Program (FY-95 thru FY-2004).

BUDGET ($K)

	NOAA
Personnel	$ 79.0
Travel	15.0
Contractual	100.0
Commodities	15.0
Equipment	10.0
Capital Outlay	0.0
Sub-total	$ 219.0
General Administration	18.9
Project Total	$ 237.9

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
OVERVIEW, MARINE ECOLOGY		
	Bob Spies Applied Marine Sciences 2155 Las Positas Ct., Ste S Livermore, California 94550	(510) 373-7142 (510) 373-7834 fax
	Don Boesch Center for Environmental and Estuarine Studies University of Maryland PO Box 775 Cambridge, MD 21613	(410) 228-9250 (410) 228-3843 fax
	Pete Peterson, PhD University of North Carolina Chapel Hill Moorehead City, NC 28557	(919) 726-6841 (919) 726-2426 fax
	Gail Irvine, PhD US National Park Service 2525 Gambell Street Room 107 Anchorage, Alaska 99503	(907) 257-2529 (907) 257-2526 (907) 257-2510 fax
	Bruce Wright NOAA/NMFS PO Box 210029 Auke Bay, Alaska 99821	(907) 789-6605 (907) 789-6608 fax
	Doug Wolfe, PhD NOAA/NOS/Damage Assessment 6001 Executive Blvd. WSC-1 Rm 323 Rockville, Maryland 20852-3806	(301) 443-8465 (301) 231-5764 fax
	Gary Mayer/Peter Hill NOAA/NMFS Restoration Center 1335 East West Highway, Rm 7120, SSCM-1 Silver Springs, Maryland 20910	(301) 713-0174 (301) 713-0184 fax

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
MARINE ECOLOGY (continued)		
subtidal communities	Stan Rice, PhD NOAA/NMFS Auke Bay fisheries Lab 11305 Glacier Highway Juneau, Alaska 99801-8626	(907) 789-6020 (907) 789-6094 fax
coastal communities	Ray Highsmith, PhD University of Alaska School of Fishery and Ocean Sciences, O'Neill Bldg. Fairbanks, Alaska 99775-1080	(907) 474-7836 (907) 474-7953 ~~(907) 474-7270 fax~~ out of order 474-7204 fax
benthic communities	Steven Jewett, PhD University of Alaska School of Fishery and Ocean Sciences, O'Neill Bldg. Fairbanks, Alaska 99775-1080	(907) 474-7841 (907) 474-7204 fax
benthic communities	Al Mearns, PhD NOAA/HAZMAT 7600 Sand Point Way Seattle, Washington 98115	(206) 526-6336 (206) 526-6329 fax
MARINE MAMMALS pinnipeds	Don Siniff, PhD University of Minnesota 318 Church Street SE 108 Zoology Building Minneapolis, Minnesota 55455	(612) 625-2435 (612) 625-4490 fax
killer whales	John Ford, PhD Vancouver Aquarium Box 3232 Vancouver V6B 3X8 Canada	(604) 631-2507 (604) 631-2529 fax
sea otters	Jim Bodkin USFWS	(907) 786-3550 (907) 786-3636 fax

	1011 East Tudor Anchorage, Alaska 99503	
sea otter	Chuck Monnett	(907) 279-2511 delete

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	**NAME/INSTITUTION**	**PHONE NUMBER**
MARINE MAMMALS (continued)		
river otters	Jim Faro ADF&G Wildlife Conservation PO Box 3150 Soldotma, Alaska 99669-3150	(907) 262-9368 (907) 262-7646 fax
river otter	Vern Byrd USFWS Alaska Maritime National Wildlife Refuge 2355 Kachemac Drive, Suite 101 Homer, Alaska 99603	(907) 235-6546 (907) 235-7783 fax
humpback whale/ killer whales	Marilyn Dahlheim, PhD NOAA/NMFS 7600 Sand Point Way Seattle, Washington 98115	(206) 526-4020 start here (206) 526-6615 fax
harbor seals	Kathy Frost ADF&G 1300 College Road Fairbanks, Alasska 99701	(907) 456-5156 (907) ~~456-3091~~ fax 459-6410 fax
FISHERIES	Ray Hilborn University of Washington School of Fisheries WH-10 Seattle, Washington 98195	(206) 543-9026 (206) 685-7471 fax
salmon	Phil Mundy, PhD 1015 Sher Lane Lake Oswego, Oregon 97304-1744	(503) 731-1260 (503) 635-7040 fax

	Joe Sullivan, PhD ADF&G 333 Raspberry Road Anchorage, Alaska 99518	(907) 267-2213 (907) 522-3148 fax

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
FISHERIES (continued)		
pink/chum salmon	Sam Sharr ADF&G PO Box 669 Cordova, Alaska 99574	(907) 424-3212 (907) 424-3235 fax 424-3235
sockeye salmon	Dana Schmidt ADF&G Commercial Fisheries Div. or 211 Mission Road Kodiak, Alaska 99615-6399	(907) 262-9368 (907) 262-~~7646~~ 4709 fax (907) 486-4791 (907) 486-4969
herring	Evelyn Biggs ADF&G PO Box 669 Cordova, Alaska 99574	(907) 424-3212 (907) 424-3235 fax
cutthroat trout	Kelly Hepler ADF&G 333 Raspberry Road Anchorage, Alaska 91518	(907) 267-2218 (907) 522-1413 fax
clams and shrimp	Charles Trowbridge ADF&G PO Box 669 Cordova, Alaska 99574	(907) 424-3212 (907) 424-3235 fax
BIRDS pigeon guillemots	Karen Oakley USFWS 1011 East Tudor Anchorage, Alaska 99503	(907) 786-3579 (907) 786-3625 fax

Send together

marbled murrelets	Kathy Kuletz USFWS 1011 East Tudor Anchorage, Alaska 99503	(907) 786-3453 (907) 786-3625 fax

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
BIRDS (continued)		
sea birds	Vern Byrd USFWS Alaska Maritime National Wildlife Refuge 2355 Kachemac Drive, Suite 101 Homer, Alaska 99603	(907) 235-6546 (907) 235-7783 fax duplicate already sent
sea birds	George Hunt, PhD Department of Ecology Rm. 716, Engineering University of California Irvine, California 92717	(714) 8556-6322 (714) 725-2181 fax
sea birds	John Piatt USFWS 1011 E. Tudor Road Anchorage, Alaska 99503	(907) 786-3512 786-3636 fax
sea ducks	Sam Patten ADF&G 333 Raspberry Road Anchorage, Alaska 91518	~~(907) 455-6101~~ (907) 276-2376 fax 267-0376 phone need a good fax number fax 349-173
bird restoration	Dennis Heineman, PhD Manomet Bird Observatory Off Point Road Manomet, Massachusetts 02345	~~(508) 224-6521~~ ~~(508) 224-9220 fax~~ (805) 389-1472 phone & fax

bird toxicology	Michael Fry, PhD University of California Department of Avian Sciences Davis, California 95616	(916) 752-1201 (916) 752-1201 fax

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
ARCHAEOLOGY	Martin McAllister, PhD Archaeological Rsc. Invest. 5922 N. Tischer Road Duluth, Minnesota 55804-9708	(218) 525-1987
	Judy Bittner, PhD Alaska DNR Division of Parks OHA PO Box 107001 Anchorage, Alaska 99510-7001	(907) 762 2622 (907) 762-2535 fax
RECREATION	Jim Richardson 308 G Street, Suite 302 Anchorage, Alaska 99501	(907) 279-2883 (907) 276-0830 fax
	Jon Isaacs 308 G Street, Suite 313 Anchorage, Alaska 99501	(907) 274-9719 (907) 276-6117 fax
SUBSISTENCE	Jim Fall, PhD ADF&G 333 Raspberry Road Anchorage, Alaska 99518	(907) 267-2359 (907) 349-4712 fax
RESOURCE ECONOMICS	Maurie Cohen, PhD University of Pennsylvannia	(215) 898-6744 ~~(215) 989-8934~~ fax 898-8934 fax
commercial fisheries	Lewis Queirolo NOAA/NMFS 7600 Sand Point Way Seattle, Washington 98115	(206) 526-6364 (206) 526-6723

GIS	Art Weiner Alaska DNR 645 G Street Anchorage, Alaska	(907) 278-8012 (907) 276-7178 fax hard copy

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
GIS (continued)		
	Richard Podalsky, PhD 235 West 56th Street #20N New York, New York 10019-4330	(212) 246-4686 (212) 246-6054 (212) 246-6074 fax
	Zane Cornett USFWS Chugach National Forest 210 East 9th Avenue Anchorage, Alaska 99501	(907) 271-2750 971-3999 fax
STATISTICS/ POPULATION BIOLOGY	Doug Robson, PhD 150 McClaren Street PH 6 Ottowa, Ontario K2P 0L2, Canada	(613) 594-5511 (613) 234-3553 fax
	Dave Bowden Colorado State University Statistics Department Fort Collins, Colorado 80523	(303) 491-5077 (303) 491-7895 fax
population biology	Lee Eberhardt, PhD 2528 West Klamath Avenue Kennewick, Washington 99336	(509) 783-8773 (509) 376-3968 fax
DECISION ANALYSIS	Ken Reckhow, PhD 2917 Wade Road Durham, North Carolina 27705	(919) ~~684-6090~~ 613 8002 (919) (919) 684-8741 fax
	James Ruttenber, PhD University of Colorado Health Services Center Denver, Colorado	(303) 270-5627 (303) 270-3183 fax
MICROBIOLOGY	Joan Braddock, PhD	(907) 474-7991 fax 474-6967

University of Alaska
Fairbanks, Alaska

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
MARINE CHEMISTRY	Jeffrey Short NOAA/NMFS Auke Bay Fisheries Lab 11305 Glacier Highway Juneau, Alaska 99801-8626	(907) 789-6065 (907) 789-6094 fax ✓
	James Bauer Florida State University Dept. Oceanography B-169 Rogers Building, Room 309 Tallahassee, Florida 32306-3048	(904) 644-9696 (904) 644-2581 fax ✓

~~Fax to Tracey Mackenzie at (206) 889-8808 fax~~

~~hard copies to RT & RPWG~~

~~mailed copy to McAllister~~

~~others on this list faxed~~

RESTORATION TEAM

Mark Brodersen
AK Dept. of Environmental Conservation
P.O. Box O
Juneau, AK 99811-1800
(907) 465-5323
(907) 465-5375 FAX

Pamela Bergmann/Paul Gates
Dept. of Interior
1689 "C" Street, Suite 119
Anchorage, AK 99501-5126
(907) 271-5011
(907) 271-4102 FAX

Marty Rutherford
Alaska Dept. of Natural Resources
3601 C Street, Suite 1210
Frontier Building
Anchorage, AK 99510-7005
(907) 762-2483
(907) 562-4871 FAX

J. Jerome Montague/Director
Oil Spill Impact Assessment & Restoration
Alaska Dept. of Fish and Game
Box 25526
Juneau, AK 99802-5526
(907) 465-4125
(907) 463-3768 FAX

Byron Morris
NOAA/NMFS
P.O. Box 210029
Auke Bay, AK 99821-0029
(907) 789-6600
(907) 789-6608 FAX

Ken Rice
USFS Office
201 E. 9th Avenue Suite 206
Anchorage, AK 99501
(907) 271-2500
(907) 271-3992 FAX

Dave Gibbons
USDA, Forest Service, AK Region
Fish & Wildlife Mgmt., Room 225
P.O. Box 21628
Juneau, AK 99802-2000
(907) 586-8784
(907) 586-7555 FAX
or

Dave Gibbons
Interim Administratine Director
Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street
Anchorage, AK 99501
(907) 278-8012
(907) 276-7178 FAX

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

February 20, 1993

RPWG
Y

Ms. Tracey P. McKenzie
Senior Marine Ecologist
Parametrix, Inc.
5808 Lake Washington Blvd., N.E.
Kirkland, WA 98033

Dear Tracey;

Please find enclosed a nearly completed list of addresses, phone and FAX numbers for potential interviewees and/or attendees of the monitoring design workshop. While there are a few addresses yet to be obtained, I have provided at least a phone number for everyone on the list. Sorry that I did not have time to have this information retyped.

Yours very truly,

John A. Strand, Ph.D.
Restoration Manager

Enclosure

cc: Mary Sue Brancato (w/o enclosure)
Byron Morris (w/o enclosure)
Don Weitkamp (w/o enclosure)
RPWG files

1st choice attendees for workshop — *
alternate " " " — **

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
OVERVIEW, MARINE ECOLOGY		
*	Bob Spies, PHD APPLIED MARINE SCIENCES 2155 LAS POSITAS, CT, STE S LIVERMORE, CA 94550	(510) 373-7142 (510) 373-7834 FAX
* CENTER FOR ENVIRONMENTAL AND ESTUARINE STUDIES	Don Boesch University of Maryland PO Box 775 Cambridge, MD 21613	(410) 228-9250 (410) 228-3843 FAX (301) 228-9861 HOME
*	Pete Peterson, PhD University of North Carolina Chapel Hill Moorehead City, NC 28557	(919) 726-6841 (919) 726-2426 FAX
*	Gail Irvine, Ph.D. US National Park Service 2525 GAMBELL STREET ROOM 107 ANCHORAGE, AK 99503	(907) 257-2526 / 257-2529 (907) 257-2510 FAX
* subtidal communities	Stan Rice, Ph.D. NOAA/NMFS Auke Bay Fisheries Lab 11305 Glacier Hwy ~~Auke Bay~~, Juneau, AK 99801-8626	(907) 789-6020 (907) 789-6094
* coastal communities School of Fishery and Ocean Sciences O'Neill Bldg.	Ray Highsmith, Ph.D. University of Alaska Fairbanks, Alaska 99775-1080	(907) 474-7836 474-7953 474-7270 FAX
* benthic communities School of Fishery and Ocean Sciences O'Neill Bldg.	Steven Jewett PhD. University of Alaska Fairbanks, Alaska 99775-1080	(907) 474-7841 (907) 474-7204 (FAX)
benthic communities	Al Mearns, Ph.D. NOAA/HAZMAT 7600 Sand Point Way Seattle, Washington 98115	(206) 526-6336 (206) 526 6329 fax

LIST OF TELEPHONE INTERVIEWEES

	RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
**	MARINE MAMMALS pinnipeds	Don Siniff, Ph.D. University of Minnesota 318 Church Street SE 108 Zoology Building Minneapolis, Minnesota 55455	(612) 625-2435 (612) 625-4490 (fax)
*	killer whales	John Ford, Ph.D. Vancouver Aquarium Box 3232 Vancouver V6B 3X8 Canada	(604) 631-2507 (604) 631-2529
*	sea otters	Jim Bodkin USFWS 1011 EAST TUDOR ANCHORAGE, AK 99503	(907) 786-3550 7863636 FAX
	humpback whale/ killer whales	Marilyn Dahlheim, Ph.D. NOAA/NMFS 7600 Sand Point Way Seattle, Washington 98115	(206) 526-~~4054~~ 4020 (206) 526-6615 FAX
*	harbor seals	Kathy Frost ADF&G 1300 COLLEGE ROAD FAIRBANKS, 99701	(907) 456-5156 (907) 456-3091 (FAX)
	FISHERIES	Ray Hilborn University of Washington School of Fisheries WH-10 Seattle, Washington 98195	(206) 543-9026 (206) 685-7471 FAX
*	salmon	Phil Mundy, Ph.D. 1015 Sher Lane Lake Oswego, Oregon 97304-1744	(503) 731-1260 635-7040 FAX 697-3474 HOME
*		Joe Sullivan, Ph.D. ADF&G 333 RASPBERRY ROAD ANCHORAGE, AK 99518	(907) 267-2213 522-3148 FAX

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
FISHERIES (continued)		
* pink/chum salmon	Sam Sharr ADF&G P.O. BX 669 CORDOVA, AK 99574	(907) 424-3212 424-3235 FAX
herring	Evelyn Biggs ADF&G P.O. BX 669 CORDOVA, AK 99574	(907) 424-3212 424-3235
cutthroat trout	Kelly Hepler ADF&G 333 RASPBERRY ROAD ANCHORAGE, AK 99518	(907) 267-2218 522-1413 FAX
clams and shrimp	Charles Trowbridge ADF&G P.O. BOX 669 CORDOVA, AK 99574	(907) 424-3212 424-3235 FAX
BIRDS		
* pigeon guillemots	Karen Oakley USFWS 1011 EAST TUDOR ANCHORAGE 99503	(907) 786-3579 786-3625 FAX
marbled murrelets	Kathy Kuletz USFWS 1011 EAST TUDOR ANCHORAGE, AK 99503	(907) 786-3453 786-3625 FAX
sea ducks	Sam Patten ADF&G ~~1670 COYOTE TRAIL~~ 333 RASPBERRY ROAD ~~FAIRBANKS, AK~~ ANCHORAGE AK 99518	(907) ~~276-2376~~ 455-6101 276-2376 FAX

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
BIRDS (continued)		
* bird restoration	Dennis Heineman, Ph.D. Manomet Bird Observatory Off Point Road Manomet, Massachusetts 02345	(508) 224-6521 (508) 224-9220
** bird toxicology	Michael Fry, Ph.D. University of California Department of Avian Sciences Davis, California 95616	(916) 752-1201 (916) 752-1201 (FAX) same
* ARCHAEOLOGY	Martin McAllister, Ph.D Archaeological Resouce Investigations 5922 N. Tischer Road Duluth, Minnesota 55804-9708	(218) 525-1987
	Judy Bittner, Ph.D. Alaska DNR DIV OF PARKS OHA P.O. BOX 107001 ANCHORAGE 99510-7001	(907) 762-2622 762-2535 FAX
* RECREATION	Jim Richardson 308 G Street, Suite 302 Anchorage, Alaska 99501	(907) 279-2883 (907) 276-0830 FAX
**	Jon Isaacs 308 G Street, Suite 313 Anchorage, Alaska 99501	(907) 274-9719 (907) 276-6117 FAX
* SUBSISTENCE	Jim Fall, Ph.D. ADF&G 333 RASPBERRY RD ANCHORAGE, AK 99518	(907) 267-2359

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
RESOURCE ECONOMICS	Maurie Cohen, Ph.D. University of Pennsylvannia	(215) 898-6744 (215) 989-8934 (FAX)
** commercial fisheries	Lewis Queirolo NOAA/NMFS Alaska Fisheries Science Center, 7600 Sand Point Way, N.E. BIN C15700, Bldg 4, Seattle, WA 98115-0070	(206) 526-6364 (206) 526-6723 (FAX)
GIS	Art Weiner Alaska DNR 645 G STREET ANCHORAGE, AK	(907) 278-8012 276-7178 FAX
GAIA software	Richard Podalsky, Ph.D. 235 WEST 56th STREET #20N NY, NY 10019-4330	(212) 246-4686 246-6054 (212) 246-6079 FAX
* STATISTICS/ POPULATION BIOLOGY	Doug Robson, Ph.D. 150 McClaren Street PH 6 Ottowa, Ontario K2P 0L2, Canada	(613) 594-5511 (613) 234-3553 (FAX)
	Dave Bowden Colorado State University Statistics Department Fort Collins, Colorado 80523	(303) 491-5077 (303) 491-7895 (FAX)
* population biology	Lee Eberhardt, Ph.D. 2528 West Klamath Avenue Kennewick, Washington 99336	(509) 783-8773 (509) 376-3968 (FAX)
* DECISION ANALYSIS	Ken Reckhow, Ph.D. 2917 Wade Road Durham, North Carolina 27705	(919) 684-6090

LIST OF TELEPHONE INTERVIEWEES

RESOURCE SERVICE REPRESENTED	NAME/INSTITUTION	PHONE NUMBER
** DECISION ANALYSIS (continued)	James Ruttenber, Ph.D. University of Colorado Health Services Center Denver, Colorado	(303) 270-5627 (303) 270-3183 (FAX)
MICROBIOLOGY	Joan Braddock, Ph.D. University of Alaska Fairbanks, Alaska	(907) 474-7991
MARINE CHEMISTRY	Jeffrey Short NOAA/NMFS Auke Bay Fisheries Lab 11305 Glacier Highway Juneau, AK 99801-8626	(907) 789-6065 (907) 789-6094 (FAX)
	James Bauer Florida State University Dept. Oceanography B-169 Rogers Building, Room 309 Tallahassee, Florida 32306-3048	(904) 644-9696 (904) 644-2581 (FAX)
RIVER OTTER	JIM FARO ADF&G Wildlife Conservation P.O. Box 3150 Soldotna, AK 99669-3150	(907) 262-9368 (907) 262-7646 (FAX)
*	VERN BRYD USFWS AK MARITIME National Wildlife Refuge 2355 KACHEMAC DRIVE, SUITE 101 HOMER, AK 99603	235-6546 235-7783 FAX

ADDITIONS TO

LIST OF TELEPHONE INTERVIEWEES

RESOURCE OR SERVICE REPRESENTED	NAME/INSTITUTION	PHONE/FAX NUMBER
BIRDS		
sea birds	Vern Byrd (See page 6) USFWS	(907) 235-6546 FAX 592-3473
sea birds	George Hunt, PhD. Department of Ecology Rm 716, Engineering University of California Irvine, CA 92717	(714) 856-6322 FAX 725-2181
sea birds	John Piatt USFWS 1011 E. Tudor Rd. Anchorage, AK 99503	(907) 786-3512 ~~FAX 869-3-~~
MARINE MAMMALS		
sea otter	Chuck Monnett	(907) 279-2511
OTHER MAMMALS		
~~river otter~~	~~Jim Faro~~ ~~ADF&G~~	~~(907) 474-5311~~ ~~FAX 474-6967~~
GIS	Zane Cornett USFS Chugach National Forest 210 East 9th Ave. Anchorage, AK 99501	(907) 271-2750
OVERVIEW	Bruce Wright NOAA/NMFS P.O. Box 210029 Auke Bay, AK 99821	(907) 789-6605 FAX 789-6608
FISH		
* sockeye salmon	Dana Schmidt ADF&G Commercial Fisheries Division 211 Mission Rd. Kodiak, AK 99615-6399	(907) 262-9368 FAX 262-7646 or (907) 486-4791 FAX 486-4969

ADDITIONS TO

LIST OF WORKSHOP ATTENDEES

* **OVERVIEW**

Gary Mayer or
Peter Hill
NOAA/NMFS
Restoration Center
RM 7120, SSCM-1
1335 East West Highway
Silver Spring, MD 20910

(301) 713-0174
FAX 713-0184

*

Doug Wolfe, PhD.
NOAA/NOS
Damage assessment Cntr.
6001 Executive Blvd.
WSC-1, Rm 323
Rockville, Md. 20852-3806

(301) 443-8465
(301) 231-5764 (FAX)

RPWG
Y

Date: *January 5, 1993*

From: *John*

To: *Barbara/Cherri*

Subject: Package of Background Information for Monitoring Program Design Contractor-Parametrix, Inc.

On January 8th, I will attend a meeting in Seattle with our new contractor. There are a number of important background documents that I would like to take (hand-carry) to this meeting. I would appreciate if you could gather the following:

1) 93' Work Plan
2) Restoration Framework Document
3) Contacts and addresses for local RCACs (Cook Inlet, Prince William Sound)
4) copy of Bob Loeffler's proposal on endowments.
5) most recent list of peer reviewers and their addresses.

I will leave for this meeting on January 7th at noon. Thank you.

RPWG
Y

RESTORATION PLANNING WORK GROUP
EXXON VALDEZ OIL SPILL OFFICE
645 "G" STREET
ANCHORAGE, ALASKA 99501

TO: Don Weitkamp
Mary Sue Brancato

DATE: January 7, 1993

FROM: John Strand

SUBJECT: Relevant Reference Materials - Conceptual Monitoring Design

Enclosed for your use in developing the conceptual monitoring design are a number of key reference materials. Your review of these documents will undoubtedly generate requests for additional information. A call to me in Juneau (907) 789-6601 or to Barbara Iseah in Anchorage (907) 278-8012 will facilitate collection of additional reference materials and the forwarding of same to your offices at the earliest possible date.

Enclosures: Restoration Framework Vol. 1.
Restoration Framework Supplement
1992 Draft Work Plan Vol. 2.
1993 Draft Work plan
Symposia presentations (restoration planning process)
Directory of Experts (peer reviewers)
Exxon Valdez Injury Assessment Principal Investigators
Regional Citizens Advisory Council Contacts
Endowments (Draft for RPWG, RT Review)
Injured Resources and Services - Subsistence

cc: Barbara Iseah
Byron Morris

RPWG
Y

RESTORATION PLANNING WORK GROUP
EXXON VALDEZ OIL SPILL OFFICE
645 G STREET
ANCHORAGE, ALASKA 99501

MEMORANDUM

TO: Distribution **DATE:** January 20, 1993

FROM: John Strand

SUBJECT: Meeting with Parametrix, Inc., January 27th in Anchorage

Representatives from Parametrix will visit our offices on January 27th to discuss with RPWG their progress to develop a conceptual design for a restoration monitoring plan. As you know, Parametrix began work on December 15th, and I already have met with Parametrix on January 8th in Kirkland. I believe that both Don Weitkamp (Principal Investigator) and Mary Sue Brancato (Project Manager) will make the trip. I would like to start at 10:00 AM; I will arrive about 9:30 AM from Juneau. The meeting will likely carry-over until the afternoon on the 27th. It also is likely that Don and Mary Sue will stay over on the 28th to gather relevant monitoring information. They may want to schedule some time with RPWG, RT and others to discuss relevant issues.

Of particular importance this trip is the development of a draft (working) outline for the conceptual plan. We also will want to review plans and a proposed schedule for the monitoring planning workshop.

I am working with Bob Spies to have present at the meeting at least two peer reviewers. I am trying to contact Jim Richardson and Pete Peterson in this regard. We also may need someone for archaeology. Pete will likely join us via teleconference. Pete has agreed to provide us peer review throughout the tenure of the project, not just at the time when draft documents are ready for review.

You are all most welcome to attend; but clearly, I need Sandy and Mark to attend because of their interest and expertise in services and resources, respectively. I also would like Barbara to attend to record our discussions and action items.

Finally, please find attached a copy of the RFP to which Parametrix responded. Let me know if you plan to attend.

Attachment

Distribution: RPWG
Mary Sue Brancato (w/o attachment)
David Gibbons
Byron Morris
Pete Peterson
Jim Richardson
Bob Spies
Don Weitkamp (w/o attachment)

REQUEST FOR PROPOSALS FOR:

COORDINATION AND DEVELOPMENT OF A COMPREHENSIVE AND INTEGRATED MONITORING PLAN FOR THE *EXXON VALDEZ* OIL SPILL AREA

I. BACKGROUND

The *Exxon Valdez* Oil Spill Trustee Council has initiated a planning effort to develop a comprehensive and integrated monitoring program for resources and services injured by the *Exxon Valdez* oil spill. A monitoring program will be implemented to follow the progress of recovery, evaluate the effectiveness of restoration activities, and document long-term trends in the condition of resources and services affected by the spill. Resulting information will not only guide restoration activities during the recovery phase of the spill, but also will provide information useful to long-term management of resources and services in the oil spill area. As described in EXXON Valdez Oil Spill Restoration Volume 1: Restoration Framework (*Exxon Valdez* Oil Spill Trustee Council, 1992), implementation of a monitoring program is one option being considered during the development of a Restoration Plan.

Because of the complexities of both institutional and technical issues associated with developing a meaningful monitoring program for the spill area, a phased approach will be undertaken. In Phase 1, a contractor will develop a conceptual design for a monitoring program. This will guide more detailed, technical planning in Phase 2. This REQUEST FOR PROPOSALS addresses only Phase 1.

II. OBJECTIVE

The objective of this REQUEST FOR PROPOSALS is to invite the services of a qualified contractor to develop a conceptual monitoring plan (Phase 1). It is the intent that this document, or elements thereof, be included in a first draft of a restoration plan now scheduled for completion on November 15, 1992.

III. STATEMENT OF WORK

TASK 1 - DEVELOPMENT OF CONCEPTUAL DESIGN FOR MONITORING

It is expected that the contractor will, at a minimum, draw on information derived from the Trustees' damage assessment and restoration science programs; the U.S. Coast Guards' clean-up program; other relevant monitoring programs (e.g., Puget Sound Ambient Monitoring Plan, Prince William Sound Regional Citizens'

Advisory Council Ecological Monitoring Project, etc.); and a monitoring workshop conducted to develop ideas for a conceptual plan. The conceptual plan will address, but will not be limited to, the following issues:

1) what process or mechanism would best assist the Trustee Council in determining monitoring, damage assessment, restoration science, and related project priorities;

2) what are realistic goals and objectives for monitoring;

3) what resources and services should be monitored and why, given the goals and objectives developed in (2);

4) which clean-up, damage assessment and restoration science studies contain elements that would best serve the purposes of the intended monitoring program, and what are these elements;

5) which surveys of services (e.g., recreation, subsistence, aesthetics, etc.) provided by natural resources contain elements that would best serve the purposes of the intended monitoring program, and what are these elements;

6) what consideration should be given to the relationships among different monitoring components (e.g., sediments, shellfish, fish, mammals, birds, etc.) and how should they be integrated;

7) what relationships need to be established with other monitoring programs within the spill area and how should they be integrated; and

8) what process (including infrastructure) should be considered to guide implementation and management of monitoring.

<u>TASK 2</u> - <u>CONDUCT MONITORING WORKSHOP</u>

The contractor also will be expected to design and conduct a two- or three-day monitoring planning workshop in Anchorage, Alaska. The first day will deal with the purpose, need and scope of the intended monitoring program and will provide a forum for presentations reviewing other relevant monitoring programs (e.g. Beaufort Environmental Monitoring Project, NOAA's National Status and Trends Program). The focus of such presentations will be on "lessons learned," particularly as they relate to issues of strategy and design. The second and possibly third day will be devoted to development of a framework for the conceptual plan.

It is anticipated that the workshop will include five participants with monitoring experience in regions outside Alaska and up to ten participants with experience gained from the *Exxon Valdez* oil spill. Prospective contractors should budget for

travel, subsistence, and honoraria for the five participants from outside Alaska.

IV. RESPONSIBILITIES

The contractor will be required to work closely with the Trustee Councils' staff and other appropriate agency and university scientists to accomplish the specific objectives of this work. The contractor will be provided access to the results of all relevant clean-up, damage assessment, restoration science and natural resource service monitoring information.

V. DELIVERABLES

A summary document from the monitoring planning workshop and a conceptual monitoring plan (including input from workshop) will be required to fulfill the proposed scope of work. Additionally, letter reports will be submitted monthly covering project status, costs to date and any problems or delays encountered or anticipated.

VI. SCHEDULE

The contract period will be six months. The monitoring workshop should be held during the second or third month of the contract period. It also is anticipated that there will be a need for at least three meetings in Anchorage, Alaska. The first meeting will be held at the beginning of the contract period to develop a working outline of the conceptual plan and to design the monitoring planning workshop. A second meeting will be held two or three months after project award to review progress on developing a conceptual design, but could occur while the contractor is in Anchorage to conduct the monitoring workshop. A third meeting will be held at the end of five months to review the draft conceptual plan. The draft conceptual plan will be submitted at least two weeks prior to the date of the third meeting. The final copy of the conceptual plan will be due one month after return of review comments. A draft summary document for the monitoring planning workshop will be submitted one month after the date of the workshop. The final monitoring workshop summary will be due one month after review and return of comments.

VII. BUDGET

Cost estimates should be developed by task. Also, costs associated with developing input to the conceptual plan for monitoring of injured natural resources should be separated from the costs associated with developing input to the conceptual plan for monitoring injured services.

VIII. PROPOSAL EVALUATION FACTORS

Proposals will be evaluated based on the qualifications and demonstrated experience of the proposed contractor (including prior experience in the design and conduct of environmental monitoring programs in northern or far southern latitudes), and the responsiveness of the proposal to the Trustee Councils' objectives and schedule. Cost is also a consideration.

It is expected that proposals will include:

1) statement of objectives,

2) proposed study plan and approach,

3) project organization, including a designated leader/liaison to the Trustee Councils' staff,

4) personnel experience,

5) deliverables, and

6) budget.

VIII. PROPOSAL SUBMISSION

Proposals should be submitted to:

Ms. Heidi Sickles, Contract Administrator
National Oceanic and Atmospheric Administration
Western Administrative Support Center
7600 Sand Point Way NE
Seattle, WA 98115

Telephone inquiries pertaining to contractual matters may be directed to Ms. Heidi Sickles on (206) 526-6028. Inquiries pertaining to technical matters may be addressed to John Strand, Restoration Planning Working Group on (907) 789-6601.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

RPWG
Y

August 6, 1992

Dr. John Armstrong
Office of Coastal Waters
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, WA 98101

Dear John:

Pursuant to our conversation on August 6th and based on my earlier transmittal, I would ask that you consider for approval the attached proposed Revision I to our (EPA/NOAA) IAG (No DW13957045-01-0) to develop a comprehensive and integrated monitoring plan for the *Exxon Valdez* oil spill area.

In addition to extending the budget period for the subject IAG, I also recommended some language changes. These suggested changes reflect the need to first develop a "conceptual" plan before proceeding with more "detailed" technical planning. What is meant by "conceptual" should become more clear if you compare my proposed revision to the IAG with the original IAG. These suggested changes also address the need to develop a monitoring approach for damaged services.

I believe the proposed revision is required to better reflect what deliverable will be produced, in this case, a "conceptual" monitoring plan and not a "detailed" monitoring plan. The proposed revision also will allow us to carry-over funds to FY-1993. We will not have selected a contractor until early October 1992.

I believe the proposed work effort (to produce a conceptual plan) is more in line with the $70K that is available from EPA and NOAA. Some additional funds could be made available by the Alaska Department of Environmental Conservation if they are required. Hopefully, the <u>Phase 2</u> planning effort to produce a detailed monitoring plan will be supported by the Trustees in 1993 out of the civil settlement funds.

While I forwarded a draft of the proposed Revision I to Susan MacMullin, I have not yet received her response. She should be familiar with the proposed changes that reflect the need to develop a conceptual plan, as I sent her a copy of the revised NOAA-RFP on April 22nd which included essentially the same changes. I would hope that she would have little or no negative comment at this time.

If there are any questions, other requirements, or I can be of further help in any way, please don't hesitate to call. I will be at the Restoration Planning Working Group Office in Anchorage (907-278-8012) from August 10 thru August 21. Thanks very much for your continued interest, advice and help.

Yours very truly,

John A. Strand, Ph.D.
Restoration Manager

Attachment

cc: Susan MacMullin
Byron Morris
RPWG

REVISION 1

TO

INTERAGENCY AGREEMENT
BETWEEN
U.S. ENVIRONMENTAL PROTECTION AGENCY
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

COORDINATE DEVELOPMENT OF A COMPREHENSIVE AND INTEGRATED MONITORING PLAN FOR THE EXXON VALDEZ OIL SPILL AREA

Background and Objective

The Restoration Planning Working Group (RPWG) with support from the Environmental Protection Agency (EPA) has initiated a planning effort to develop a comprehensive and integrated monitoring strategy for resources and services injured/damaged by the EXXON Valdez oil spill. A monitoring program is required to follow the progress of recovery, evaluate the effectiveness of restoration activities, and document long-term trends in the condition of resources and services affected by the spill. Resulting information will not only guide restoration activities during the recovery phase of the spill, but also will provide information useful to the long-term management of resources and services in the spill area. As described in *Exxon Valdez Oil Spill Restoration Volume 1: Restoration Framework* (Exxon Valdez OiL Spill Trustee Council 1992), implementation of a monitoring program is one option being considered during the development of a restoration plan.

Because of the complexities of both institutional and technical issues associated with developing a meaningful monitoring program for the spill area, a phased approach will be undertaken. In Phase 1, a contractor will develop a conceptual design for a monitoring program. This will guide more detailed, technical planning in a follow-on Phase 2.

It is the objective of this IAG to provide opportunity for the National Oceanic and Atmospheric Administration (NOAA) through the National Marine Fisheries Service (NMFS) to assist the RPWG and EPA in the development of a conceptual design (Phase 1) for a comprehensive and integrated restoration monitoring plan.

Approach

In order to meet this objective, at least two tasks have been identified. These are:

Task 1. Obtain Services of Qualified Consultant to Provide Technical Assistance in the Development of a Conceptual Design for Monitoring

With EPA input, NOAA will prepare and issue a Request for Proposals (RFP) soliciting the services of a qualified consultant to provide technical assistance in the initial planning phase of developing a more comprehensive and integrated monitoring strategy for the oil spill area. NOAA will also design procedures for evaluating the resulting technical proposals and chair a RPWG committee to select a consultant. The successful consultant will have previously demonstrated capabilities in the design and implementation of multi-discipline environmental monitoring plans.

The consultant will be required to work closely with the RPWG, Restoration Team, EPA, the Chief Scientist and other Federal and State peer reviewers (the Monitoring Planning Committee [MPC]) in an initial planning phase to develop a "conceptual" framework for a restoration monitoring plan. It is expected that the consultant will utilize information derived from the Trustee's Natural Resource Damage Assessment and Restoration Program, the U.S. Coast Guard' clean-up program, other relevant monitoring programs (e.g., Puget Sound Ambient Monitoring Plan, Prince William Sound Regional Citizens' Advisory Council Ecological Monitoring Project, etc., and a future workshop conducted to develop input specific to the conceptual plan (see Task 2). This approach assumes that the MPC will organize and implement a program of peer review upon completion of the "conceptual" plan.

The conceptual plan will address such issues as:

A. what process or mechanism would best assist the Trustee Council in determining monitoring, damage assessment, restoration science, and related project priorities;

B. what are realistic goals and objectives for monitoring;

C. what resources and services should be monitored and why, given the goals and objectives developed in (B);

D. which clean-up, Natural Resource Damage Assessment studies (includes restoration science studies) contain elements that would best serve the purpose of the intended restoration monitoring program, and what are these elements;

E. which surveys of services (e.g., recreation, subsistence, aesthetics, etc.) provided by natural resources contain elements that would best serve the purposes of the intended monitoring program, and what are these elements;

F. what consideration should be given to the relationships among different monitoring components (e.g., sediments, shellfish, fish, birds, mammals etc.) and how they should be integrated;

G. what relationships need to be established with other monitoring programs within the spill area and how should they be integrated; and

H. what process (including infrastructure) should be considered to guide implementation and management of monitoring.

Costs of this task are estimated at $50K and are exclusively associated with the hiring of a consultant. For these funds, the consultant will be expected to deliver a "conceptual" plan at the end of an anticipated six-month subcontract. The costs of preparing and managing the contract will constitute NOAA's contribution to this task.

TASK 2. Design and Conduct Workshop to Develop Conceptual Design for a Restoration Monitoring Plan.

With RPWG, EPA and consultant input, NOAA will also design and implement a workshop to collect information important to the conceptual design of a comprehensive and integrated monitoring plan. The workshop would focus on those key elements listed in Task 1. Attendees would include the RPWG, their consultant, Management Team, Chief Scientist, Federal and State peer reviewers, Federal and State regulators, and Trustee Agency and university scientists.

Costs of this task are estimated at $20K of which $11K would be provided by EPA through this IAG. It is anticipated that an additional $9k would be contributed by NOAA. These costs are associated with the logistics (materials, travel reimbursement for attendees form outside Alaska).

Term of Agreement

This Interagency Agreement should remain in effect for a period of two (2) years (9/1/91 - 9/30/93). This facilitates the addition of future as yet undefined organization and coordination tasks as the need arises.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

August 7, 1992

Dr. Jeff Hartman, Economist
Fisheries Rehabilitation Enhancement
and Development Division
State of Alaska Department of Fish & Game
P.O. Box 25526
Juneau, AK 99802-5526

Dear Jeff:

On behalf of the Restoration Planning Working Group (RPWG), I wanted to thank you for attending our August 5th Economics Workshop on how we might better integrate economics analyses into restoration planning. I am certain that we all gained a greater appreciation of the necessity to develop better economic guidelines for evaluating restoration options and projects. In particular, you helped us understand the differences between and how best to apply the concepts of cost effectiveness and cost/benefit. I believe we also recognized the wisdom of involving an economist in our planning on a more routine basis.

Your participation and advice was timely and your recommendations will soon be addressed. The need for more routine economics advice is the basis of a topic that will be discussed at our next RPWG planning meeting now scheduled for the week of August 10th. It is possible that Sandy Rabinowitch or I will call you regarding your thoughts on how RPWG could best fulfill this need. We also will forward to you copies of the Workshop "minutes" and the Framework Supplement when they become available. Thanks again for your efforts.

Yours very truly,

John A. Strand, Ph.D.

cc: David Gibbons
Jerome Montague
Byron Morris
RPWG

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

August 7, 1992

Dr. Anthony T. Nakazawa, Director
Rural Development Division
State of Alaska
Department of Community and Regional Affairs
333 West 4th Avenue
Anchorage, AK 99501-2341

Dear Tony:

On behalf of the Restoration Planning Working Group (RPWG), I wanted to thank you for attending our August 5th Economics Workshop on how we might better integrate economics analyses into restoration planning. I am certain that we all gained a greater appreciation of the necessity to develop better economic guidelines for evaluating restoration options and projects. In particular, you helped us understand the differences between and how best to apply the concepts of cost effectiveness and cost/benefit. I believe we also recognized the wisdom of involving an economist in our planning on a more routine basis.

Your participation and advice was timely and your recommendations will soon be addressed. The need for more routine economics advice is the basis of a topic that will be discussed at our next RPWG planning meeting now scheduled for the week of August 10th. It is possible that Sandy Rabinowitch or I will call you regarding your thoughts on how RPWG could best fulfill this need. We also will forward to you copies of the Workshop "minutes" and the Framework Supplement when they become available. Thanks again for your efforts.

Yours very truly,

John A. Strand, Ph.D.

cc: David Gibbons
Byron Morris
RPWG

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

August 7, 1992

Dr. Lewis Queirolo
Resource Ecology & Fisheries
Management Division
National Marine Fisheries Service
S/AKC2 Alaska Fisheries Science Center
7600 Sand Point Way N.E.
Seattle, WA 98115

Dear Lew:

On behalf of the Restoration Planning Working Group (RPWG), I wanted to thank you for attending our August 5th Economics Workshop on how we might better integrate economics analyses into restoration planning. I am certain that we all gained a greater appreciation of the necessity to develop better economic guidelines for evaluating restoration options and projects. In particular, you helped us understand the differences between and how best to apply the concepts of cost effectiveness and cost/benefit. I believe we also recognized the wisdom of involving an economist in our planning on a more routine basis.

Your participation and advice was timely and your recommendations will soon be addressed. The need for more routine economics advice is the basis of a topic that will be discussed at our next RPWG planning meeting now scheduled for the week of August 10th. It is possible that Sandy Rabinowitch or I will call you regarding your thoughts on how RPWG could best fulfill this need. We also will forward to you copies of the Workshop "minutes" and the Framework Supplement when they become available. Thanks again for your efforts.

Yours very truly,

John A. Strand, Ph.D.

cc: David Gibbons
Byron Morris
Steve Pennoyer
RPWG

RPWG
Y

COOK.INLET.
RCAC

"The mission of the Council is to ensure the safe operation of the oil terminals, tankers, and facilities in Cook Inlet so that environmental impacts associated with the oil industry are minimized."

July 1, 1992

The Environmental Monitoring Committee (EMC) of Cook Inlet Regional Citizens Advisory Council is pleased to provide you with a copy of this **DRAFT** document, which has been submitted to the EMC for comment and revision. Once complete, this document will become part of the record on which the EMC will base recommendations to the Cook Inlet RCAC. Cook Inlet RCAC may, in turn, make recommendations to industry and/or government based on this information. All interested parties are requested to comment on the document addressed **prior to July 14, 1992** to assist us in formulating final recommendations.

Parties which may be affected by this work or have useful information include:

Organization	Contact Person	Telephone
Cook Inlet RCAC	D. Doug Coughenower, EMC Chair	235-5643
Cook Inlet RCAC	Dave Woodruff, EMC	486-5749
Cook Inlet RCAC	Karl Pulliam, EMC	234-7641
Cook Inlet RCAC	Lisa Parker, Executive Director	283-7222
Univ. of Alaska, Anchorage	Douglas Segar	257-2706
Univ. of Alaska, Fairbanks	Brenda Norcross	474-7531
ADF&G, Habitat Division	Chris Swenson	267-2324
ADEC	Mark Sienkiewicz	262-5210
MBC Applied Environ. Sci	Thomas Kauwling, consultant	(714)646-1601
ARCO Alaska	Jim Ives	263-4307
Marathon Oil	Bruce Cox	564-6350
Unocal	John Beitia	276-7600
Tesoro Alaska Petroleum	Jim Meitner	776-8191

In reviewing this work please keep it in its proper context. **The document is still in a DRAFT format and no position has been taken by either the Committee or the Council.** Following completion for the final document, near July 31, 1992, the EMC will discuss at its next scheduled meeting, time permitting, conclusions and recommendations from the report, if any, to be forwarded to the Council.

Should you have any further questions on the Council or this document please feel free to contact us at (907) 283- 7222.

Jim Dey, Program Coordinator
Environmental Monitoring Committee

Cook Inlet Regional Citizens Advisory Council
11355 Frontage Rd. • Suite 228 • Kenai, Alaska 99611 • (907) 283-7222 • FAX (907) 283-6102

received
6/23/92

A COMPREHENSIVE MONITORING PROGRAM FOR COOK INLET, ALASKA

Draft Report
June 1992

Prepared for:
Cook Inlet Regional Citizens Advisory Council, Inc.

Prepared by:
MBC Applied Environmental Sciences
947 Newhall Street
Costa Mesa, California 92627

TABLE OF CONTENTS

EXECUTIVE SUMMARY

BACKGROUND

Following the Exxon *Valdez* oil spill incident and passage of Public Law 101-380 (the Oil Pollution Act of 1990, OPA 90), the Oil Terminal and Oil Tanker Environmental Oversight and Monitoring Demonstration for Cook Inlet, Alaska was established. This program includes a Regional Citizens Advisory Council (RCAC) which is charged with ensuring safe operations of oil-related activities such as offshore production, transshipment, and terminal on- and off-loading. One of the primary goals of the RCAC is to minimize environmental impacts as a result of such activities. To help achieve this goal, an Environmental Monitoring Committee (EMC) was established within the RCAC. The EMC, in turn, contracted MBC Applied Environmental Sciences to develop a comprehensive monitoring program for Cook Inlet.

The monitoring program is envisioned to serve as an "early warning" system, capable of detecting chronic, low-level oil pollution in Cook Inlet before it assumes critical magnitudes. Development of the monitoring program targeted several specific goals:

- To examine Cook Inlet at the ecosystem level
- To collect monitoring data (and as a result generate baseline data)
- To be capable of detecting chronic (and acute) impacts
- To measure both temporal and spatial conditions
- To be comprehensive, including air, water, land, submerged land, and biota
- To be capable of measuring toxicity levels and risk in the ecosystem
- To identify habitats and biota present and "prioritize" on the basis of ecological significance; economic importance; and vulnerability, susceptibility, and/or sensitivity to oil pollution
- To be cost effective
- To meet or exceed requirements of regulatory compliance

MONITORING DESIGN AND APPROACH

In order to design a feasible monitoring program that would produce useful, meaningful results, the project team made maximum use of existing information, focussing on techniques which would show results in the areas, habitats, and environmental factors most likely to be affected by oil-related activities. The conditions of existing habitats and resources, sources and fates of potential contamination, and potential monitoring techniques were thoroughly examined.

All of the elements of the air, water, land, submerged land, and biota, in all areas of Cook Inlet cannot be monitored with equal vigor on a regular, frequent basis (if at all) even with an unlimited budget. Fortunately, they need not be; an effective monitoring program can be designed and conducted which tracks changes and impacts in a limited number of key ecological components. As most of the oil production, processing, and shipment activities are in the marine environment, the design emphasized primarily marine habitats. The air and fresh water habitats were eliminated from further consideration because of high costs per return and the need for so many stations all around each potential source to produce meaningful results.

The recommended approaches and components of the plan were selected to meet the prescribed goals after careful consideration of such factors as:

- What is to be monitored? What are the pollutant(s) of concern and what chemical tests are best applied to test for them?

- What resources (environments/habitats/species) are of concern and which are most likely to be affected?

- What species are most likely to be impacted?, keeping in mind some species that are affected by oil may not necessarily be the best organisms to use in a monitoring program.

- What are the best indicator species? Just as there are indicator contaminants, there are indicator species. Some of these may not be year-round residents in Cook Inlet so if they are affected by oil in some way, the exposure to oil contamination did not necessarily occur within the study area; some species may not be affected by oil, while others may only be vulnerable at certain life stages; also some such as marine mammals and birds may be too rare or too expensive to sample.

- What techniques should be used? Which combination is most practical (cost-effective and logistically feasible) and most sensitive in detecting low-level concentrations or lethal/sublethal impacts attributable to oil?

RECOMMENDED PROGRAMS

The recommended programs consist of four integrated projects elements: 1) *in situ* mussel bioaccumulation studies; 2) subtidal benthos studies; 3) intertidal studies; and 4) monitoring of terrestrial vegetation.

Within each component both physical-chemical (i.e., measurements of hydrocarbon levels in sediment or tissue) and biological (such as mortality rates, bioaccumulation rates, growth rates, apparent health of the individuals) information is collected. The results of each sampling component are then compared with those obtained for the other components at the same and different stations within the same habitat type.

By measuring the levels of petroleum in the environment, we examine the potential for an impact; by measuring population and/or community parameters we can describe how the contamination is presumed to have affected an entire assemblage. Ultimately, we can determine if chronic, low-level oil pollution is indeed impacting Cook Inlet.

Overall, this design incorporates environmental conditions, oil operations/activities, and potential monitoring techniques into a comprehensive, cost-effective program which will satisfy the requirements of the CIRCAC.

In situ Bioaccumulation (Mussel Watch)

Mussels are especially useful detectors of dissolved or particulate pollutants because, as filter feeders, they accumulate and thus concentrate substances from the water column. Substances can be detected in mussel tissues when the concentration of the pollutant is too dilute to detect in the water mass or suspended particulates. Mussels also serve to average long term pollutant levels, since they filter the water constantly even as the pollutant levels fluctuate.

Replicate test mussels (*Mytilus edulis*) will be obtained from a common source in the study region and will be deployed for three to four months at each station. Upon retrieval, mussel tissues will be tested for the recommended hydrocarbon traces. The results will demonstrate the dispersion of petroleum away from the potential sources as well as its accumulation in particular areas.

Oil-degrading Bacteria

To the extent that it is applied only to ascertain the presence or absence of hydrocarbons, the use of oil-degrading bacteria is a preliminary approach which can be applied to subtidal and intertidal sediments, as well as water column samples. Oil-degrading bacteria represent the lowest possible members of the trophic structure which can respond to the presence of oil and are sensitive to even minor accumulations. The use of hydrocarbon degrading bacteria as an indicator of oil pollution is a relatively new technique, however, several studies (including some in Prince William Sound) have shown that hydrocarbon degraders are a sensitive and relatively inexpensive indicator of hydrocarbon in the environment.
hydrocarbons.

Subtidal Benthos

Sediments are the ultimate sink for most contaminants, in particular heavy fractions of petroleum hydrocarbons (crude oil and refined product) which enter the marine environment. These compounds generally combine with suspended material and eventually sink to the seafloor. Once in the sediments, they may simply continue to accumulate, or they may be incorporated into animal tissues, adversely affecting single populations and, by extension, the community as a whole. A three-part subtidal benthos program is envisioned.

The first part will measure the concentrations of the recommended hydrocarbon "marker" substances in the sediments, thereby indicating whether oil has, in fact, been dispersed to and accumulated at the particular site. Although most potential chronic oil-leak sources are near the middle of Cook Inlet, tide and wind-induced currents and local topography may determine where oil is actually carried.

The second part would consist of collecting infauna or near-bottom, filter-feeding organisms for bioaccumulation assays. The presence of oil in the physical-chemical environment does not necessarily indicate an actual impact. The concentration of hydrocarbons in tissues will indicate the extent to which the hydrocarbons are "bioavailable" and thus represent an early step in the food-chain accumulation of pollutants.

The third part includes the collection of at least three cores for infaunal community composition analysis. Sediment grain size would also be analyzed as it is a major determinant of natural (and impacted) infaunal community structure.

Intertidal Studies

Crude oil and most petroleum products are buoyant, so a large portion of that which remains after a spill or leak is eventually transported to the intertidal zone. Because of this and because of the multitude of uses and users of this particular habitat (e.g., humans harvesting marine resources throughout the zone, salmon, herring, and other fish using it as spawning areas, marine mammals hauling out and/or pupping here, migrating birds using it as a forage area etc.), it is sensible/logical/important to examine the changes in the intertidal zone which might be reflective of lethal and sublethal impacts due to chronic oil pollution.

Major elements of the intertidal program include sediment chemistry analysis (if soft sediments are available), and bioaccumulation levels (body burden concentrations) of hydrocarbons in two mollusk species. Community structure and composition, and growth of the select mollusks will be sampled in the $800,000 program. The population/community parameters sampled (e.g., total number of individuals and species, presence-absence of key organisms, frequency of occurrence of certain species) will be crude indicators of the subtle effects of chronic impacts. The measurement of hydrocarbon levels in the animal tissues will be a reflection of the presence of oil in the intertidal environment, and the potential for transfer of petroleum-derived contaminants to organisms higher on the food chain.

Terrestrial Vegetation

There is considerable concern that fugitive air emissions of various hydrocarbons from refineries and processing facilities as well as production platforms and terminals in Cook Inlet adversely affect air quality. Of more direct concern than air quality itself is the potential impact of aerial fallout from this source on local vegetation and associated fauna. Therefore, limited vegetation and soil monitoring is recommended for the $500,000 and $800,000 programs.

An array of transects should be established in a radial pattern from the "center" of oil-related activities at Nikiski and at Drift River. Semi-permanent stations would be established at fixed distances along each transect, monitored twice each year. At each station the upper-story brush community would be surveyed over a fairly large area and the lower story assemblages would be assessed at several smaller sites within each study area. Soil samples would be obtained from the upper 2 to 3 cm of soil at three locations per site and would be analyzed for the recommended hydrocarbon geochemical markers.

SAMPLING SCHEMES

Although all four elements are recommended to be used at some stations in some programs, the funding levels dictated that the smaller program ($200,000) comprise fewer elements, fewer stations, and fewer surveys than the $500,000 or $800,000 programs.

Sampling is to be conducted once or twice per year (weather permitting) as early as late April and as late as mid September) depending on the program element and the funding level. Similarly 12 to 18 stations would be established throughout Cook Inlet; the actual use would vary according to program element and funding level.

CHAPTER ONE: INTRODUCTION

A. BACKGROUND

Public Law 101-380 (the Oil Pollution Act of 1990, OPA 90) was enacted as a result of the Exxon *Valdez* incident in Prince William Sound and in part established an Oil Terminal and Oil Tanker Environmental Oversight and Monitoring Demonstration Program for Cook Inlet, Alaska. This Program includes a Regional Citizens' Advisory Council (RCAC), which in turn, established: 1) a Terminal and Oil Tanker Operations and Environmental Monitoring Committee, and 2) an Oil Spill Prevention, Safety, and Emergency Response Committee.

The duties of the Environmental Monitoring Committee (EMC) include:

- Advising the Council on a monitoring strategy to permit early detection of environmental impacts from terminal and tanker operations.
- Developing monitoring programs and recommending implementation of them to the Council.
- Selecting and contracting with universities and other scientific institutions to carry out monitoring programs authorized by the Council.

In November 1991, the EMC requested proposals from interested firms to design a comprehensive monitoring program model for Cook Inlet that is consistent with the requirements of OPA 90 (section 5002, P.L. 101-380). In January 1992, MBC Applied Environmental Sciences was awarded the contract. This report constitutes MBC's draft final report for the study.

B. PURPOSE

The general purpose of the project was to design a monitoring program that could be implemented in Cook Inlet; would produce meaningful results that could be utilized by government agencies as either a management or an enforcement tool; and would serve as an alarm mechanism, warning of environmental harm. A "watchdog" program such as this must be designed to detect contamination before concentrations reach levels at which significant biological effects occur.

As stated in the RFP, specific goals of the monitoring program were:

- To examine Cook Inlet at the ecosystem level, both spatially and temporally, and to collect monitoring data as well as baseline information.
- To be capable of detecting chronic oil contamination and impacts (chronic contamination is either the result of continuous or intermittent discharges or from repetitive, accidental spills), and to be capable of measuring toxicity levels and risk in the ecosystem.

- To be comprehensive, including air, water, land, submerged land, and biota; to identify habitats and biota present; and to "prioritize" them on the basis of ecological significance, economic importance, and vulnerability, susceptibility, and/or sensitivity to oil pollution.

- To be cost-effective and to meet or exceed requirements of regulatory compliance.

C. SCOPE AND LIMITATIONS

It is fairly obvious that not all elements of the air, water, land, submerged land, and biota in all areas of the 300 km long Cook Inlet can be monitored with equal vigor on a regular, frequent basis, even with an unlimited budget. The size and complexity of the ecosystem, the available money, and the need for scientific value all impose intrinsic limits on the scale of the monitoring plan, and necessitate prioritizing individual program elements.

1. Geographic Scope

The recommended stations are restricted to Cook Inlet as defined in the RFP. This area includes the public and private properties, beaches, harbors, bays, estuaries and waters in the Cook Inlet watershed drainage. The northernmost portion includes the Matanuska River with its tributaries, while the southernmost boundary of Cook Inlet is the latitude of Amatuli Island (58° 55N) (Figure 1).

2. Environmental Scope

Cook Inlet comprises at least six distinct environments: the air, terrestrial, freshwater streams and rivers, lakes, estuarine, and marine. Each, in turn, includes a diversity of ecologically important components (intertidal, subtidal, and open-water or pelagic in the marine realm, for example), as well as commercial, recreational, and subsistence resources. Since funding for the conduct of the monitoring programs will be limited, the design focussed on those environments most likely to be impacted.

3. Target Contaminants

The RCAC is mandated to monitor potential impacts resulting from the production and transportation of oil (i.e., petroleum hydrocarbons); a scope that is interpreted to include refined product as well as crude oil. Activities associated with natural gas, although sometime difficult to separate from oil-related activities, were clearly excluded from consideration, while discharges of drilling muds and cuttings remain problematic.

4. Limitations Regarding Techniques

Actual and potential impacts to the environment can be measured in a variety of ways. Contamination is commonly measured as input levels at or near the source or accumulations in various compartments (e.g., air, water, and sediments) of the environment as a whole. Another major method is to measure an effect (impact) on the biota: tissue- or organ-level impacts to particular species, sublethal aspects of specific populations, or community-level parameters.

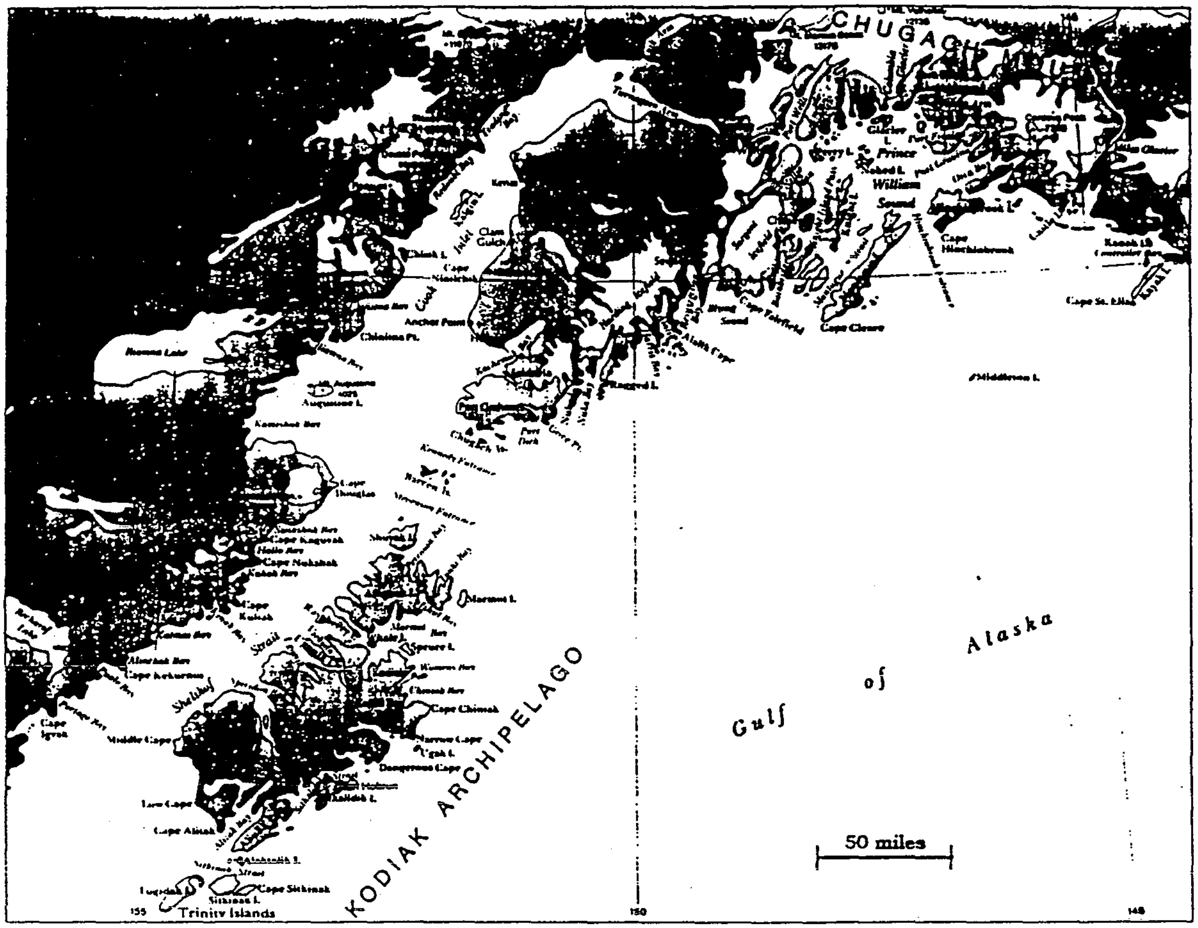

Figure 1. Map of Cook Inlet and surrounding area (from Hood and Zimmerman 1986).

A truly comprehensive, region-wide monitoring program is likely to include a dozen or more separate elements. However, not even an $800,000 per year program would satisfy all concerned parties. Nevertheless, no particular technique or monitoring approach was eliminated *a priori* by the RFP or the study team. All possibilities were considered; those that were eliminated did not meet one or several important criteria.

5. **Logistical Limitations**

Certain limitations are placed on the program design by virtue of the naturally harsh, though diverse environment of the study area. Although a function of budget as well, sampling regularity and frequency are clearly at the mercy of weather much of the time in Cook Inlet. The natural distribution of species in the study area also limits which organisms can be used as test subjects or as indicator species.

6. **Cost Limitations**

The RFP actually imposed the severest limitation on the program design when it assigned potential funding levels of $200,000; $500,000; and $800,000. Although in and of themselves, these are probably reasonable amounts; the former two in particular, limit the scope of work that could be proposed.

D. METHODS

In developing proposed monitoring programs for Cook Inlet, the project team made maximum use of existing information, targeted areas, habitats, and environmental factors most likely to be affected by oil-related activities, and identified monitoring methods that would be appropriate.

1. **General Considerations**

It was necessary first to establish the full range of possibilities (areas, habitats, techniques, frequency, costs, etc.) available and incorporate them into a single large matrix. The recommended approaches and components of the plan were selected to meet the prescribed goals after careful consideration of such factors as:

- Which contaminant is of concern and is to be monitored? What chemical tests are best used to identify them?
- What contaminant transport pathways are of concern?
- What resources are of most concern? Which environments, habitats, and species are most likely to be affected?
- Which habitats are most susceptible and what species are most likely to be impacted?
- What ecological "levels" (i.e., individual organisms, populations, or communities) react most noticeably to the contaminant of concern? Are there particularly useful "indicator" species?

- What techniques should be used? Which combination of method, species, and location is most practical (cost-effective and logistically feasible), and most sensitive for detecting low-level concentrations or lethal/sublethal impacts attributable to oil?

2. Project Tasks

a) Identify and Collect Literature and Data

The first task was to identify, collect, and review all literature and data that might be relevant to the project. The literature and information search included published documents in peer-reviewed and gray sources, unpublished datasets, as well as interviews with personnel (academia, agencies, and consultants) directly involved in similar work. Environmental studies vary widely in their usefulness in designing a monitoring program, ranging from anecdotal recollections of "the way it used to be" to very sophisticated scientific examinations of a small section of the ecosystem.

Information of two sorts was sought: 1) studies describing previous and/or existing conditions and programs in Cook Inlet, and 2) studies describing methods or programs that have been, or are being, used to monitor oil pollution. The information acquired included: general, qualitative inventories by self-named naturalists; quantitative baseline inventories performed by agencies; very detailed, quantitative studies of populations by university researchers; source-, or resource-specific monitoring studies; field studies using standard monitoring approaches; and site-specific effluent monitoring programs as required by state and federal agencies.

b) Rank Alternative Approaches

The literature search and data collection component identified the habitats and resources of concern; the sources and fates of potential contamination; and potential monitoring techniques. After all were compiled, they were "prioritized" in terms of their appropriateness for use in Cook Inlet.

c) Select and Design Program Elements

The potential value of various monitoring program components was measured by several criteria:

- Cost-effectiveness -- producing the most and best data for the least possible money.

- Scientific soundness and statistical robustness.

- Feasibility -- considering the diverse, yet harsh environment of the study area.

Specific techniques were selected primarily on the basis of the sensitivity of the method for detecting petroleum hydrocarbons in the environment. Station locations were selected to represent habitats of concern in susceptible areas.

d) Estimate Costs by Element and Program

In the final analysis, potential funding levels were probably the most important consideration. As each method was identified, the cost to obtain even qualitative information was estimated for each and the total budget divided by the total cost for several elements at one station decided how many stations could be sampled.

E. ORGANIZATION OF THE REPORT

This report includes six chapters in addition to the Introduction:

Chapter Two briefly describes the physical and biological (natural resources) setting of the study area, and Chapter Three summarizes the nature and location of petroleum-related activities in Cook Inlet, i.e., the potential source of chronic oil pollution.

Chapter Four discusses the various kinds of monitoring elements that could be considered for use in a monitoring program, while Chapter Five evaluates criteria for selection or elimination of elements into the proposed programs.

Chapter Six describes the three proposed programs, including station locations and estimated costs by element for each monitoring program, and suggests additional considerations for incorporation into the final program design.

CHAPTER TWO: THE EXISTING ENVIRONMENT

There are numerous different habitats within Cook Inlet and nearby coastal areas. Oceanographically, the marine environment varies daily due to the 30 to 40 foot tidal exchange, which may produce currents as fast as 12 kn during tidal bores. During winter, the Inlet is affected by low air temperature and the formation of sea ice; in spring, low salinity and high turbidity result from river flow and glacial melt. Overall, Cook Inlet is an area of considerable spatial and temporal variability depending on changes in weather and oceanographic conditions.

A. THE PHYSICAL ENVIRONMENTS

Because the Cook Inlet monitoring program is intended to be comprehensive, the air, terrestrial, freshwater, and marine (including estuaries, shores, subtidal, and water column) environments all had to be considered. However, because of cost restrictions imposed on both the design and implementation of the monitoring program, it was necessary to balance spatial and temporal coverage and scientific soundness against funding in order to obtain the most cost-effective program.

1. **Air** -- The air, while not a habitat *per se*, is an important medium involved in the transport and deposition of many contaminants. Aerial pollution around Cook Inlet includes pollution produced by processing facilities; airborne wastes from well head operations, gas flares and power generating turbines; and non-point fugitive wastes from a variety of oil-related activities. The contaminants carried by air masses will eventually be deposited in terrestrial, marine, or freshwater systems.

2. **Terrestrial** -- The terrestrial environment is a potential sink for contamination from spills and leaks at shore-based facilities as well as from airborne pollutants. Contaminants may be especially persistent in terrestrial systems where runoff is limited. Contaminants that accumulate in the soil could be taken up by organisms at the base of the food chain thereby affecting the entire biotic community.

3. **Freshwater** -- Freshwater systems are vulnerable to pollutants from a variety of sources. Lakes and rivers serve as a potential sink for contaminants from direct contact with aerial and point sources of pollution, as well as from drainage of the terrestrial environment. Terrestrial runoff also serves as a means of transporting pollutants to the ocean.

4. **Marine** -- The great marine water mass and associated resources that define Cook Inlet to most persons is the environment of major concern. Like the air, this environment is a medium for transport of oil-related pollution and it is ultimately the major sink for contaminants of all sorts.

B. DISTRIBUTION OF PHYSICAL HABITATS

Cook Inlet is a region of a wide diversity of habitats including rocky outcroppings, boulder fields, pocket beaches of gravel and cobble, mudflats and salt marshes, eelgrass beds and kelp beds. The basic geological substrate type within these habitats is rock, sand, mud, or mixed. Protected habitats composed primarily of unconsolidated sediments dominate the coastline (Lees 1978, O'Clair and Zimmerman 1988); 38% of Cook Inlet is embayed shorelines, and 28% is low rock scarps (Michel *et al.* 1981, Hayes *et al.* 1976)

The shoreline in most of Upper Cook Inlet consists of depositional coasts, offshore of which sedimentary materials (soft-bottoms) predominate. Intertidally, mudflats and saltmarshes extend from the Forelands to the ends of Knik and Turnagain Arms.

In lower Cook Inlet, because of the counterclockwise circulation pattern and swift currents within the Inlet, there is an obvious dissimilarity between the physical characteristics of habitats on the eastern versus the western side. With the exception of Kachemak Bay, the eastern shores are primarily gravel and cobble with pocket beaches interspersed with rocky outcroppings. Mudflats are found at the head of most embayments. The shallow and deep (> 25 m) subtidal habitats offshore are largely soft material. In contrast, the west side of the Inlet is dominated by sand beaches that are found along sections of the coast that are more exposed. As on the east side, mudflats occur in the embayments. The subtidal habitats offshore are largely cobble and rock (Lees 1978).

C. BIOLOGICAL RESOURCES

Associated with each habitat is a characteristic and sometimes unique assemblage of biotic resources. Some of these have commercial or recreational importance; others are valuable to humans primarily for aesthetic or scientific worth; while some are simply, but still importantly, integral parts of the ecosystem.

Most of the oil production, processing, and shipment activities are in or adjacent to the marine environment so that impacts from both small, chronic leaks and from any large, catastrophic spill are likely to be more pronounced in the marine habitats and resources. To a lesser degree, terrestrial habitats adjacent to onshore facilities such as refineries are also likely to be impacted as there are also fugitive hydrocarbon emissions that undoubtedly settle out over land and contaminate both terrestrial and freshwater habitats.

A diverse array of organisms inhabit the marine and terrestrial regions of Cook Inlet and thus have the potential to be directly and indirectly exposed to (and impacted by) chronic oil pollution. A partial list of the important marine and terrestrial resources of Cook Inlet includes:

- Marine Mammals - cetaceans, pinnipeds, and otters
- Marine and Shorebirds - both migratory and resident species
- Fish such as salmon, herring, halibut, and other flatfish

- King, tanner, and Cancer crabs
- Shrimp - pink, sidestripe, coonstripe, and spot
- Razor, littleneck, and soft-shell clams
- Intertidal Assemblages - fucus, barnacles, and mussels,
- Subtidal Assemblages - hard-bottom epifauna and soft-bottom infauna
- Ecologically important habitats such as fish spawning and nursery grounds, eelgrass beds, saltmarshes, kelp beds
- Lakes and riparian habitats
- Coniferous forests and associated flora and fauna

The diverse landscape and abundant food supply in the Cook Inlet area supports a wide variety of marine, freshwater and terrestrial animals that have important ecological, aesthetic, and economic value (Figure 2A). Among the marine mammals found in Cook Inlet, the sea otter (*Enhydra lutris*) is one of the most obvious (Figure 2A). Sea otters are found throughout lower Cook Inlet with the highest concentrations in Kamishak and Kachemak Bays and at the Barren Islands.

Stellar sea lions (*Eumetopias jubatus*) and harbor seals (*Phoca vitulina*) also occur in the Inlet (Figure 2A). Harbor seals are found most frequently in Kachemak Bay, along the western coast of the Inlet and in northern Lower Cook Inlet near Kalgin Island. Stellar sea lions are not as populous as harbor seals in Cook Inlet but one of the major rookeries in the Gulf of Alaska is on the Barren Islands.

Of the seven species of cetaceans that have been recorded in Cook Inlet the harbor porpoise (*Phocoena*), Dall porpoise (*Phocoemoides dalli*), minke whale (*Balaemoptera acutorostrata*), and beluga whale (*Delphinapterus leucas*) have been reported in large numbers. The beluga whale is the only cetacean known to occupy the Inlet year-round and is most frequently sighted near Kalgin Island in the northern part of Lower Cook Inlet (Figure 2A).

Several species of terrestrial mammals forage along the Cook Inlet coast line (Figure 2A). Brown bears (*Ursus arctos*) are common along the west shore, especially near stream mouths. Black bears (*U. americanus*) tend to use the shoreline only in the forested regions; they are common north of Tuxedni Bay and east of the city of Nikiski. A variety of other mammals occupy the coastal habitats around Cook Inlet including river otters, moose, and red and arctic foxes.

The extensive system of marine and freshwater habitats and resources in and around Cook Inlet supports a diverse avifauna (Figure 2A). A variety of loons, grebes, cormorants, raptors, gulls, alcids, and passerines are resident to the Inlet. In addition major waterfowl breeding areas for geese and some species of migratory shorebirds, are found on western Cook Inlet north of Kalgin Island and in Kachemak Bay.

Ecologically and economically important demersal, pelagic, and anadromous fishes are found throughout Cook Inlet depending on weather conditions and the time of year

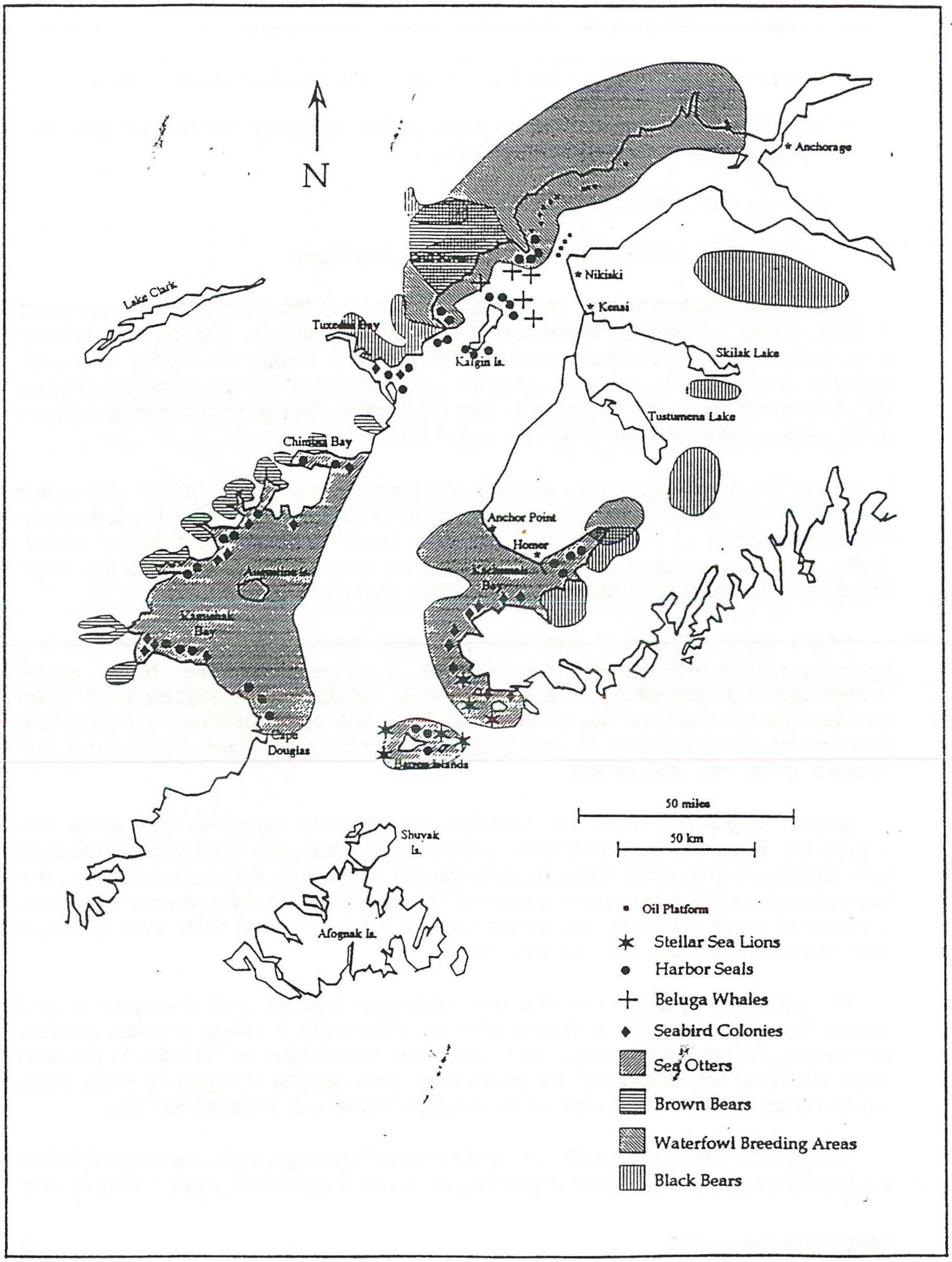

Figure 2A. Distribution of highest concentrations of important mammals, seabirds, and waterfowl in Cook Inlet.

(Figure 2B). Several species of salmon are found in the area in spring and early summer including steelhead (*Salmo gairdneri*), sockeye (*Oncorhynchus nerka*), chum (*O. keta*), chinook (*O. tshawytscha*), coho (*O. kisutch*) and pink salmon (*O. gorbuscha*). These species are most commonly found associated with the Sustitna, Kenai, and Kasilof River systems, although all suitable streams and river systems are used by spawning salmonids. In lower Cook Inlet, Dolly Varden (*Salvelinus malma*) are most numerous in nearshore areas especially on the east side of the Inlet.

Among the flatfish species, yellowfin sole (*Limanda aspera*) are most abundant east and southeast of Augustine Island while starry flounder (*Platichthys stellatus*) and Pacific halibut (*Hippoglossus stenolepis*) are most abundant on the west side of the Inlet, especially in Kamishak Bay (Figure 2B).

Walleye pollock (*Theragra chalcogramma*) and Saffron cod (*Eleginus gracilis*) are abundant throughout Lower Cook Inlet (Figure 2B). Pollock are particularly abundant in deeper waters south of Augustine Island while cod are most common in the coastal zone from Cape Ninilchick to the East Forelands.

Pacific herring (*Clupea harengus pallasi*) are seasonally abundant in the nearshore area with highest concentrations in Kachemak and Kamishak Bays (Figure 2B). Longfin smelt (*Spirinchus thaleichthys*) are found only in the nearshore zone from northern Ninilchick to the Forelands; they are known to spawn in the Kenai River. Capelin (*Mallotus villosus*) are most abundant in the west side of the Inlet, particularly in Kamishak Bay.

A variety of shrimp (pandalids) are found throughout lower Cook Inlet (Figure 2C). Among the commercially important shrimp species, coonstripe (*Pandalus hyspinotus*), pink (*P. borealis*), humpy (*P. goniuris*) and sidestripe (*Pandalopsis dispar*) shrimp are most abundant in Kachemak Bay. Spot shrimp (*Pandalus platyceros*) are most abundant in Kamishak Bay north of Augustine Island.

Several species of economically important crab species are found throughout Cook Inlet (Figure 2C). King crab (*Paralithodes camtschatica*) and tanner crab (*Chionecetes bairdi*) are found throughout the Inlet south of Anchor point. The most critical habitats for these species is in deep water midway between Augustine Island and the Barren Islands. Dungeness crabs (*Cancer magister*) are found in shallow areas in southern Cook Inlet with the densest concentrations off Anchor Point near Kachemak Bay.

Razor clams (*Siliqua patula*) are found on sandy beaches throughout Lower Cook Inlet with highest concentrations at Polly Creek north of Chinitna Bay on the west coast of the Inlet and from Anchor Point to Cape Kasilof on the east coast (Figure 2C). Hardshell clams are abundant throughout Lower Cook Inlet, particularly on the eastern shore from the Kenai River south.

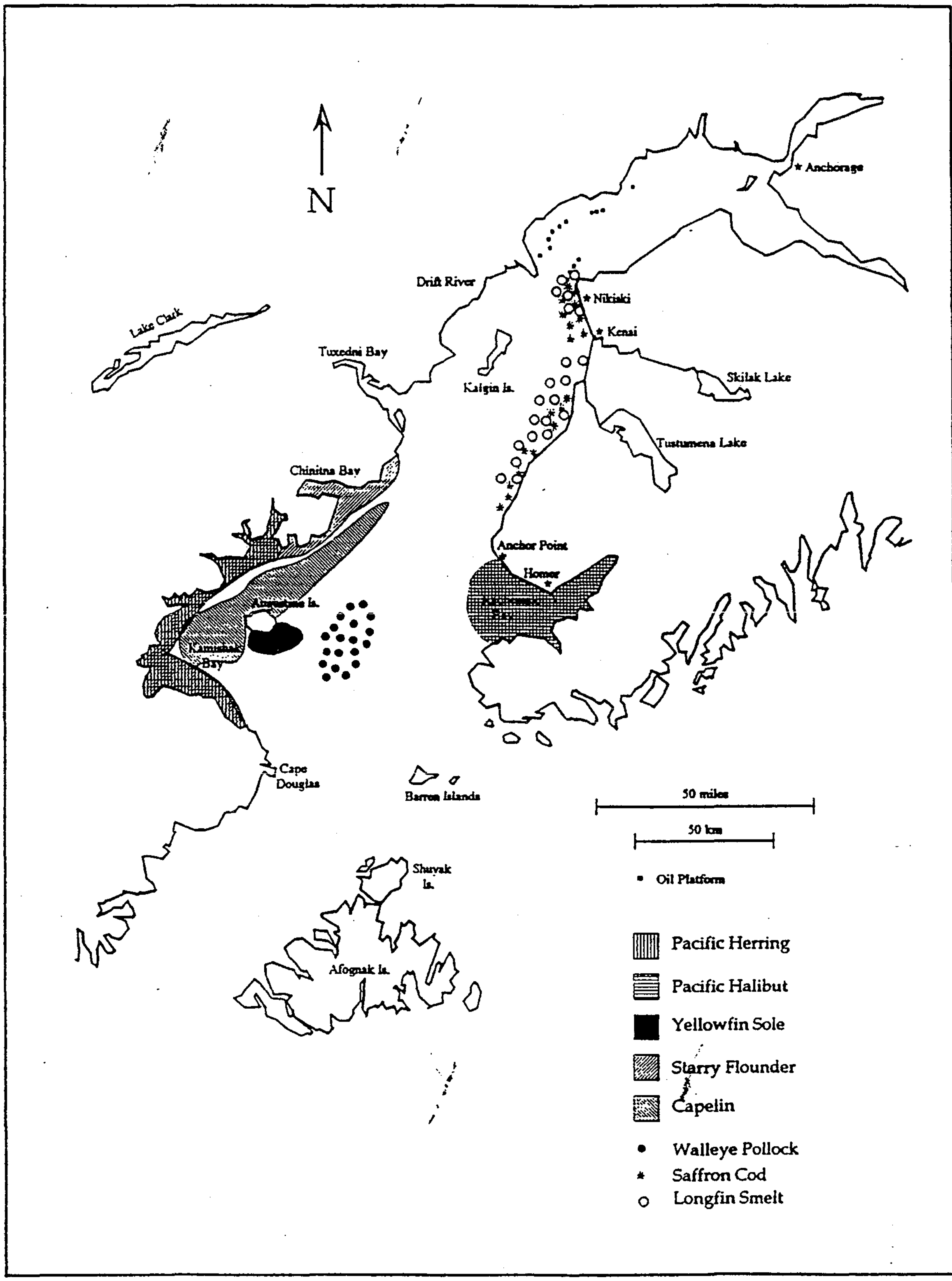

Figure 2B. Distribution of highest concentrations of important fishes in Cook Inlet.

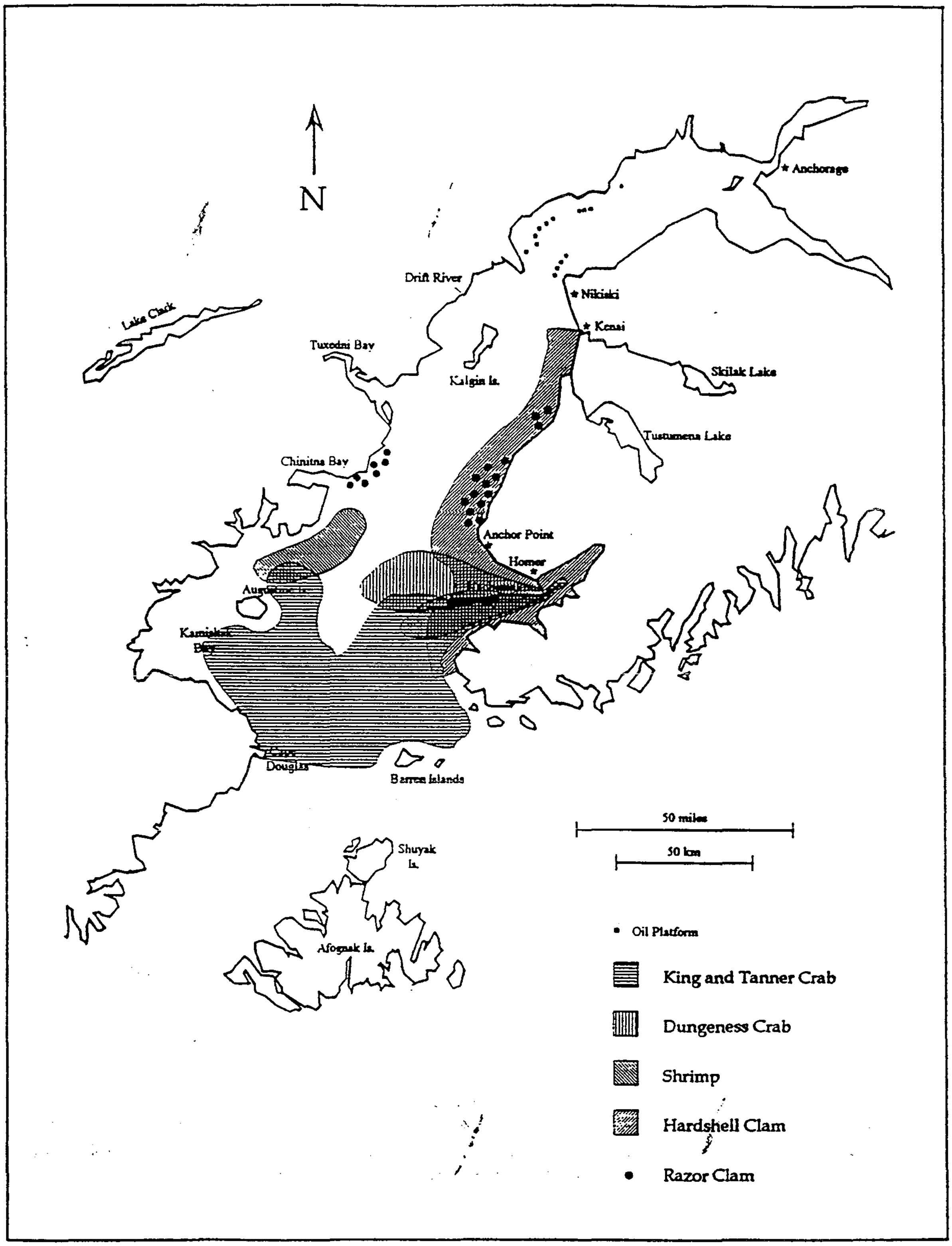

Figure 2C. Distribution of highest concentrations of commercial shellfish in Cook Inlet.

CHAPTER THREE: PETROLEUM CONTAMINANTS

The presence of oil and natural gas in Cook Inlet has long been known. Native Alaskans reportedly used pitch from natural oil seeps to fuel their stone lanterns. Russian colonists were aware of oil and gas seeps on the west shore of Cook Inlet, near the Iniskin Peninsula, and in 1892, a prospector named Edelman staked claims to these seeps.

Actual drilling of wells for oil began in 1892 in the Iniskin area, and a wildcat well first "came in" at Oil Bay. Commercial quantities of recoverable oil were discovered on the Kenai Peninsula in 1957, and by 1959, three production wells were operating. By the late 1960s, five fields in the Kenai-Cook Inlet area were producing oil and nine fields were producing natural gas. The first offshore exploration took place in 1959 and offshore fields were producing by 1968. Production has expanded considerably since 1970 and exploratory drilling continues.

A. SOURCES OF CONTAMINATION

Petroleum hydrocarbon and trace metal contamination of the continental shelf waters derive from a variety of oil-related activities. If untreated, routine discharges of drilling fluids, cuttings and produced water from oil and gas wells can contribute significantly to the mass input of hydrocarbons. Discharges of bilge, ballast, and cleaning waters from vessels, as well as discharges of industrial and municipal effluents, river flow from inland sources, and natural oil seeps also add to the chronic input of hydrocarbons to coastal waters.

Cook Inlet has a long history of chronic exposure to crude oil arising from both production and transfer operations. In 1970, the total mass emission was estimated to be 9,500 to 17,500 bbls (*** gallons) per year. The major sources of chronic oil pollution to Cook Inlet include oil production, refinery operations, transshipment, and process water disposal (Figure 3).

1. Oil Production Activities

At present, there are approximately ** active oil production wells in Cook Inlet, ** of which are located on land, both on the Kenai Peninsula and in fields on the western foreshore areas opposite Kenai. The 14 offshore oil production platforms support a total of ** production wells.

As indicated in Figure 3, most oil production wells are located on land near or offshore of the Forelands in central Cook Inlet. To date, approximately ** bbls of crude oil and ** cubic feet of natural gas have been produced in Cook Inlet and transported out of the area. At present, (19** to 19**) production of crude oil from Cook Inlet averages bbls (x42 gallons) per day or *** (x42 gallons) annually.

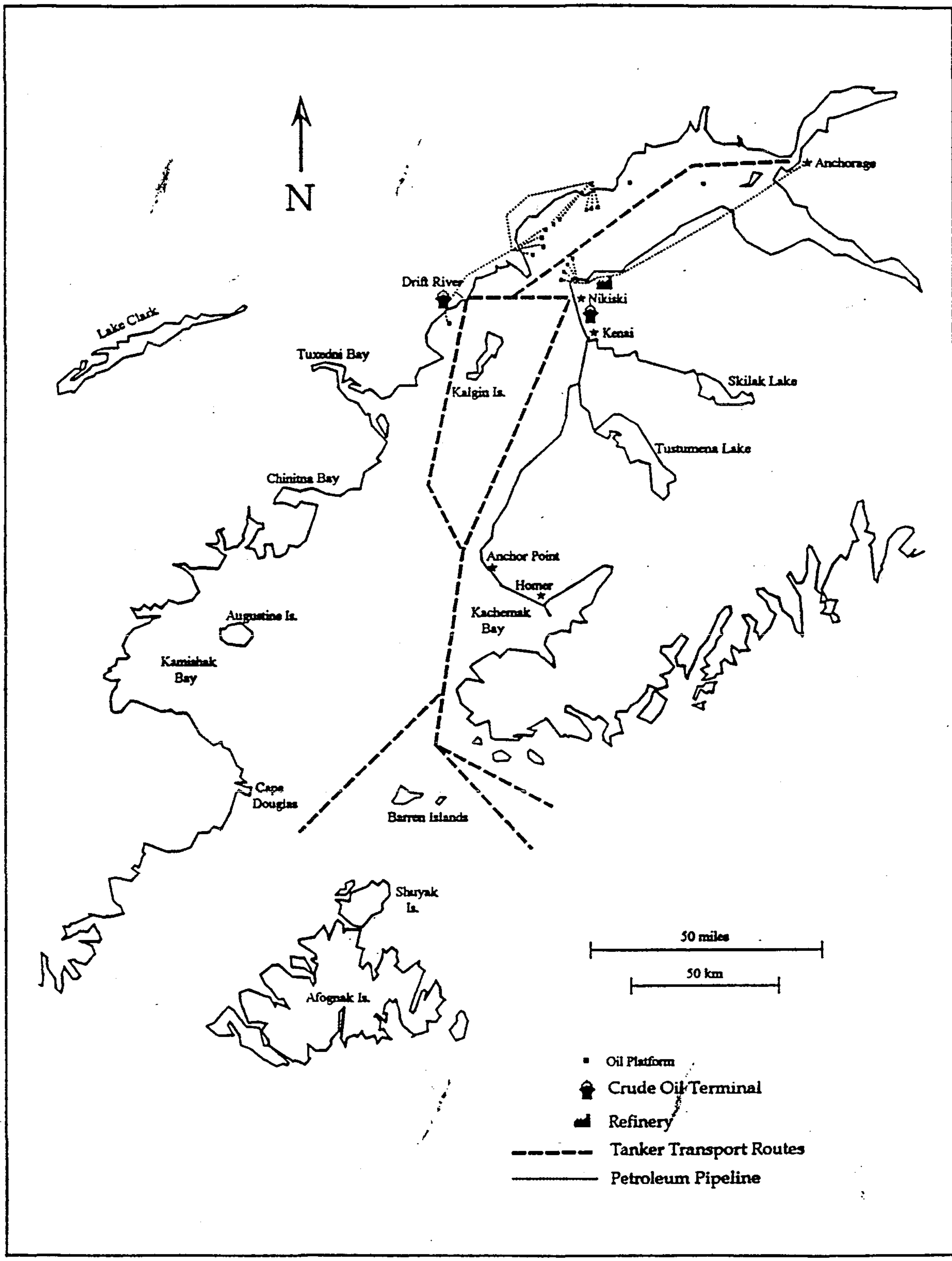

Figure 3. Locations of potential sources of chronic pollution from oil-related operations facilities in Cook Inlet.

2. Terminal Operations

There are marine terminals at Nikiski and Drift River (Figure 3). Annual throughput has averaged **

Small spills and leaks are undoubtedly common during transfer operations (connecting and disconnecting hoses and pipes), and collectively may contribute substantially to total hydrocarbon input to the Inlet.

The discharge of untreated ballast and/or bilge water directly to Cook Inlet is prohibited, yet the discharge of treated water is permissible. (It is regulated and monitored by DEC.) This water contains low levels of petroleum compounds.

3. Refinery Operations

The facilities at Nikiski refine crude oil into a variety of products, including diesel oil, jet fuel, gasoline, propane, and butane (Entropy 1989). The Tesoro facility is the only active refinery in the Nikiski area (Figure 3). It processes crude oil both from Cook Inlet and the North Slope and has a production capacity of *** bbls/day. Previously, the Chevron refinery processed only North Slope crude and had a production capacity of 18,000 bbls/day; however, the refinery closed in June 1991. The Tesoro facility produces air pollution of several types.

The emissions released from the stacks following crude oil refinement include nitrogen and sulfur oxides, carbon monoxide, chloroform, formaldehyde, and tons of particulate matter. Waste oil burning releases lead, polycyclic aromatics, chromium and cadmium into the atmosphere. In addition, fugitive emissions from nonpoint sources include benzene, xylene, ethylbenzene, and naphthalene. Aerial fallout of hydrocarbons originating from the refineries may be deposited directly to the surface of Cook Inlet during offshore wind conditions, or may be deposited on land when the prevailing wind is onshore. Less than half of the pollutants are regulated and little is known about the impacts of air pollutants on the environment.

In addition to air pollution, the facilities at Nikiski generate millions of gallons of wastewater annually. The majority of the waste is discharged directly into Cook Inlet, but wastewater also contaminates groundwater under the facilities (Entropy 1989).

4. Tankering Activities

The transport of petroleum by tanker in Cook Inlet includes two components: the import of North Slope crude and the export of refined product.

Tankers generally follow shipping lanes down the center of Cook Inlet except when approaching or departing a terminal (Figure 3).

5. Process Water Disposal

Approximately ** percent of the "oil" extracted from wells in Cook Inlet is actually formation water which is separated from the oil and any gas to produce crude oil. In the process of extracting and the production of Cook Inlet crude oil, approximately ** bbls of production water has resulted; annual amounts of production water

Typically this production water is either re-injected into the formation or it may be discharged.

Of the ** bbls of process water produced, approximately ** % are returned to the formations via ** injection wells; ** % are treated and discharged to the surface waters of Cook Inlet.

Permits allow the discharge of certain amounts of treated process water.

Both injection wells and treated water discharges are permitted by ... in terms of amounts and effluent quality. Thus, approximately ** bbls have been discharged to Cook Inlet without treatment beyond the initial separation.

6. Miscellaneous Sources

Persistent leaks may characterize all or most of the older land and submarine pipelines which cross Cook Inlet and the Kenai Peninsula (Figure 3).

Prince William Sound probably serves as a source of many water-borne substances which enter Cook Inlet on north-bound currents through Kennedy and Stevenson entrances

Also aerial fallout directly to the sea surface.

River run-off of contaminants deposited on land and freshwater.

Collectively, the small "nuisance" wastes from the above sources constitute the major "unknown, but potentially significant source of chronic oil contamination.

B. FATE OF OIL CONTAMINATION

The impacts of concern are those associated with oil exploration, production, refinement, and transporting activities. Both chronic inputs/influx and catastrophic spills occur in a particular area in proportion to the level of oil-related activities of that area. Generally, the likelihood of impacts to habitats and resources is greater the closer they are to the source. However, wind and ocean currents do carry both large and small oil spills away from the source. And while dilution reduces the concentration, dispersion spreads the potential over larger areas.

The fate of oil in the environment is a function of local winds, currents, and the prevalence of depositional environments. Historical observations of contaminant levels may confirm predictions and help to predict where future oil might go. Contaminant levels are commonly measured in three or four compartments of the environment: air, water, sediment, soil, and tissue. Therefore, knowledge of where low-level, chronic fugitive oil goes is needed to effectively locate sampling stations.

1. Marine Habitats

While the fate of large surface oil spills is largely a function of wind- and tidally induced currents immediately following the incident, the fate of low-level, chronic leaks is more likely to be determined by persistent currents and prevailing wind patterns in the area.

The general surface circulation pattern in Cook Inlet consists of a counterclockwise gyre. Seawater enters lower Cook Inlet from the Gulf of Alaska through Kennedy and Stevenson entrances, and moves northeast along the western shore of the Kenai Peninsula. Outward currents in upper Cook Inlet are primarily along the northwest shore and are supplemented by river flow and glacial melt. At about the Forelands, most of the main water mass turns west and is joined by water from upper Cook Inlet. This water continues southwest along the western side of the Inlet, around Augustine Island, through Kamishak Bay, and past Cape Douglas into Shelikov Strait.

The currents in Cook Inlet result in transport of material out of Cook Inlet. There is a net inward movement of oceanic water and suspended material along the eastern shore and a net outward movement of mixed oceanic and runoff water with suspended matter along the western shore. Thus, the bulk of suspended mud and any residual fugitive oil settles out of suspension (as current speeds diminish) along the western shore and throughout Shelikof Strait.

2. Terrestrial

In the terrestrial environment, deposition and accumulation of contaminants is dependent on the extent of the pollutants entering the atmosphere and the wind patterns that disperse them. In the Cook Inlet area, the predominant winds vary seasonally. A north- northeasterly wind dominates from September through April, while from May through mid-September a south- to south-southwesterly influence dominates (Entropy 1989). This suggests that pollutants from the Tesoro refinery are distributed onto the terrestrial environment of Kenai Peninsula only during winter. However, pollutants distributed on snow-pack will be absorbed into the soil or carried to Cook Inlet during spring runoff.

CHAPTER FOUR: MONITORING TECHNIQUES

Low-level but continuous pollution, as from refinery effluents, may cause progressive environmental deterioration, which may be slower to appear but is no less destructive than spectacular accidents (Mann and Clark 1978). The chronic effects of oil pollution are of concern because they are insidious and potentially long-term. Because ecosystems are complex, open, and dynamic, there are fundamental problems in identifying the nature and extent of any oil-related environmental effects, especially in establishing causality. A program to monitor chronic and low-level oil pollution must be especially well thought out, comprehensive, and planned to address the appropriate (sensitive) conditions, contaminants, and organisms.

A. GENERAL CONSIDERATIONS

Relatively few monitoring studies have been conducted in Cook Inlet, although numerous related studies have been done in the region and nearby. Most of these, however, are site-, source- (e.g., NPDES monitoring at point discharges), or incident-specific (e.g., studies following the Exxon *Valdez* spill) studies or are very general and out of date (e.g., Feder studies of the benthos of lower Cook Inlet). According to Cowell and Monk (1981), ecological monitoring throughout Alaska is hampered by a lack of understanding of the essential processes of the ecosystem, lack of data relating to temporal and spatial variations in the populations, and incomplete knowledge of the biology and taxonomy of some species.

The aim of the present project was to identify all potential sampling techniques that have been used to describe interactions between the existing environment and any small, chronic or large, acute contamination events. Thus, techniques to be considered included those from on-going or historical studies in Cook Inlet as well as "proven" techniques employed anywhere else in the world.

Environmental monitoring programs are based on a series of repetitive measurements designed to detect changes from the present state and to identify specific impacts (e.g., to the biological community) as a result of those changes. Ideally then, a monitoring program involves measuring physical, chemical, and biological variables in order to predict environmental impacts.

Baseline data are a prerequisite to any monitoring study since impacts can only be detected as departures from the "unimpacted" state. It is not the purpose of the proposed project, however, to study everything and specifically establish a baseline, although a baseline is automatically generated as monitoring is conducted.

Oil-related activities and chronic, low-level oil pollution have been a part of Cook Inlet for several decades; it is not possible to establish now what conditions were like in 1950. Natural oil seeps are actually a part of the pristine background. Thus, the first survey of the proposed monitoring program will constitute the new baseline. As monitoring is repeated, a better, more complete baseline will result because annual variation and spatial differences will be better documented.

In addition to being an integral part of the monitoring program, this baseline dataset will be useful in the event of a disaster or major disturbance, such as a large oil spill, because pre-event conditions will have been established.

The proposed monitoring program focuses on identifying chronic, low-level oil-related contaminants in the environment, documenting biological impacts that might result from them, and "tracking" the impacts through space and time. This kind of anticipatory monitoring is totally unlike compliance monitoring, such as an NPDES effluent monitoring program, which measures the environmental concentrations of substances known or assumed to be present.

B. MONITORING TECHNIQUES

It is important to distinguish two very different types of monitoring approaches: those that measure contaminant levels, and those that measure contaminant effects. Measurements of contaminant levels only indicate if the habitat (or species) is polluted; measurement of changes in biological parameters indicate whether there is an adverse effect from the pollution.

Environmental Levels

Although the absolute levels of contaminants are usually of less concern than the adverse impacts, direct measurement of contaminants in the environment is in effect the most sensitive monitoring tool available. Sophisticated chemical analyses can detect the environmental levels of potential contaminants at or below natural background (i.e., unpolluted) concentrations. Importantly, these analyses can be used to measure changes in concentrations over time, thus providing a warning system if contamination levels approach a threshold at which they may cause an adverse effect.

Air - The concentration of most contaminants in air is very low, despite the very strong odor associated with some air pollutants. Measurements of air quality are important for general, area-wide aesthetic considerations and for human health.

Monitoring of hydrocarbons in air is likely to be prohibitively expensive, given that stations would have to be located at several locations and in many directions from the potential source. Generally, for air-quality purposes, measurements are taken close to the source as an indication of mass emissions, rather than air quality downwind where dispersion has diluted levels. At locations near multiple sources, the presence of contaminants may be detectable, although the actual point source may not be discernable, again because of dispersion.

Water - Much the same is true for contaminants dissolved in water (fresh or marine) as for chemical compounds in air. Mass emissions can be estimated from measurements at known point sources, but dilution is usually so marked that it is difficult (i.e., very costly and time consuming) to measure contaminants in the water away from the source. Many, if not most, contaminants, including petroleum, are not readily dissolved in water; they bind to suspended organic and inorganic particles, which can be filtered from a large quantity of water to obtain a measure of contaminants in solution.

Sediments and Soil - Because "what goes up, must come down", organic and inorganic particles suspended in air or water (as well as any contaminants bound to them) eventually settle out in marine sediments or terrestrial soils. The seafloor in particular is regarded as the ultimate sink for most kinds of pollutants. As a result, compounds tend to accumulate within this "medium" and this increases detectability.

Tissue - Most, if not all, organisms accumulate some pollutants in their body tissues. The pollutant itself may enter the organism directly through the body surface or indirectly via the digestive process. In either event (if the pollutant is not lethal or debilitating), tissue concentrations may, over time, be several or many times what they are in the food item or in the environment.

Although elevated body burden levels are frequently interpreted as an adverse effect, this is not necessarily the case. The pollutant may actually be sequestered physically or chemically so that it does not interfere with the species' normal metabolism. Nevertheless, a species' ability to bioconcentrate dilute pollutants is an effective tool for detecting lower levels of environmental pollution; elevated body burden levels suggest that there is an increased potential for biological impacts, lethal of sublethal.

Environmental Effects

High levels of pollutants in the environment are not necessarily hazardous to organisms or human health, and elevated body-burden levels do not necessarily imply an effect on the biota. However, high concentrations of contaminants in the environment or the organism coupled with adverse effects on the biota may provide the link between cause and effect.

Within this "biological effects" category, both sublethal and lethal effects can be measured. Both require extensive and representative sampling of the target species in natural, though presumably polluted, environments.

Sublethal effects are considered to be measures of biological "stress". They are an indication of the impaired "health" of the organisms in question. Sublethal effects studies aim at identifying morphological, physiological, biochemical, or behavioral changes in individual organisms or species. Changes in epifaunal and infaunal populations and recruitment rates are also examined.

Sublethal effects generally have subtle consequences to populations of exposed species. However, the possibility does exist for these consequences to become more conspicuous and no longer sublethal. For instance, sublethal effects due to exposure to oil, such as locomotory impairment, could result in increased predation on the effected individuals and therefore increase mortality as an indirect result of oil pollution. In the terrestrial environment air pollution may weaken plants and make them more susceptible to insect infestation and disease. Prolonged exposure to contaminants at sublethal levels could ultimately affect populations and community structure dynamics.

Lethal effects due to oil contamination are obviously those ultimately associated with the death of an organism, and thus are quantified in terms of mortality rates. They may be more pronounced in some organisms, depending on the type and extent of oil-contamination involved, the amount of exposure to the contamination, and the organism's sensitivity to the oil-related toxins.

Oil pollution can induce lethal effects in many different life stages of many different organisms. The aftermaths of recent oil spills have shown this to be the case. However, in general, oil contamination (both acute and chronic) is more detrimental to the larval stages of organisms. For example, the planktonic larval forms of many crustaceans, such as commercially important crab and shrimp, are extremely sensitive and are, in fact, killed by exposure to low concentrations of oil, including Cook Inlet crude oil (Rice *et al*. 1976, Feder 1980).

C. TECHNIQUES AT VARIOUS ORGANISM LEVELS

Both sublethal and lethal effects may be measured at one or all of several organism levels.

Individuals of a species or population may be examined for histological changes; mutagenic responses such as the growth of tumors; physiological changes such as locomotory impairment or chemosensory dysfunction; reproductive impairment as indicated by reduced fecundity; or changes in physiology as indicated by respiration rates or metabolism.

The lethal impact of pollution can be assessed in entire **populations** by measuring mortality rates, changes in population size, and/or changes in population structure, such as different adult: juvenile ratios, through time.

Community level assessments address changes in the population size of several species within a given area. A decrease in species abundance over time is generally thought to be an adverse impact, yet both increases and decreases will affect community structure.

D. TECHNIQUES BY HABITATS

Whether discharged into the air, or at, below, or above the surface of the ocean, petroleum and petroleum byproducts are generally dispersed along four major pathways: air, ocean surface to shore (intertidal), into solution (picked up by sediment or organisms), and "fall out", which becomes part of the sediment/soil. Likewise, the target contaminants and/or organisms (individuals, populations, or communities) may be studied in any of the habitats influenced by these pathways.

CHAPTER FIVE: EVALUATION OF PROGRAM ELEMENTS

The criteria utilized in selecting the recommended program elements included: those implicit in the scientific purpose of the monitoring program; those explicit in the terms of the RFP and mandate of the CIRCAC; and those dictated by logistical considerations such as geography, oceanography, weather, and availability of samples. These are discussed in greater detail in the appropriate sections.

Although the ultimate aim of the project was to select **for** appropriate techniques and targets (resources and areas), in actual fact, the process was one of selecting **against** certain elements. By eliminating those which were judged to be inappropriate for one reason or another, the investigators were able to concentrate on designing practical sampling programs.

A. ELEMENTS NOT RECOMMENDED

The following elements were eliminated categorically from further consideration; they would only be considered if manpower and funds were almost limitless, and the recommended programs were already being conducted.

1. **Contaminants**

- detailed chemical analysis of all oil-related pollution

Using workable "finger-printing" techniques to obtain the maximum detailed compositional information , it is possible and sometimes desireable to analyze all environmental oil to as to the precise composition and source. However, for this proposed program, the per sample cost was determined to be so high that it was immediately judged to be impractical.

- monitoring of drilling fluids and muds

No accumulations of drilling materials/discharges have been observed in the area of offshore platforms in Cook Inlet (Dames and Moore 1978a) The swift currents of the region rapidly disperse and dilute the slurry of solid particles within a short distance from the source, therefore sampling for accumulations of barium, vanadium, and other inorganic markers of contamination due to drilling fluids/muds is rather pointless.

In addition, benthic studies from the region indicate that because of the rapid dispersion and dilution rates, drilling fluids/muds have reduced impact to the marine biota. For example, pink salmon fry, shrimp, and hermit crabs suspended in live boxes downstream of the platforms did not die nor did they show sublethal effects attributable to the drilling fluids/muds even at 100m, 200m and 1000m downstream (Neff 1987)

According to Rice *et al.* 1984. (NOAA document), drilling fluids/muds are probably not as toxic to such things as planktonic larvae as the water-soluble fractions of oil. Therefore, based on the conditions of the oceanographic conditions of the region and the information from previous toxicity studies, it was deemed not cost-effective nor productive to sample this type of environmental contaminant.

2. **Environments and Habitats**

- water column chemistry

Given the strong currents and tidal flushing in the region, inputs of pollution in the water column are not present for any length of time at all. Therefore, sampling only once a year is not likely to detect even chronic, low-level contamination.

- air quality (chemistry)

As with the water column, dispersion and dilution of chronic pollution is too great to be detected with annual sampling.

- freshwater streams and lakes

Although these habitats are susceptible to receiving aerial fallout and/or contamination from spills on land, it is not possible to include them in this particular monitoring program given the budgetary constraints

- deep-water channels

Based on cost restrictions and the element-specific criteria/considerations evaluated (e.g., resources present, vulnerability to chronic oil pollution, likelihood of detecting chronic pollutants, accessibility of the habitat) deep areas of the Inlet, although possible repositories of oil contamination, are not recommended for inclusion in the program.

- kelp beds

Despite the ecological importance of kelp, it was deemed impractical to allocate funds to sample this habitat for low-level contamination. Because depositional areas tend to accumulate chronic oil contaminants, the proposed programs allocate most funds for sampling these areas. Kelps are usually associated with hard (rock or cobble) substrate and although adjacent areas may have soft sediments, the likelihood of hydrocarbons accumulating in the kelp beds themselves is low. Kelps and other marine algae, may become coated with oil but they do not incorporate oil into tissues, thus do not provide an internal record of chronic oil contamination.

In addition, as with most natural populations, temporal and spatial variability can be substantial, therefore changes in the presence-absence of kelp and organisms associated with the kelp beds, increases or decreases in the size of the beds, cyclic fluctuations, and changes in the overall "health" of the kelp beds cannot be directly attributable to chronic oil pollution unless intensive sampling takes place. This, of course, is extremely costly and again, not recommended for this particular program.

3. Species

Perhaps the most difficult idea to "sell" to the average concerned citizen is the fact that we do not propose to study the plants and animals of most direct concern and interest to them, whether from a subsistence, sport or commercial fishing standpoint or for aesthetic reasons. The simple fact is, however, that the species of most direct importance or concern are not usually the most tractable for monitoring purposes. Thus, although marine mammals, birds, and fisheries species are "most important" to a wide range of local citizens, these were not seriously considered for one or a combination of several factors.

- transient; i.e., non-resident species

Many important species do not spend their entire lifetime within the Inlet. For example, birds, marine mammals, and various sport and commercial fisheries species are generally not permanent year-round residents of the study area. Many species of concern are only in Cook Inlet briefly during migrations. For example, fish such as herring and halibut move about freely, spending a large part of their life-cycle offshore or in coastal areas other than Cook Inlet, and salmon migrate to sea for several years before returning to spawn.

Not only are such organisms exposed to low-level, fugitive oil less than year-round residents, but even if an oil-related impact is detected (at the tissue, individual, or population level), it cannot be ascertained that the oil was from Cook Inlet proper as opposed to elsewhere in the species' normal range.

- protected and/or regulated species

Many of the species of concern in Cook Inlet are protected (birds and mammals) or regulated (fisheries species) by state and/or federal law. Thus, they are in a sense "unnatural" populations to start with and any perceived impact to them at the population level may actually be a result of other factors, not oil-related pollution. For example, the apparent population levels of fisheries species (if established by landing records) may be a result of the prevailing market price or fishing pressures.

In the case of protected species, it could prove very time-consuming and costly to obtain the permits necessary to secure enough specimens to generate statistically reasonable data. Furthermore, the sampling for sublethal effects often involves destructive sampling (i.e., killing the organism in order to obtain the sample) and this is clearly not justified when dealing with species already low in numbers.

- organisms high on the trophic scale

Since the intent of the proposed monitoring program is to serve as an early warning system, it is necessary to use those organisms low on the trophic scale as this is closer to the point of entry of contaminants. By the time impacts are manifested in large organisms higher on the trophic scale, the damage is essentially done and the program has failed its intended purpose.

According to Gray (1989) as cited in Gray *et al.* 1990 stress indices (i.e., the results of sublethal effects) such as changes in population size or structure; elimination of certain sensitive or vulnerable species; tumors or reproductive impairment all indicate end-points rather than the first effects of pollution-induced change. Ultimately, in order to detect these first-order changes, it is most desirable to combine population sampling (numbers of individuals; numbers of species) with laboratory experiments (scope for growth studies; oxygen: nitrogen ratios; behavioral, physical, physiological, and biochemical changes). However, this is not feasible in the Cook Inlet situation given the budgetary constraints.

- organisms too costly to collect

Permitting aside, factors such as low abundance, patterns of distribution, and seasonal variations would make simply collecting sufficient specimens and samples from the higher trophic-level consumers (such as whales or birds) cost-prohibitive. By contrast, ample numbers of mussels can be collected from shore in a matter of a few hours and a sufficient number of infauna can usually be collected from a support vessel in several hours at the most.

- eliminate the use of lichens as biological indicators in the terrestrial environment

Investigations show that lichen populations decrease with an increase in air pollution and they have been used for many years as biological indicators of air pollution around industrial areas/facilities. However, the use of these plants as long-term indicators of air pollution is most appropriate and useful in field studies involving continuous surveillance type programs, not annual sampling. In addition, the species of lichens native to the Kenai Peninsula are not particularly good indicators of pollution (Vandry 1992, pers. comm.).

4. Techniques

- use of oil-degrading bacteria as an indicator of oil

The use of oil-degrading bacteria as a means of ascertaining the presence (or absence) of petroleum hydrocarbons was seriously considered and even proposed at the earlier stages of the project. It is a proven, sensitive technique that produces reliable results with relatively little field and laboratory effort. However, when used in conjunction with sediment chemistry analysis, there is duplication of results. The "sheen screen" sampling technique used in bacteria monitoring provides only presence-absence (of hydrocarbon) information, whereas analysis of sediments for total petroleum hydrocarbons gives presence-absence of hydrocarbons as well as quantitative levels. The use of gas chromatography gives additional detailed compositional and source information for the sediments (see details below). Overall, chemical analyses of the sediments (which are a necessary component the program) are cheaper and provide more information than more expensive bacteria testing.

- sampling population parameters of organisms not used in bioaccumulation analyses

Although population structures contain a record of recent environmental changes, these changes may have been due to many different natural and/or man-made factors. Populations of organisms are inherently variable, therefore, it is difficult to determine the cause of changes in population size, distributions, and/or structure. Without bioaccumulation data, it is even more difficult to attribute these changes to chronic oil pollution. For example, if a general population decline occurs, there is no way to ascertain which of many potential environmental factors was the cause; it may have been something related to the oil industry but outside Cook Inlet or some area-wide and natural fluctuation operating within Cook Inlet. Because of the difficulty in distinguishing and separating out causal factors and because most natural populations are inherently variable, population structure information that is collected once a year is not a "valuable"/useful tool in a monitoring program such as the one proposed unless it is collected in conjunction with bioaccumulation information.

- laboratory studies

The use of laboratory studies to examine region-wide changes in physiology, histology, growth rates, etc. of organisms due to exposure to chronic oil pollution is not practical. In general, it is necessary (but difficult) to keep the animals alive in captivity for considerable lengths of time, which is labor-intensive and costly. In addition, laboratory studies are often criticized because the organisms are stressed and the laboratory set-ups are not representative of field conditions.

- bioaccumulation studies in fish

It is recommended that marine fish not be used in bioaccumulation studies because although aromatic hydrocarbons (oil-related contaminants) are accumulated, subsequent metabolism, which is substantial according to Rice *et al.* (1984), and excretion of metabolized byproducts reduce body burdens and so increased hydrocarbon concentrations are not always detected (Capuzzo in Boesch and Rabalais). Therefore, examining these organisms in this manner does not serve as a reliable means of monitoring increasing or accumulating chronic oil pollutants.

B. ELEMENTS CONSIDERED

In a monitoring plan of unrestricted monies, one could measure the full suite of physical, chemical, and biological parameters known to be indicators of chronic contamination. However, budgetary limitations dictate that only the most practical, cost-effective, and productive (in terms of producing useful results) techniques and approaches be proposed for the monitoring plans.

1. Target Contaminants

Although OPA90 and the RFP reference monitoring the impacts of oil operations involving terminals and tankering, subsequent discussions with the CIRCAC indicated that the study was to address environmental contamination from crude oil and refined product in general. The oil industry in Cook Inlet introduces a wide variety of potential pollutants to the local environment, and much of the concern with regards to these discharges is clearly on petroleum-derived hydrocarbons. Natural gas was ruled out by law/charter.

Hydrocarbons belong to a large group of organic compounds categorized in a general sense on the basis of their origin or source. Petrogenic (e.g., from natural seeps or crude oil), pyrogenic (from the combustion of petroleum or plants), terrigenous (directly from plants or coal deposits), and biogenic (produced in seaweeds and phytoplankton) hydrocarbons are all present in Cook Inlet (Table 1). Because of

Table 1. Analytes of petrogenic, pyrogenic, and biogenic hydrocarbons.

Pyrogenic		**Biogenic**
Fluoranthrene		Algae
Pyrene		squalene (polyolefin)
Unsubstituted aromatics		pristane
Chrysene		heneicosa-hexaene
Benzofluoranthenes		pantaene
Benzopyrene		penta-, nona-, heptadecane
		Terrigenous
Petrogenic		retene
Aromatics		simonellite
2-4 ring PAH's		perylene
Unresolved complex mixture (UCM)		cadalene
Pristane		tri-, penta-, hepta-, nonacosane
Phytane		hentriacontane
Low odd-even ratio of n-paraffins		Odd carbon n-alkanes
17aH,21βH hopanes		High odd-even ratio of n-paraffins
Saturated aliphatics		Alkenes C21, 31, 33, 37, and 38
Alkyl substituted		Unsaturated hydrocarbons
benzenes	pyrenes	Tetraenes
phenanthrenes	fluorenes	17βH,21βH hopanes
naphthalenes	chysenes	
dibenzothiophenes	napthobenzothiopenes	

this, it is necessary to distinguish between the naturally-occurring and petroleum-derived hydrocarbons; to do so will also help to differentiate various sources of oil pollution, e.g., North Slope crude from Cook Inlet crude from refined product.

Specific hydrocarbons proven to be valuable indicators of petroleum resulting from the production, processing, and transportation of crude oil have been identified. However, some of the hydrocarbons common to petroleum are also produced by marine organisms, so it will be necessary to evaluate the normal background levels of hydrocarbons before an accurate assessment of anthropogenic input can be made.

Analysis of the "mixture" of the hydrocarbons should be performed through a hierarchical scheme because of the costs involved. UV/fluorescence analysis can be performed relatively inexpensively and it provides information on the presence and approximate quantities of oil in a sample although it does not separate or quantify individual compounds (Rice *et al.* 1984). Once the presence of oil has been detected, then it is justified cost-wise to perform a more detailed, diagnostic analysis. Gas chromatography (especially gas chromatography/mass spectrometry, GC) is the most useful method for detailed analyses of the general sources and components of oil pollution because individual compounds considered to be chemical markers can be identified and quantified. For example, marine animals do not usually naturally contain aromatic hydrocarbons, so that the presence in tissues of compounds, such as of alkyl-substituted naphthalenes, phenanthrenes, dibenzothiophenes, 2-4 ringed PAH's etc., constitute strong evidence of oil pollution. These and other substances will often cause a gas chromatogram to have an unresolved complex mixture (UCM) signal of alkanes and cycloalkanes indicative of fossil fuel hydrocarbon contamination, the concentration of which can be measured (Goldberg *et al.* 1978). In addition, the presence of phytane (significant quantities of which are found in crude oil) and a phytane: pristane ratio near unity in marine sediments are also inferred as indicating petroleum pollution. By analyzing for these and other petrogenic hydrocarbons characteristically found associated with petroleum, the amount of chronic contamination can be assessed.

In addition to hydrocarbons, three metals, lead, cadmium, and arsenic, are also target contaminants in the terrestrial component of the proposed programs. These are considered toxic to vegetation and/or herbivorous animals which feed on affected plants. All three metals are emitted as byproducts from petrochemical facilities/sources and have been found in the air in the vicinity of Nikiski.

Overall, the recommended process for hydrocarbon and/or metals extraction and analyses represent a compromise between cost and the need to identify specific fractions (i.e., petroleum-related contaminants).

2. Target Habitats

The selection of appropriate habitats was based on several criteria, as described below:

a) Habitat Value

The "value" of a habitat was judged in terms of its ecological and/or economic importance. Selection focussed on important habitats in terms of the biological production or support of a diverse community or assemblage. For example, Clam Gulch, Fox River, Kalgin Island and the extensive mudflats and saltmarshes of upper Cook Inlet are considered to be "critical habitats" for a variety of resident and migratory species.

In addition to the ecological importance, the economic significance of an area was also considered. For example, Kachemak Bay is an economically important region of Cook Inlet because of the major sport, commercial, and subsistence fisheries associated with the area. Valuable habitats are defined as those that if impacted by chronic oil contamination would cause substantial detrimental impacts to the organisms associated with the habitat and/or to the humans that utilize the resources of that area.

b) Susceptible/Vulnerable Habitats

Those habitats or areas at greatest risk are those with the greatest (multiplicative) sum of valuable resources and greatest risk of being hit by chronic and acute oil spills. Habitats which are immediately adjacent to pollutant sources or which, by virtue of currents, winds, or stream flow are exposed to the pollutants are most likely to be exposed to oil-contamination of whatever amounts.

c) Sensitive Habitats

The sensitivity of a habitat was judged in terms of the potential for the resident biota to be affected by oil-contamination. For example, on a species-by-species basis, the zooplankton of the water column might be more subject to a given level of oil-pollution than shrimp inhabiting the nearshore benthos. However, due to the mixing, dispersion and dilution of (especially) low-level contamination in the water column, the zooplankton might be relatively immune to lethal or sublethal effects. On the other hand, if the shrimp inhabit a depositional environment (which most of the benthos is), they would be subject to accumulated contamination for an extended period of time.

The focus of the proposed monitoring programs is on nearshore marine habitats primarily because petroleum hydrocarbons resulting from chronic oil leaks and spills during "normal" operations are more likely to reach the sea bed and become incorporated into the sediments in these areas. In addition, the history of oil spills (chronic leaks and otherwise) suggests that the nearshore environment is where most biological impacts occur, are most readily discerned, and can be measured most accurately. The nearshore habitats are usually areas of increased productivity and many of the most important (ecologically and economically) animal groups, such as crabs, flatfish, juvenile salmon, shorebirds, and seaducks, forage in these habitats.

Terrestrial environments near land-based oil facilities should also be monitored as they too are the recipients of chronic contamination. Habitats such as coniferous forests, riparian habitats, and tundra-like areas are known to be sensitive to airborne pollutants and accumulations of petroleum-derived contaminants in the sediments and on the vegetation itself can directly and indirectly impact the flora and fauna associated with this habitats.

3. Target Species

Ironically, although most interest and concern is for damage done to the biota of commercial, sport, subsistence, and aesthetic interest, those species are generally least tractable when it comes to monitoring. Therefore, scientists must identify those species which are known to be sensitive to contamination and assume (by strong inference) they represent what happens to those components of concern.

The species recommended for inclusion in the proposed monitoring program are primarily a function of the habitats selected to be studied, in combination with what is left after other species were eliminated, and are tentative at this time. Criteria which will be used to recommend specific species will include the following:

- organisms "low" on the trophic scale

Previous studies have shown that lower trophic organisms play an important role in the Cook Inlet marine system (Dames and Moore 1979). In addition to the dangers to benthic organisms from direct exposure to the toxic properties of oil, hydrocarbon fractions associated with subtidal sediment may be ingested and assimilated by clams, pandalid and crangonid shrimps, hermit crabs, and post-larval king crabs, all of which feed by sediment sorting. If organisms low on the trophic scale display bioaccumulation of petroleum-derived compounds or show evidence of impacts due to oil, then there is an increased chance organisms higher in the food chain (which prey bon the subject species) may be indirectly impacted. Large crab species as well as some fishes can be affected by feeding on the contaminated prey organisms. Dames and Moore (1979) present evidence of fossil hydrocarbon uptake by marine animals of lower Cook Inlet. Dames and Moore also illustrate the transfer of biogenic hydrocarbons from one trophic level to another, suggesting that if biogenic hydrocarbons can be assimilated and passed on, fossil hydrocarbons probably are also.

- indigenous benthic, preferably sedentary, species

Benthic organisms live in close contact with the substrate where contaminant concentrations may be elevated. Plankton drift with the currents while nekton move in and out of the area at will. Meanwhile, the benthos remains in whatever the environmental conditions are. As a result, cumulative exposure is increased, as is the likelihood of biological impact. Non-motile organisms from a given site generally have body burden contaminants that reflect the degree of contamination at that site. Therefore, they provide more information as to the extent and possible source of any contamination than motile species.

- organisms known to bioaccumulate oil-derived pollutants

The presence of contaminants in the physical-chemical environment does not necessarily indicate an actual impact, but their presence in the biological environment is certainly more suggestive of the potential for impact. The concentrations of hydrocarbons in tissues indicate the extent to which contaminants are bioavailable; thus they represent an early step in the food chain accumulation of pollutants. By using species documented in previous studies to uptake hydrocarbons and exhibit sublethal effects, quantitative and qualitative comparisons can be made. These organisms should accumulate the levels of pollutant encountered in the environment without substantial mortality; they should be abundant throughout the region and sufficiently long-lived to allow sampling of more than one year-class if desired. They must be of reasonable size, giving adequate tissue for analysis (small organisms present in adequate numbers are acceptable), and relatively easy to sample.

- use "indicator" species, if possible.

Indicator species are essentially receptors which signal impact due to their demonstrated sensitivity to or tolerance of chronic contamination of some sort or another. Species which are especially sensitive to oil pollution, would be eliminated from areas where they would be expected, because of oil pollution. Species which are especially tolerant of oil pollution might attain greater densities in oil-polluted areas because the pollution has eliminated other species, or rendered them less competitive.

- use filter-feeders or surface deposit feeders

In bioaccumulation studies, filter-feeders and surface deposit feeders, are especially useful as "concentrators": they uptake pollutants more readily than organisms with other modes of feeding because they ingest sediment or particulate matter to which contaminants are bound. If contaminants are present in the environment, they tend to appear in the tissues of such species first.

a) Target Techniques

It was of paramount importance that those techniques considered appropriate/feasible for the proposed programs be workable in Cook Inlet, scientifically sound, cost-effective, and produce worthwhile information (i.e provide sufficient "hardcore" evidence for the RCAC to deliver to the appropriate regulatory agencies). In addition, the investigators believed it would be valuable to recommend those techniques that made use of existing information and possibly provided supplemental information for other programs.

Specific details of the field sampling procedures for each of the recommended components of the program are obvious considerably different and are discussed separately in Appendices A-D. Hydrocarbon analysis of sediments/soil and tissue samples, on the other hand, follow the same general procedure for each of the components.

C. RECOMMENDED ELEMENTS

As indicated above, based on the general fate of oil and oil-related products released into the environment, the focus of the proposed monitoring programs must be on susceptible habitats, that is those where chronic oil is likely to go and concentrate, thus where it is possible to detect (since working with low levels)and where impacts are likely to occur. The focus must also be on selected target species and assemblages which it is hoped reflect "what is going on" in each of the study areas of concern, and serve as the "alarms" in the early warning system.

The process of elimination resulted in the recommendation of four integrated project elements: 1) *in situ* mussel bioaccumulation studies; 2) subtidal benthos sampling; 3) intertidal studies; and 4) monitoring of terrestrial sediments and vegetation. The first four elements relate to the marine environment, while the fourth element is on land. Monitoring of terrestrial sediments and vegetation is recommended primarily because of the concern of various members of the CIRCAC in an attempt to increase the comprehensiveness of the overall program.

Within each element both physical-chemical (i.e, measurements of hydrocarbon levels in sediments and/or tissue) and biological (such as mortality rates, bioaccumulation rates, growth rates, apparent health of the individuals) information is collected and then compared to results obtained from the other elements at the same and at different stations within the same habitat type. Each component utilizes a combination of physical/chemical/biological sampling techniques in order to provide the maximum ability to interpret changes in the parameters monitored. In particular, sediment chemistry and bioaccumulation in indicator species/ecologically important species are examined as they are probably the two techniques with the greatest chance of detecting increasing contamination levels. While causality is not readily established, the increase in concentrations is sufficient to "send up a red flag", indicating the potential for lethal and sublethal biological impacts.

1. *In situ* Bioaccumulation (Mussel Watch)

Measuring pollutant/contaminant levels in marine organisms has been an integral part of ocean monitoring for many years. Mussels, other bivalves, many species of fish, and other organisms are used throughout the U.S. and the world to determine levels of bioaccumulation (e.g., NOAA National Status and Trends 1989, Houghton 1984). Sediment chemistry and "mussel watch" provide more reliable and economical physical and biological indications of pollutant buildup in the environment than many other biological indices (Houghton 1984).

Mussels in particular are valuable in bioaccumulation studies because they are widely distributed, sedentary, stable populations which as a result of being filter-feeders concentrate many chemicals from the water column by factors of 10^2 to 10^5 (Fossato and Canzonier 1976). They exhibit low or undetectable enzyme activity for metabolizing many xenobiotics such as aromatic hydrocarbons and PCBs (Livingstone and Farrar 1984 in Murray *et al.* 1991). Consequently, they provide a measure biological availability of environmental contaminants.

Mussels can be used to monitor various depths in the water column, and can be placed where constant exposure, intermittent exposure, or no exposure is expected. Analysis of mussel tissue levels integrates pollutant levels over a period of time, not achievable by analyzing individual water samples. They can generally survive under conditions of pollution that often eliminate other species and can be transplanted to areas where no population currently exists, e.g., due to lack of substrate. In addition, mussels are a commercially valuable seafood resource on a worldwide basis and are therefore of interest to public health considerations (Farrington *et al.* 1983).

Relatively small increases in mussel tissue levels can be used as an early warning that environmental contaminant levels have increased in the area that could possibly affect other organisms (Houghton 1984). Transplanted mussels will conform to baseline levels of hydrocarbon within a few weeks of introduction (Di Salvo *et al.* 1975, Pruell *et al.* 1986, Farrington *et al.* 1980, Widdows *et al.* 1981) and will then successively accumulate chronic pollutant sand slowly depurate the accumulated pollutants over weeks or months. (Di Salvo *et al.* 1975, Farrington *et al.* 1980, Burns and Smith 1981, Pruell *et al.* 1986).

A long-term mussel watch program can result in a large database that can be used to track pollutant changes over time and over distance, to identify sources or areas of higher-than-normal levels of particular toxic pollutants, and to provide a basis for follow-up intensive studies and regulatory actions (SWRCB 1987).

2. Subtidal Benthos

Sediments are the ultimate sink for most contaminants, in particular, the heavy fractions of petroleum hydrocarbons from crude oil and refined products which enter the marine environment. Both chronic and acute contaminant inputs of hydrocarbons become adsorbed to suspended particulate matter and deposited in bottom sediments. Once in the sediments, the pollutants may simply continue to accumulate, or they may persist for a long time, be chronically released, and be incorporated into animal tissues. According to Feder 1980, "oil contamination of the benthic environment of Kachemak and Kamishak Bays or the large area in the mouth of Cook Inlet between Shaw island and the Barren islands could negatively affect the populations of crab and shrimp. This type of contamination may seriously disrupt food webs, change the population dynamics of many organisms, and even enter human food supplies.

The importance of the benthos in assessing water and sediment quality has been well documented. Epibenthic and infaunal organisms are frequently chosen to monitor the long-term effects of pollution, and often reflect the biological health of marine areas (Pearson 1971, 1972, 1975; Rosenberg 1973). Benthic species and communities are largely sedentary; they cannot avoid an impact and therefore "integrate" impacts over their life-span reflecting normal and adverse conditions. Impacts to the benthos include: elimination of species which are sensitive to hydrocarbons; increases in numbers of tolerant species (due to the elimination of competing species); changes in community diversity, abundance, and structure; community-wide changes in dominant feeding forms; and impaired health, vitality, size , and fecundity of surviving populations.

It is virtually a necessity to monitor the benthos considering that natural processes have a tendency to concentrate accumulations of oil there, and that elevations in the levels of these petroleum-derived compounds that have the possibility of inducing persistent toxic effects to the ecologically and/or economically important species associated with this habitat.

3. Intertidal Habitats

Intertidal habitats are of direct concern and should be focussed on in a monitoring program because a sizeable fraction of most fugitive oil (whether from large spills or small leaks), being buoyant, does end up in the intertidal zone. According to Cowell and Monk (1980) (MBC 18), oil industry discharges have the potential to impacts which will be found first in the intertidal zone and these will provide the best "early warning" of unacceptable environmental effects developing.

The intertidal region should also be monitored because of its multitude of uses and users. For humans, it is generally a high-profile environment which is used for recreation, aesthetic enjoyment, and harvesting of marine resources. For wildlife, it serves as a haul-out and/or pupping area for pinnipeds (seals and sea lions) and sea otters; a spawning area for pink salmon, chum salmon, and herring; a nursery area for juvenile crabs; and as a forage area for many terrestrial organisms of importance such as bears, foxes, deer, and birds (e.g., eagles, waterfowl and shorebirds). The organisms that inhabitat this particular realm of the ocean are generally considered hardy by virtue of the environmental stresses they normally encounter, but their sensitivity and vulnerability to pollution should not be overlooked (Clark *et al*. 1978).

Intertidal organisms which have been found to be particularly suitable for monitoring oil pollution include: bivalve mollusks such as *Mytilus, Mya*, and *Macoma* (Shaw and Wiggs 1980, Stekoll *et al*. 1980); gastropod mollusks such as *Littorina* and various limpets (NOAA-PWS monitoring report by EREC/Pentec, Shaw and Wiggs 1980); fouling-community organisms such as bryozoans; microcrustaceans such as amphipods and copepods; marine algae, especially fucoids; and flowering saltmarsh plants.

Of these organisms, the following are recommended for use in the proposed programs: limpets (*Collisella= Lottia),* periwinkles snails (*Littorina)* in rocky intertidal habitats; and clams (*Macoma*) in soft sediments (i.e., mudflats .Limpets and littorines were chosen because they are distributed throughout the region in relatively abundant numbers and so are fairly accessible as for sampling. Both are herbivorous grazers, therefore by the nature of their feeding behavior they incorporate any oil that may be coating the surfaces of rocks and algae (Stekoll *et al*. 1980). Hydrocarbons have been found within limpet and snail tissues (Stekoll *et al*. 1980, Shaw and Wiggs 1980, Dames and Moore 1979, Houghton *et al*. 1991) so known bioaccumulators. *Macoma* was chosen as one of the clams to study because like limpets and littorines in rocky intertidal, it is abundant in the region and by virtue of its feeding mode (suspension and filter-feeding) is exposed to oil that is stranded as well as in suspension which then accumulates in its tissues (Shaw and Wiggs 1980). All three species are food items for larger predators such as migratory birds and thus have the potential to pass petroleum hydrocarbons up through the food web

4. Terrestrial Plant Assemblages

Long distance transport from anthropogenic sources via atmospheric fallout could be an important source of terrestrial contamination. Pollutants accumulate in soil and affect health of vegetation and all closely associated organisms such as insects, birds, small rodents, and even larger animals, especially herbivorous species.

Typically, the effects of pollution are seen initially in the vegetation. Non-vascular plants, such as lichens, which obtain all of their nutrients from the atmosphere, are particularly susceptible to air pollution. Contaminants could impact the terrestrial environment at several levels. For example, particulate matter can accumulate on leaves and vegetative portions of the plant and can limit respiration. Also contaminants in the sediment or groundwater could be taken up by the roots of vascular plants and transported to other tissues where cellular metabolism could be affected. Buds and reproductive structures may be particularly sensitive to contaminants since these areas are undergoing rapid cell division and provide the means for genetic exchange. Continued, chronic influx of contaminants could lead to permanent changes in community structure.

Plants are useful indicators of air pollution and are injured by a wide variety of toxins in the environment. Most of the injury is produced by three or four major air pollutants. These include: 1) the photochemical oxidants (including ozone), 2) oxides of nitrogen (primarily nitrogen dioxide), 3) sulfur dioxide, and 4) a variety of metals. Ethylene is also an important air pollutant although it is a naturally occurring plant growth substance. Measuring the concentrations of contaminants in the air, soil, and tissues of plants can be useful in monitoring the detrimental effects of pollutants on vegetation.

CHAPTER SIX: RECOMMENDED PROGRAMS

The recommended monitoring programs were designed primarily on the basis of three criteria: the scientific sensitiveness of the program elements relative to the object of the program; spatial and temporal coverage; and the costing levels provided by the RCAC.

The $200,000 program is the minimum program which should even be attempted. Because of the limited budget, it emphasizes stations nearest the potential sources using techniques with the greatest sensitivity to low-level pollution. The $500,000 and $800,000 programs include: additional program elements (to sample additional ecosystem components); more stations (in order to obtain greater spatial coverage); and some bi-annual sampling (to describe any seasonal differences in potential impacts).

Although this document represents a draft final report, the proposed programs should not be considered final. The exact funding level which becomes available may vary year to year and thus would affect level of effort can be expended. More importantly the information collected during the first and subsequent surveys will help define the ecology of Cook Inlet and the sampling needs. The needs are likely to change year to year for as long as monitoring is conducted.

A. STATION LOCATIONS

Forty-three potential station locations are indicated in Figures 4 and 5. These stations are paired more-or-less across from one another along the east and west shores of Cook Inlet and on the three largest islands in the study area. Stations have been numbered in sequential order as they would be contacted by seawater entering the study area at Kennedy entrance, following a counterclockwise gyre in the Inlet, and exiting through Shelikov Strait.

The identification of proposed sampling areas was based on a complex of criteria, including those described below. Consideration of best sampling design also involved proximity to potential sources of pollution as well as equitable distribution of stations among habitats of different substrate types. Previous studies were consulted especially if they indicated hotspots of hydrocarbon accumulation and impacts and/or provide background (baseline) data for eventual comparisons. For example, Kaplan *et al.* (1979) discussed the amounts sediment hydrocarbons present in Cook Inlet, giving quantitative data that can be used for comparative purposes after just the first year.

Precise station locations would be established during or before the first sampling effort. Because the monitoring program is designed to detect low-level, chronic contamination, many stations will be located in embayments or coastal indentations where deposition should be high.

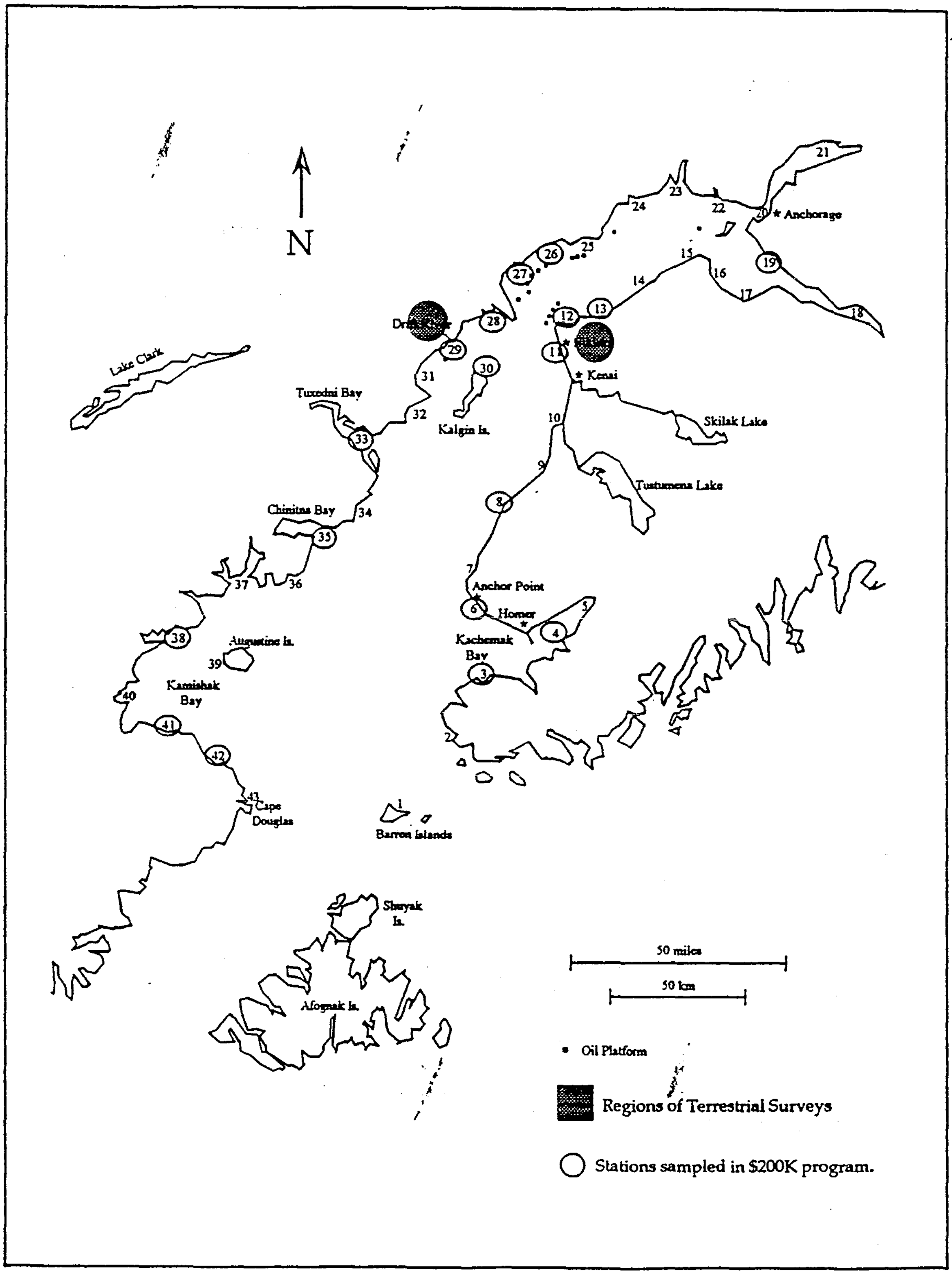

Figure 4. Map of Cook Inlet showing sampling locations for the proposed $200,000 monitoring program.

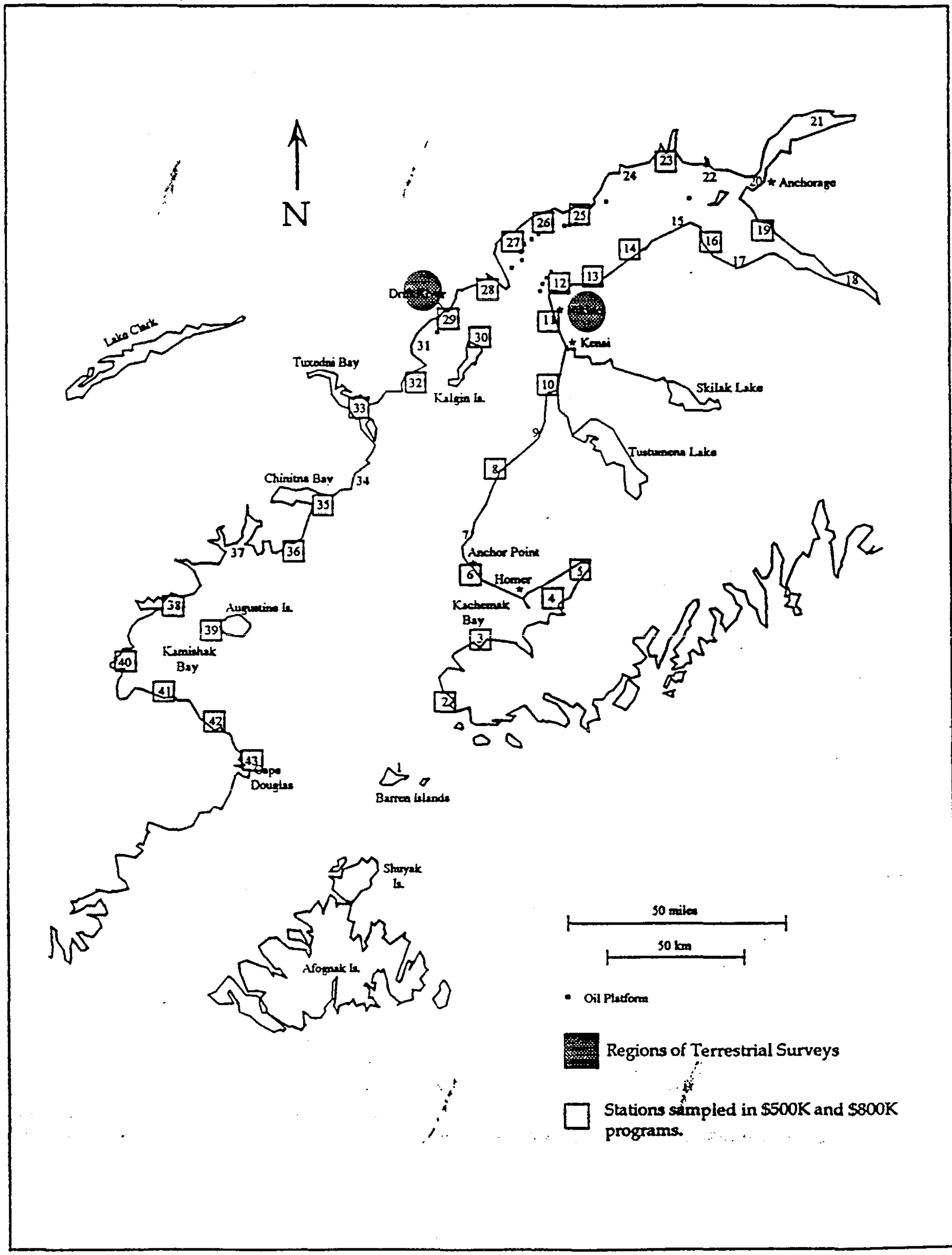

Figure 5. Map of Cook Inlet showing sampling locations for the proposed $500,000 and $800,000 monitoring programs.

General Circulation Patterns in Cook Inlet

Since some, if not most, fugitive oil will be transported at the sea surface, circulation patterns are important in locating stations. Figure 6 depicts general circulation patterns in Cook Inlet and suggests that Stations 1 through 10 should constitute relatively "clean" stations. Stations 11 through 20 are downcurrent of oil-related activities at the eastern Forelands and might be somewhat contaminated. Contaminant levels would diminish up-Inlet as they are dispersed and diluted north of Nikiski. Stations 21 through 25 are in or immediately downcurrent of the potential contamination introduced at offshore production platforms and the terminal facilities at Drift River and the western Forelands and might also be moderately contaminated. Stations 26 through 41 are progressively removed from potential sources, these stations should be increasingly cleaner as dispersion and dilution reduce contaminant levels.

Because the deposition and accumulation of air-borne contaminants in the terrestrial environment is very much affected by the wind patterns that disperse them, the stations on land (Figures 4 and 5) were selected according to the predominant wind patterns (as well as proximity to the source).

Spill Trajectories

The trajectories of oil spills in Cook Inlet have been predicted under a variety of circumstances, including circulation patterns, tidal state, wind conditions, as well as size, nature, and location of the spill (Schlueter 1979, Schlueter and Rauw 1981). Figure 6 represents the generalized fate of surface spills in Cook Inlet thereby indicating which locations are more likely to receive chronic low-level inputs of petroleum-derived contaminants.

Depositional Environments

Although some fugitive oil will be transported to the intertidal on the sea surface, other fractions will adhere to suspended particulates (both organic and inorganic) which eventually settle to the seafloor. Settling takes place in depositional environments, where inorganics, organics, and pollutants all accumulate. The distribution of organic carbon in the sediments confirm the net water movements and settling patterns suggested by current measurements. In addition, studies of the distribution of oil-degrading bacteria suggest that fugitive hydrocarbons from Cook Inlet settle out of suspension in the same pattern as the organic detritus. Figure 7 depicts the relative levels of sediment organic carbon and bacterial "hotspots" throughout lower Cook Inlet, and thus provide indirect, but empirical evidence of depositional environments.

Habitat Vulnerability

Michel *et al.* (1978) developed "vulnerability index" values for the coastline of Cook Inlet as a means of predicting where an oil spill might have the greatest impact (Figure 8). The index is based on the integration of a variety of environmental factors including: geological vulnerability based on coastal geomorphology and deposition, penetration, and the persistence of oil; as well as biological vulnerability based on species-specific sensitivity to oil and the length of exposure, rate of recovery, and toxicity of oil fractions.

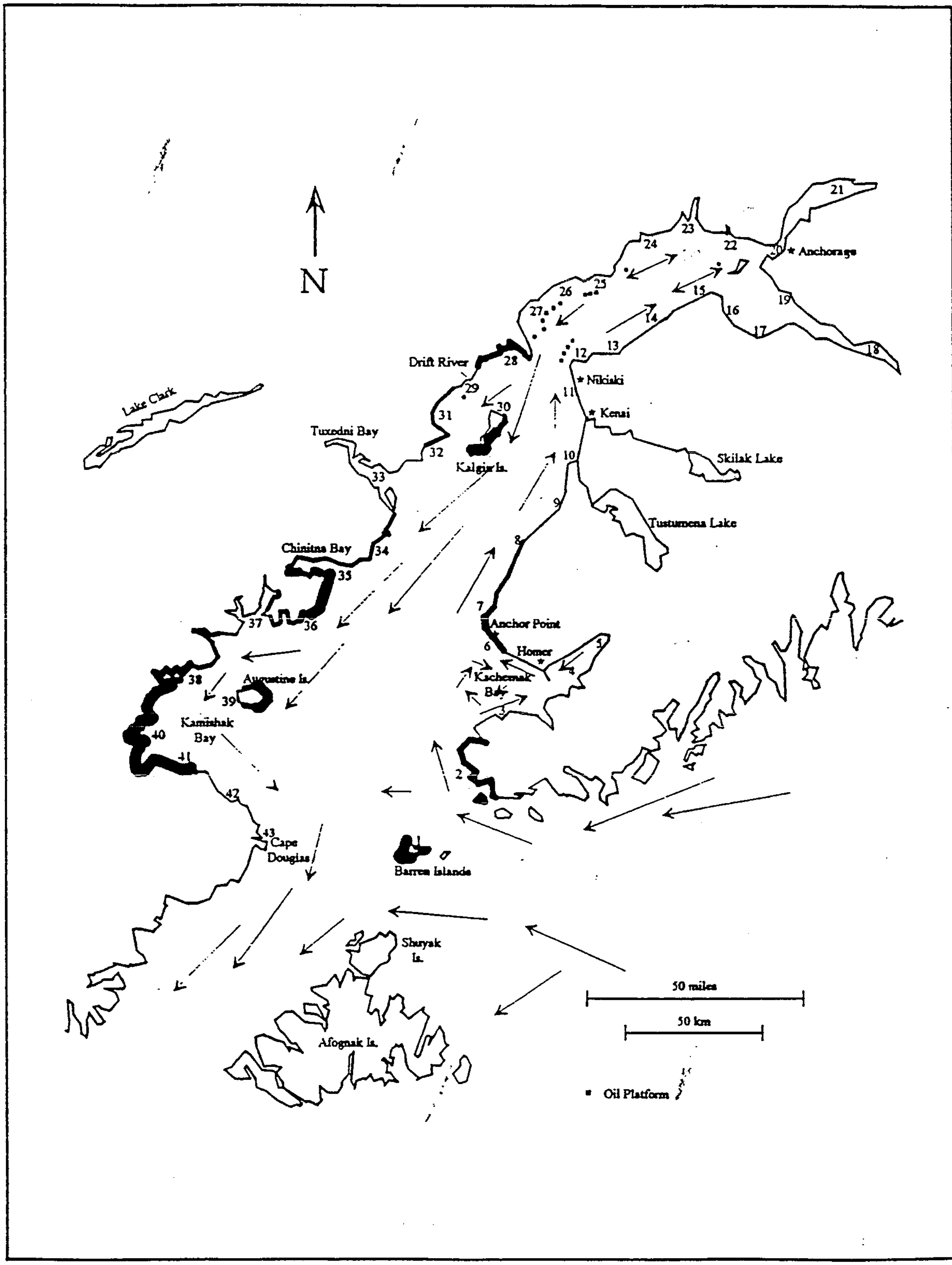

Figure 6. Net surface circulation in Cook Inlet (from Schumacher and Reed 1980) showing locations most likely to be impacted by oil spills. Width of shoreline is proportional to the relative frequency of oil spill contacts simulated by drifter buoys (from Schleuter and Rauw 1981 and Schleuter 1979).

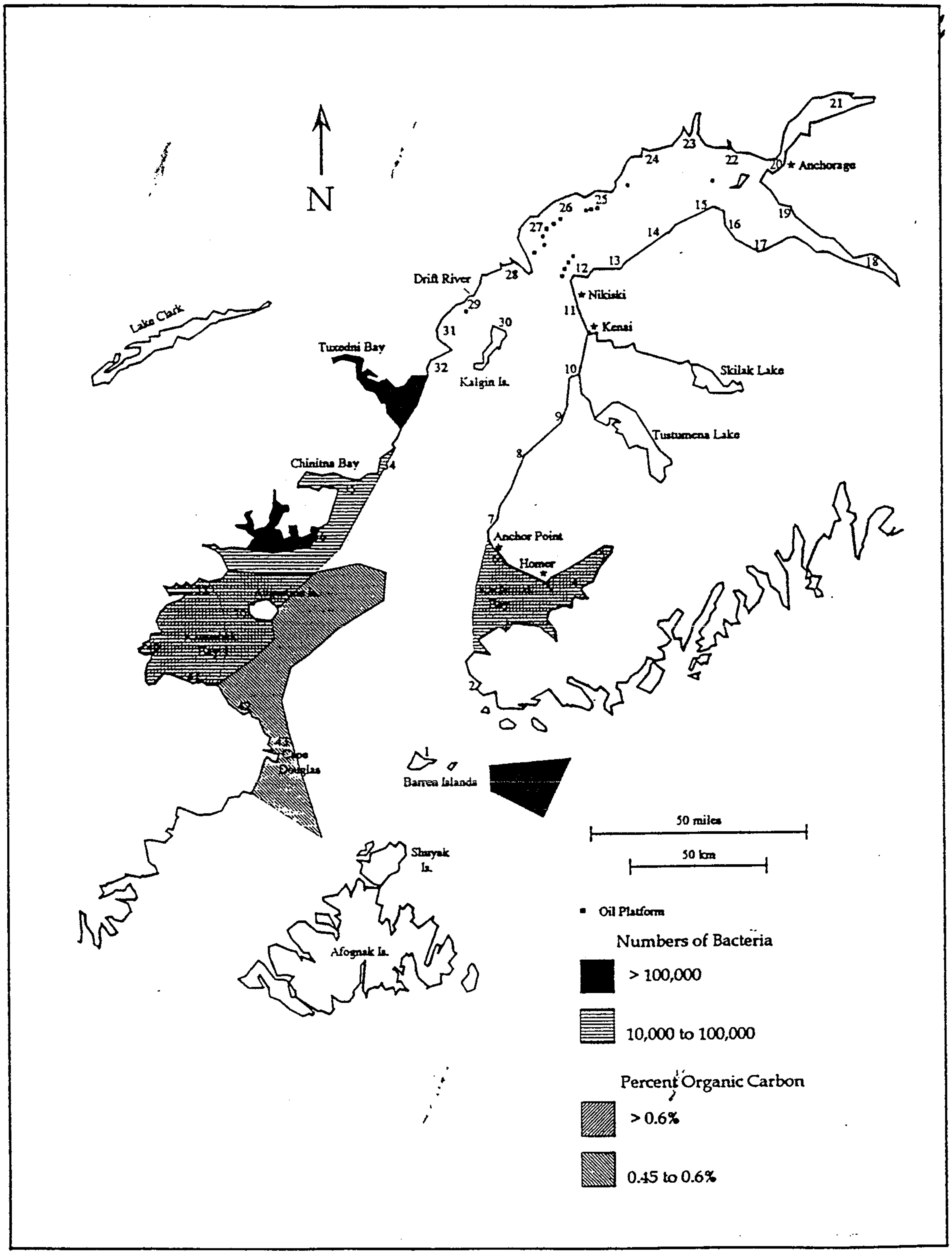

Figure 7. Percent organic carbon and Most Probable Numbers of hydrocarbon degrading bacteria in sediments of Cook Inlet (from Atlas et al. 1983).

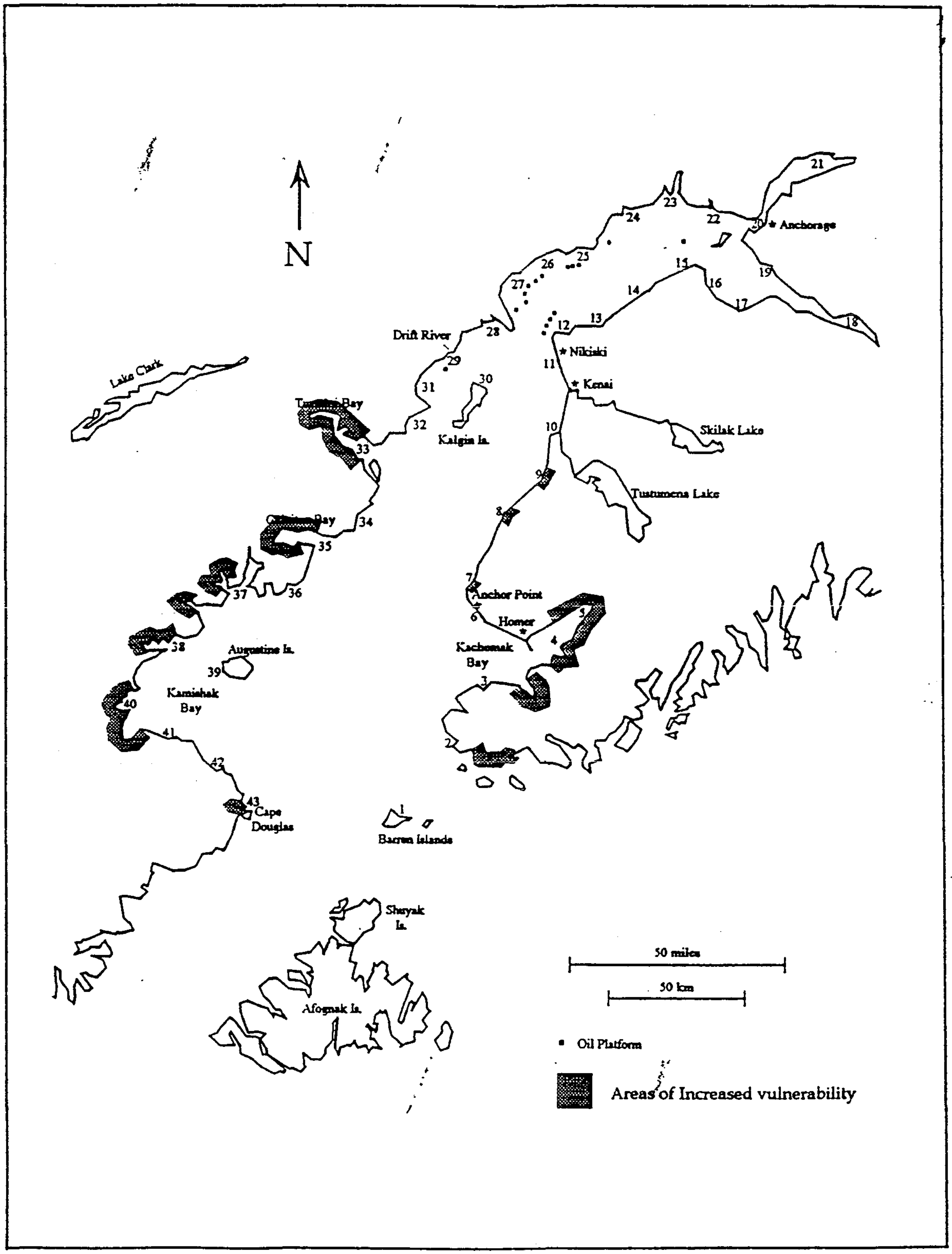

Figure 8. Vulnerability to oil spill damage of coastal environments in Cook Inlet (based on Hayes et al. 1977).

Habitat Value

In an ideal comprehensive monitoring plan all aspects of the environment would be examined. However, factors such as time and budget constraints limit what can and cannot be included in the monitoring program. Consequently, the wide diversity of habitats in the Cook Inlet region, each with its own characteristic plant and animal assemblages and complex community structure and interactions were "prioritized" partially on the basis of habitat "value". Areas of resources of concern and ecological/economical importance (Figure 2), such as nursery grounds for commercially valuable fish and shellfish, productive habitats, major sport, commercial, and subsistence fishing areas, and feeding grounds for resident and migratory species, were the primary targets for the proposed monitoring programs for reasons discussed in Chapter 5. Impacts from chronic oil pollution to these areas of natural resources could be significant, if not devastating, to both the organisms and the local citizens of Cook Inlet.

"Control" versus "Experimental"

The proposed programs are designed specifically for monitoring chronic pollution and are well suited for comparisons at specific points in time between stations in similar habitats but different geographical locations. Despite gradients in the regimes of salinity, turbidity, and exposure, station selection is based on "area-wide" surveying as opposed to randomly chosen or specific to areas most at risk of oil impacts.

In the interest of scientific soundness and statistical validity, each "impact" site should be balanced against a "reference" site, one not impacted at all (though an impact can never be ruled entirely). The use of controls in the statistical sense of experimental biology is clearly difficult, if not impossible, in the field, primarily because of natural variation from place to place: it is exceedingly difficult to find a control site where conditions are exactly like those at the "experimental" site except for the impact. This is especially difficult in situations in which it is uncertain where the impact is going to take place, i.e., where the oil will go.

Thus, although strict "control" and "experimental" sites are not possible, an attempt was made to balance potentially impacted and reference stations. Spatial comparisons will be difficult to make on a firm statistical basis (spatial comparisons can only be made among contaminant levels) and analyses may be primarily from a dose-response model. Temporal comparisons will be valid on a site-specific basis, i.e., for contaminant levels and impacts (changes to biota) at particular sites through time (Boesch 1985).

In lieu of strict control and experimental sites and because the programs seek to identify low-level contamination, "impacted" sites (down-current of potential input sources) and "reference" sites (up-current of such sources) will both be sampled and compared.

B. SAMPLING DESIGN

The three proposed programs are summarized in Table 2. Specific aspects of each program are presented below.

The $200,000 Program

The $200,000 program would consist of conducting studies at 18 basic stations (Figure 4), once per year. The components to be studied include: mussel watch; subtidal sediment chemistry and tissue chemistry of first-order, subtidal consumers; and intertidal sediment chemistry (where appropriate) and tissue chemistry of first-order, intertidal consumers. Terrestrial chemistry and vegetation studies would also be conducted once per year, along three transects -- two near Nikiski and one near Drift River.

Stations selected for examination in the $200,000 program are concentrated near the major source of fugitive petroleum, the Forelands on both sides of Cook Inlet proper. Intermediate distances from the Forelands are not heavily sampled; however, Kachemak and Kamishak Bays are included since they are known to be rich in various resources of sport, commercial, and aesthetic interest.

The 18 stations were selected on the basis of expected contamination levels (known or suspected depositional areas) as well as known resources. Specific reasons for each station are provided below.

Stations 3 and 6 are in outer Kachemak Bay whereas Station 4 is in the inner Bay. All of these should represent relatively clean conditions (i.e., reference stations) and are highly productive areas.

Station 8 is located along the Kenai Peninsula, in the vicinity of Clam Gulch, while Station 11 is in the vicinity of oil facilities at Nikiski. Clam Gulch is known for its rich marine resources, but should be free of oil contamination from platforms and terminals; however, tanker leaks, spills, and deck-wash could affect the area. Station 11 is near a variety of oil facilities and there are indications of a possible gyre (and hence depositional conditions) nearby. Between September and April both stations might be impacted by air-borne hydrocarbons from offshore platforms and the facilities at Nikiski.

Stations 12 and 13 are up-Inlet and down-current of the refining and terminal facilities at Nikiski and might also be subject to air-borne hydrocarbons from platforms between September and April.

Station 19 is well removed from Nikiski, but is subject to opposing dispersion and settling patterns; it is located in Potter's Marsh, another resource-rich area of concern to many Alaskans.

Stations 26 and 27 are located opposite or down-current of offshore production facilities and may receive low-level hydrocarbon contamination by aerial as well as seawater pathways.

Table 2. Summary of preliminary cost estimates for $200,000, $500,000, and $800,000 monitoring programs.

	PROGRAM ELEMENT	$200,000	$500,000	$800,000
A.	Mussel Watch	Once	Once	Once
	Tissue Chemistry	18 sta	30 sta	30 sta
	Number replicates	54	90	90
B.	Subtidal Sediments	Once	Once	Twice
	Sediment Chemistry	18 sta	30 sta	30 sta
	Number replicates	54	90	180
	Tissue Chemistry	1 sp, 12 sta	2 spp, 20 sta	2 spp, 20 sta
	Number replicates	36	120	240
	Infauna	**	**	30 sta
	Number replicates	**	**	180
C.	Intertidal Studies	Once	Once	Twice
	Sediment Chemistry	12 sta	20 sta	20 sta
	Number replicates	36	60	120
	Tissue Chemistry	1 sp, 12 sta	2 spp, 20 sta	2 spp, 20 sta
	Number replicates	36	120	240
	Population Growth	**	1 sp, 20 sta	2 spp, 20 sta
	Number replicates	**	60	240
	Community Structure	**	**	30 sta
	Number quadrats	**	**	180
D.	Terrestrial Vegetation	Once	Once	Once
	Number Transects	3	6	9
	Soil Chemistry	15 sta	30 sta	45 sta
	Number replicates	45	90	135
	Community Structure	15 sta	30 sta	45 sta
	Number quadrats	45	90	135

Stations 28 and 29 are immediately down-current of potential sources at the western Forelands, where concentrations should be reduced through dispersion and dilution. Station 30 is located at the up-current end of Kalgin Island, an area known for biological richness. Studies of oil-degrading bacteria indicate that fugitive hydrocarbons are abundant there.

Stations 33 and 35 are located in Tuxedini and Chinitna Bays, along the west side of lower Cook Inlet. Both are resource rich, have been shown to be depositional environments, and are down-current of potential hydrocarbon inputs at the western Forelands.

Stations 38, 41, and 42 are located in Kamishak Bay. Like Kachemak Bay, Kamishak is highly productive and studies of oil-degrading bacteria have indicated hydrocarbon accumulations throughout. It may be depositional over much of its considerable area and may represent an important sediment/contaminant sink in the study area. Kamishak Bay is the last part of the study area where the accumulation and impacts of oil pollution may be detected before the water mass moves toward Shelikov Strait. Conditions there may reflect the balance between dilution of low-level contamination through dispersion and its concentration through deposition.

The mussel watch element would be conducted at all 18 stations, as would the subtidal chemistry element. However, intertidal sediment chemistry sampling would only be conducted at about 12 stations, where unconsolidated intertidal material is available.

Samples for tissue chemistry (bioaccumulation) would be collected at each of about 12 subtidal and 12 intertidal stations; a single species would be examined at each stations, but the species may probably vary from site to site since the habitats vary so widely from upper to lower Cook Inlet. A first-order consumer (filter-feeder, surface deposit feeder, or herbivorous grazer) would be targeted in both soft sediment sub- and intertidal habitats, possibly *Macoma balthica*, and in rocky intertidal habitats, possibly *Littorina*.

Under this minimal program, one terrestrial transect would be located downwind of the Drift River terminal, along the axis of the most prevalent direction of on-land wind. Two terrestrial transects would be located near Nikiski, in the two most commonly observed directions of prevailing winds. Replicate soil samples would be examined for hydrocarbon residue at five stations along each of the terrestrial transects. At each station community structure and health of the vegetation would be described as quantitatively as possible.

The $500,000 Program

The $500,000 monitoring program expands on the $200,000 program by increasing the number of marine stations from 18 to 30 and the number of terrestrial transects from one and three to two and four.

The mussel watch and subtidal sediment chemistry elements would be conducted at all 30 stations and intertidal chemistry at approximately 20 stations. Tissue chemistry sampling would be increased from one to two species in the subtidal section (a second order consumer such as a crustacean, e.g., one of the species of crabs) at 20 of the 30 stations and population growth and dynamics studies would be conducted at 20 intertidal stations.

Stations in the $500,000 program are indicated in Figure 5. Station 2 would be added to sample the presumably clean conditions at Kennedy entrance and Station 5 would be added in Kachemak Bay, in order to better track changes in this highly productive area.

Station 10 may indicate the degree to which contamination is carried down-Inlet (from Nikiski) by prevailing winds from May to September while Stations 14 and 16 will provide better definition of the degree to which contamination may extend up Cook Inlet.

Station 23 may reflect any input of hydrocarbon contamination from the Anchorage area and Station 25 increases coverage in the immediate vicinity of oil platforms. Station 32 provides better coverage of the dispersion of petroleum hydrocarbons and impacts down current of inputs and south of Kalgin Island. Stations 36, 40, and 43 improve coverage of resource-rich Kamishak Bay.

The $800,000 Program

The $800,000 monitoring program would employ the same 30 marine stations as the $500,000 program (Figure 5) but extends the subtidal and intertidal elements by sampling twice per year. In addition, community structure would be assessed at all 30 subtidal and intertidal stations, and population growth and dynamics would be examined in two intertidal species. The number of terrestrial transects would be increased from two and four to three and six.

In the largest program, tissue chemistry sampling would be expanded from two to three species in the subtidal section (a predator such as a demersal fish species) and expanded from one to two species in the inter-tidal section (a carnivorous species such as the snail *Nucella*). Community structure studies would be added to the intertidal element as well.

C. PRELIMINARY COST ESTIMATES

Preliminary cost estimates by study element for each of the three programs are summarized in Tables 3, 4, and 5. Unlike most situations, the present programs were developed around fixed, maximum costs, rather around a fixed, minimum scope of work. Thus, obtaining a balance between scope of work (including technical tasks, number of stations, and number of surveys) and the three potential funding levels consisted of countless iterations of changing the number of stations and program elements to meet the funding levels.

The following cost estimates are necessarily very approximate; any of the unit costs described below can change in the next few years and weather and logistical difficulties could severely impact actual costs. The following assumptions were used in establishing the "unit costs" of Tables 3, 4, and 5.

Table 3. Preliminary cost estimate, $200,000 program.

PROGRAM ELEMENT	NO. UNITS	UNIT COST	SUBTOTAL
A. Mussel Watch, one survey			
Field Days	11	5000	55000
Arrays	20	250	5000
Tissue Chemistry – 18 stations			
Number replicates	54	230	12420
B. Subtidal Sediments, one survey			
Field Days	6	5000	30000
Sediment Chemistry – 18 stations			
Number replicates	54	200	10800
Tissue Chemistry – 1 sp, 12 stations			
Number replicates	36	230	8280
Infauna			
Number replicates			
C. Intertidal Studies, one survey			
Field Days	6	3000	18000
Sediment Chemistry – 12 stations			
Number replicates	36	200	7200
Tissue Chemistry – 1 sp, 12 station			
Number replicates	36	230	8280
Population Growth			
Number replicates			
Community Structure			
Number quadrats			
D. Terrestrial Vegetation, one survey			
Field Days	3	2000	6000
Soil Chemistry – 15 stations			
Number replicates	45	150	6750
Community Structure – 15 stations			
Number quadrats	45	280	12600
E. Analyze and Report			25000
PROGRAM TOTAL			$205,330

Table 4. Preliminary cost estimate, $500,000 program.

PROGRAM ELEMENT	NO. UNITS	UNIT COST	SUBTOTAL
A. Mussel Watch, one survey			
Field Days	18	5000	90000
Arrays	33	250	8250
Tissue Chemistry – 30 stations Number replicates	90	230	20700
B. Subtidal Sediments, one survey			
Field Days	15	5000	75000
Sediment Chemistry – 30 stations Number replicates	90	200	18000
Tissue Chemistry – 2 spp, 20 stations Number replicates	120	230	27600
Infauna Number replicates			
C. Intertidal Studies, one survey			
Field Days	20	3000	60000
Sediment Chemistry – 20 stations Number replicates	60	200	12000
Tissue Chemistry – 2 spp, 20 stations Number replicates	120	230	27600
Population Growth – 2 spp, 20 stations Number replicates –	120	140	16800
Community Structure Number quadrats			
D. Terrestrial Vegetation, one survey			
Field Days	6	2000	12000
Soil Chemistry – 30 stations Number replicates	90	200	18000
Community Structure – 30 stations Number quadrats	90	350	31500
E. Analyze and Report			45000
PROGRAM TOTAL			$462,450

Table 5. Preliminary cost estimate, $800,000 program.

PROGRAM ELEMENT	NO. UNITS	UNIT COST	SUBTOTAL
A. Mussel Watch, one survey			
Field Days	18	5000	90000
Arrays	33	250	8250
Tissue Chemistry – 30 stations			
Number replicates	90	230	20700
B. Subtidal Sediments, two surveys			
Field Days	20	5000	100000
Sediment Chemistry – 30 stations			
Number replicates	180	200	36000
Tissue Chemistry – 2 spp, 20 stations			
Number replicates	240	230	55200
Infauna – 30 stations			
Number replicates	180	750	135000
C. Intertidal Studies, two surveys			
Field Days	20	3000	60000
Tissue Chemistry – 2 spp, 20 stations			
Number replicates	240	230	55200
Sediment Chemistry – 20 stations			
Number replicates	120	200	24000
Population Growth – 2 spp, 20 stations			
Number replicates	240	140	33600
Community Structure – 30 stations			
Number quadrats	180	280	50400
D. Terrestrial Vegetation, one survey			
Field Days	9	2000	18000
Soil Chemistry – 45 stations			
Number replicates	135	200	27000
Community Structure – 45 stations			
Number quadrats	135	140	18900
E. Analyze and Report			65000
PROGRAM TOTAL			$797,250

1. The cost estimates assume first that all work will be conducted using local, Alaska personnel, equipment, and services; no significant travel time and fares are included.

2. A $5,000 field day for mussel watch and subtidal elements includes:

   a) A 50-foot vessel with winch, fuel and lubes, and one deck hand for a 12-hr working day -- $3,500.

   b) A scientific party of three for a 10-hr day, at an average wage of $35 per hr per person -- $1,050.

   c) Daily food, equipment, and expendables costs of $450.

3. Tissue chemistry analyses ($230 per sample) include appropriate digestion and extraction procedures as well as analysis for hydrocarbon amount and source and two or three trace metals.

4. Sediment chemistry analyses ($200 per sample) include fewer digestion and extraction procedures than tissue, but are subjected to analysis for hydrocarbon amount and source.

5. A $3,000 field day (intertidal studies) includes:

   a) A 35-foot vessel, fuel and lubes for a 12-hr working day -- $1,500.

   b) A scientific party of three for a 10-hr day, at an average wage of $35 per hr per person -- $1,050.

   c) Daily food, equipment, and expendables costs of $450.

6. A $2,000 field day (terrestrial vegetation) includes:

   a) Transportation to site (airfare or travel time and vehicle) of $300 per day.

   b) A scientific party of four for a 10-hr day, at an average wage of $35 per hr per person -- $1,400.

   c) Daily food, equipment, and expendables costs of $300.

7. The "soil chemistry" estimate ($200 per sample) as used for marine sediment analyses, with additional analysis for 2-3 trace metals.

8. The "community analysis" entry under terrestrial vegetation assumes that it will take 4 hours per quadrate (at $35 per hour) to enter and reduce data and to perform preliminary analyses.

9. The $750 per 0.1 m^2 infaunal sample is high in order to compensate for the variability and unpredictability of infaunal samples. This estimate should be enough to provide for data entry (into computer spreadsheet files) as well as data reduction, computation of statistical community parameters, and preliminary analyses.

10. The $140 per replicate for intertidal population and growth studies assumes that it will take 4 hours per replicate (at $35 per hour) to measure and weigh specimens, to enter and reduce data, and to perform preliminary analyses.

11. The $280 per quadrate for intertidal community structure studies assumes that it will take 8 hours per quadrate replicate (at $35 per hour) to enter and reduce data and to perform preliminary analyses.

D. RECOMMENDED PROGRAM MODIFICATIONS

Scaling of Monitoring Effort

In effect, the programs outlined above assume that one fixed level of funding would be available in the first and all subsequent years of the multi-year effort and that all allotted monies would have to be spent in that year. Ideally, several years (total) funding could be allocated among years at the discretion of the investigators and the Council.

Experience in pollution-prone areas of England (Smith 1968), Scotland (Pearson 1972, 1975; Pearson and Roxenberg 1978) and California (Straughan 1971) suggests that after the completion of an initial study, selected stations should be examined regularly for several years to determine changes in species content, diversity, abundance, and biomass (Feder 1980). However, the aims, strategies, and methods of monitoring should be reappraised annually in light of current information and future needs. Sampling should be extensive and detailed in the first year in order to establish a thorough baseline. For example, a complete chemical analysis could be done area-wide the first year to establish initial conditions. Thereafter the number of stations and level of chemical analysis can be reduced, in order to increase the precision and sensitivity of monitoring and to focus on those areas found to be hotspots. Every five years the detailed chemical analysis and station array could be conducted to determine if baseline conditions persist. Money not spent during the 2nd, 3rd, and 4th years of monitoring could be allocated to the 1st and 5th years.

Special consideration should be given to increasing the precision and sensitivity of monitoring the more sensitive and more vulnerable species. Indigenous or resident animals of the same species may not be found in sufficient numbers at all stations for continued analysis. A first year of intensive sampling analysis may provide more information as to the availability of indigenous species.

Expanded Study Area

As pointed out by numerous scientists, local residents, and commercial fishermen, Cook Inlet is not isolated from the surrounding areas. Kodiak, Shuyak, and Afognak Islands, the Kodiak Shelf, and Shelikov Straits in particular are intimately connected to Cook Inlet oceanographically and they act as a sink for suspended sediments (and contaminants) which originate in Cook Inlet. For this reason and because the area west of Cook Inlet is an important commercial fishing area, it is recommended that station there be sampled if and when a monitoring program is implemented, even though it is beyond the boundaries of CIRCAC's jurisdiction. Incorporation of these areas into the proposed program from the very beginning will be cost-effective in the long run.

E. ANALYSIS OF RESULTS

A comprehensive monitoring program depends on sufficient long-term data and the magnitude of natural population fluctuations in order to identify long-term trends. Such a database is not now available but the monitoring program will form the basis for assembling the appropriate information.

Once an adequate baseline has been established (via sufficient replication of a single parameter and assessment of natural or induced variability), the actual monitoring phase of the program can proceed as intended. The between years results can be compared qualitatively and quantitatively to the baseline information. Also, the concentration of contaminants, if detected, should be compared whenever possible to concentrations used in toxicity tests with the same species. For example, Stekoll *et al.* 1980 found that exposure of the bivalve *Macoma* to oil-in-seawater concentrations as low as 0.03 mg^{-1} will in time lead to population decreases. If the measurable concentrations of contaminants are similar or are projected to approach to those levels found to be detrimental in previous studies, or if demonstrable increases in petroleum hydrocarbons levels (in the sediments and/or animal tissues) occur over time, particularly in a short amount of time, and changes in biotic community structure take place, essentially, it is cause for "a flag to go up" alerting investigators of the first stages of possible impacts from chronic contamination. Attempts should then be taken to verify the findings and to notify all appropriate personnel.

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APPENDIX A: MUSSEL WATCH

This appendix constitutes a guidance document pertaining to the proposed "mussel watch" program for Cook Inlet. In some cases the recommendations are very specific; in others, they are general or not yet finalized. In either case, they are subject to modification; the annotated outline will be refined for the final report.

A. DEPLOY ARRAYS AT EACH STATION

Arrays (preferably with subsurface acoustic release buoys) must be deployed at each station prior to deployment of mussels. Mussel cages should be constructed of inert materials and large enough to hold the requisite number of organisms without crowding.

When mussels are deployed, the location of each numbered set should be recorded.

B. LOCATE SOURCE FOR TEST ORGANISMS

An uncontaminated area must be found with sufficient numbers of collectable mussels. Subtidal mussels tend to have more uniform growth rates than those from the intertidal zone and are preferable over intertidal specimens (Lobel *et al.* 1991).

1. Collect sufficient number of mussels

Fast-growing mussels tend to have lower contamination levels per *mg* tissue than near-maximum-length mussels due to the "dilution" effect by more tissue. It cannot be assumed that mussels of the same length from different sites are the same percent of maximum length or the same age. The width: height ratio is generally a better indicator of relative growth rate (and hence dilution) than length alone, and therefore is worth considering in a mussel watch program where many sites are being examined with possibly different growth rates. Generally young, fast-growing mussels have a width: height ratio of about 0.6-0.8 while older mussels have a typical ratio of 1.0-1.1 (Lobel *et al.* 1991).

2. Prepare mussels

a) Select mussels of correct size range

Variance due to size/age can be reduced by compositing a large number of mussels and by using a consistent size range at all sites. However, it is also important to document the size and width: height ratio for individuals in each set.

i) Use mussels 5-8 cm

ii) Use mussels of uniform size

iii) Avoid extra large mussels

iv) Separate into sets of 60; measure (length and width) record all individuals in each set. One to three sets should be kept for analysis of predeployment levels.

b) Clean of all encrusting organisms

i) Allocate into sets keeping track of numbered sets

ii) Allow at least 25 mussels per set (International Mussel Watch 1980)

iii) Maintain in deployment cages in seawater

C. DEPLOY NUMBERED SETS AT EACH STATION

1. Keep track of which set goes where

2. Record observations

D. MUSSELS SHOULD BE RETRIEVED AFTER THREE MONTHS

1. Avoid contamination from boat exhaust, retrieval gear, contact on deck, etc.

2. Measure length and width of each set to determine relative growth; count the number of live and dead mussels.

3. Recheck set number.

4. Rinse mussels in clean water, freeze, transport to lab.

E. LABORATORY CONSIDERATIONS

1. The removal of tissue from shells and all other preparations for analysis must be done under clean conditions using clean methods.

2. Composite appropriate number of individuals for three replicate samples from each station; process and analyze.

3. Tissues should be analyzed for petroleum-derived hydrocarbons; percent moisture and lipids should be assayed.

Appropriate quality assurance and quality control during both sampling and analytical procedures cannot be over-emphasized; follow procedures endorsed by NOAA's Status and Trends Program and/or the International Mussel Watch Program.

Expressing the results in dry weight will avoid the introduction of variability due to the moisture content of tissue, a factor which varies greatly. For example, mussels collected in 1985-1986 in California ranged from 75 to 90% moisture (SWRCB 1987). Most mussel watch studies do report results in dry weight (or in both dry and wet weight) as well as in per lipid weight to enhance comparability to other studies.

After each year of monitoring, the natural variability can be determined and further calculations made to estimate the number of replicates needed to determine statistical differences among stations.

APPENDIX B: SUBTIDAL SEDIMENTS

This appendix constitutes a guidance document pertaining to the proposed subtidal sediments element for Cook Inlet. In some cases the recommendations are very specific; in others, they are general or not yet finalized. In either case, they are subject to modification; the annotated outline will be refined for the final report.

The proposed subtidal sampling project comprises three separate study elements: sediment chemistry, bioaccumulation of petroleum hydrocarbons, and the analysis of infaunal community structure. Given the cost constraints of the Cook Inlet monitoring program, sediment chemistry and bioaccumulation are conducted in the $200,000 and $500,000 programs; infauna would only be examined in the $800,000 program.

1. Sediment Chemistry

The clay mineral deposits in lower Cook Inlet can be traced back to the Copper and Susitna Rivers. There is a net inward movement of oceanic water and suspended material along the eastern shore of Cook Inlet and a net outward movement of mixed oceanic and runoff water with suspended matter along the western shore (Muench *et al.* 1978). Thus, the bulk of the mud deposits settle along the western shore and throughout Shelikof Strait (Feely *et al.* 1979 in Venkatesan and Kaplan 1982).

It appears that the deposition of lipids, hydrocarbons, and organic carbon in the Shelikof Strait is consistent with the above postulated net circulation pattern of the water and suspended matter. Thus, any significant petroleum hydrocarbon release from an oil spill, due to natural seepage or production activity in upper Cook Inlet could be dispersed to and deposited in lower Cook Inlet and Shelikof Strait (Venkatesan and Kaplan 1982). The most direct way to verify this is to measure hydrocarbon accumulations in the sediments.

In 1978-1979, two stations in Cook Inlet, north of Kalgin Island 1978, displayed *n*-alkane UCM profiles typical of weathered petroleum (Wakeham and Carpenter 1976, Farrington *et al.* 1977, Venkatesan *et al.* 1980; in Venkatesan and Kaplan 1982). Verification of the source of hydrocarbons in lower Cook Inlet and/or Shelikof Strait will require GC analyses to separate petrogenic hydrocarbons from those of biogenic and terrestrial origins. A variety of terrestrial (detrital) plant wax is known to accumulate in Cook Inlet, especially Kamishak and Kachimak Bays (Venkatesan and Kaplan 1982).

2. Infaunal Bioaccumulation

Subtidal sediments are an important sink for contaminants transported in seawater. Because the contaminants accumulate at the seafloor, organisms which live in or on the seafloor are among the first expected to bioaccumulate contaminants in their tissues. Many, if not, most benthic species consume sediments directly, or feed on the suspended organics which lie at the sediments surface; thus, they are not only in direct contact with contaminated sediments, but they ingest those sediments, thereby increasing the likelihood that they will assimilate contaminants into body tissues.

These "first-order" consumers thus represent one of the first potential steps in the food-chain process of bioaccumulation and biomagnification in which contaminants are passed from one trophic level to the next, potentially through predators such as halibut to man. The contaminants may or may not have adverse effects at any trophic level, but the mere presence of elevated contaminant levels constitutes the early warning which monitoring programs are intended to provide.

Subtidal bioaccumulation studies are proposed for the $500,000 and $800,000 Cook Inlet monitoring programs. In the lesser effort, one species would be collected at each of about 12 of the 18 stations. Costs limit the number of stations to be sampled, but it is also likely that only 12 of the 18 stations will support sufficient organisms to provide the requisite amount of tissue.

The target species of choice in the $500,000 is the clam *Macoma balthica*, which is fairly common/abundant in Cook Inlet. It is a surface deposit feeder; it has been used previously in bioaccumulation work; and it occurs in the low intertidal habitat as well as offshore, subtidally. *Macoma* has been examined in Port Valdez and was shown to be a good indicator of oil pollution (Shaw *et al.* 1976). Thus, comparisons can be made to historical tissue burden levels; from year to year in the present study; among stations in the present program; and between the subtidal and intertidal habitats.

The target subtidal species will have to be collected with a small scientific bottom dredge in order to collect sufficient numbers to composite three replicate samples for tissue chemistry analysis. It is not expected that *Macoma* will be available at all targeted stations. However, a reasonable field effort should be made to collect specimens. For example, if six 10-minute hauls are made and no *Macoma* are collected, another species should be targeted. If the first four hauls produce enough tissue for one composite replicate, additional hauls should be made until enough specimens for at least a second composite tissue are collected. In anticipation of "cancelling" the preferred species at any station, all catches at each station should be retained until it has been determined what species will be used. The alternate (which should also be a first-order, filter or surface-detritus feeder) target may be sufficiently abundant in the first few hauls that no more or only a few more have to be made.

It is proposed to sample two benthic species in the $800,000 program for bioaccumulation analyses. The second primary target species of choice would be a second-level consumer, such as a crab, and its alternative should be of the same tropic level. Whatever species are selected would become the second and third alternatives (third and fourth choices) in the $500,000 program. Third and perhaps fourth choices should also be named for the second-order consumer of the $800,000 program.

3. Infaunal Community Analyses

Sediments are the ultimate sink for most contaminants in the marine environment, including petroleum hydrocarbons from crude oil. Most contaminants bind to suspended particulate matter and eventually settle to the seafloor where they may persist for decades. Once in the sediments, the pollutants may be incorporated into animal tissues directly through body surfaces or by way of ingestion and assimilation. The cumulative impact on individuals of a species affect that species' population; cumulative changes in several species' populations alter, by extension, the benthic community structure a whole.

Although the marine benthos (infauna and epifauna) is of little direct concern to humans, it is the first step of bioaccumulation and biomagnification in many food webs. There is a direct relationship between trophic structure (feeding type) and bottom stability (Rhoads 1974). The most common infauna of Cook Inlet are suspension or deposit feeders and these same infauna are food of commercially important fish and shell fish of the region. Thus, oil-related impacts to the near-bottom sediment regime could alter infaunal species composition, and by extension, the food webs which support commercial fishing.

The various community-wide analyses referenced above are routinely performed in thousands of monitoring programs nation-wide. These biological analyses are based on the identifying and counting all individuals collected in a standard unit-area of soft sediment from each station. Physical-chemical data describing the immediate environment at the station are also desireable, primarily so they can be used to explain the natural or background variance in community parameters. Sediment grain size and the amount of physical disturbance; the amount of organic carbon; and a measure of near-bottom dissolved oxygen are among the most important determinants of infaunal community structure under "normal" conditions.

Natural environmental variability (of physical-chemical and biological parameters) is probably the greatest impediment to the general usefulness of community analyses in ascribing impacts to a particular cause. The population and community structure monitoring element will minimize the problems associated with environmental variability by:

- concentrating on infauna
- collecting sufficient number of replicates
- carefully matching of sediment characteristics to infauna
- sampling stations at various distances from oil sources

It is both costly and time consuming to sort, identify, count, and interpret large species lists from numerous samples, but it is necessary to get an accurate picture of the benthos. Analysis, on the other hand, will emphasize changes in relatively few indicator species and generally abundant taxa. Those forms indicative of pollution tend to tolerate low oxygen levels, have high biotic potential, and small size.

The range of analytical methods which should be attempted includes: 1) Univariate methods, in which, for example, the relative abundances of the different species at each site or time are reduced to a single index which values are then compared using classical ANOVA; 2) Graphical distributional methods, in which the relative abundances or biomasses of different species are plotted as a curve; and 3) Multivariate methods of classification and ordination which compare communities on the basis of the identity of the component species as well as their relative importance in terms of abundance or biomass. For graphical and multivariate techniques, ANOSIM can also be applied (Warwick and Clarke 1991).

Multivariate analyses should be performed routinely, both to reduce data and simplify its presentation, and to elicit relationships between biotic and abiotic parameters. The use of numerical methods to determine the distribution of the benthic fauna has been described by many authors (Day and Field 1971). The ancillary physical-chemical data, sediment hydrocarbon contaminant levels, and bioaccumulation data for each station must be combined with the community structure information to present an integrated analysis of the amount and effects of oil contamination at each station.

Proposed Sampling Program

Five replicate sediment samples will be obtained at each station, in water depths of 45 to 60 feet. (Appropriate areas of soft sediments in station "area" may have to be located initially by trial and error; Loran C or other coordinates should be recorded to ensure subsequent re-sampling of the same habitat.)

Samples are to be obtained with a "grab" which samples 0.1 m^2 of surface area to a depth of 10 cm. (Grabs not penetrating 10 cm or showing marked surface disturbance are not retained.) A standard Van Veen or Smith-McIntyre grab may work; a large spade or box corer may be required at some locations. All samples and subsamples will be labelled with a minimum of date, station number, and replicate number.

Replicates A, B, and C will subsampled first with a small core for: 1) grain size and total organic carbon, and 2) detailed hydrocarbon analysis. The bulk of these samples will be screened for infaunal analyses. Similar subsamples will be taken from replicates D and E and will be archived (frozen) for possible future use; the screened portions will be fixed and archived for possible future use.

The infauna portions of all grabs will be screened on 0.5 mm screen, fixed in formalin, and transferred to alcohol within 48 hours. In the laboratory infauna will be sorted from debris, identified to the lowest practical taxon, and counted. Initially only replicates A, B, and C will be analyzed; replicates D and E will be archived, to "replace" unrepresentative samples, for program QA/QC, to verify questionable results, or to increase the database.

Sediment Grain Size

Sediment grain size is a major determinant of the suitability of the seafloor for most species; thus grain size indirectly affects community structure also. Furthermore, PAHs, as well as many other organic contaminants, covary with the amount of fine material (silt and clay) in the sediments (Battelle 1985). The hydrocarbon content of marine sediments in Alaska is generally higher nearshore and decreases offshore, except in the southeastern Bering Sea, where hydrocarbons are low in coarse-grained nearshore sediments and higher in fine-grained sediments near the shelf edge (Venkatesan and Kaplan 1982).

APPENDIX C: INTERTIDAL STUDIES

This appendix constitutes a guidance document pertaining to the proposed Intertidal Studies component of the Cook Inlet monitoring program. In some cases the recommendations are very specific, in others they are general or not yet finalized. In either case they are subject to modification; the annotated outline will be refined for the final report.

The proposed intertidal monitoring studies of Cook Inlet comprise four separate sub-elements: 1) Sediment Chemistry; 2) Tissue Burden Levels; 3) Population/Growth Studies; and 4) Community Structure. These four elements are arranged in the order of their sensitivity to detecting and quantifying potential hydrocarbon contamination in the intertidal habitats of the study area.

There are at least four distinctly different intertidal habitats of interest in Cook Inlet: rocky, sand/gravel, mudflat, and saltmarsh. Each should be sampled since there is some chance of oil accumulating in each and thus the potential for impacts. Because the four are so different physically, different sampling techniques and different target organisms must be established for each.

Above all the proposed programs attempt to make the sampling efforts and resulting data types as similar as possible among stations. Thus, sediment would be collected and analyzed when sedimentary material is present; bioaccumulation will be examined in at least one species at most stations; and population dynamics and community structure will be studied (in the more costly programs) at all stations, even though the organisms studied will differ. With comparable databases among all stations or all habitats, data presentation and analyses can be comparable.

Univariate methods will be applied to all datasets: for example, by using the relative abundances of species at each site to calculate a diversity index and ANOVA to partition variance. Graphical techniques will be used to describe distributional information as single or multiple curves and multivariate methods of classification and ordination will be used to compare the component species of communities and define their relative importance in terms of abundance or biomass. Other analysis of similarity (ANOSIM) techniques should be applied as appropriate (Warwick and Clarke 1991)

Multivariate analyses should be performed routinely, both to reduce data and simplify its presentation, and to elicit relationships between biotic and abiotic parameters. The use of numerical methods to determine the distribution of the benthic fauna has been described by many authors (Day and Field 1971). The ancillary physical-chemical data, sediment hydrocarbon contaminant levels, and bioaccumulation data for each station must be combined with the community structure information to present an integrated analysis of the amount and effects of oil contamination at each station.

Sediment Chemistry

The intertidal habitat of most apparent interest to most people is the rocky intertidal, where offshore kelp and the rich flora and fauna in tidepools and surge channels as well as marine birds and mammals give provide a special aesthetic appeal. However, chronic, low-level oil pollution (whether floating at the surface or suspended in the water column) does not tend to accumulate in such high-energy environments. Although there are pockets of sand and finer material among the tidepools and crevices, the distribution of oil contamination is expected to be very patchy in the rocky intertidal. Therefore intertidal sediments for chemical analysis will only be collected at approximately 12 of the 18 marine stations of the $200,000 program. These will probably be limited to central and upper Cook Inlet, in salt-marsh, mudflat, and sand beach habitats.

Three replicate sediment samples will be obtained at suitable stations, one from within each of the quadrats targeted for sampling in the $500,000 and $800,000 programs.

Tissue Burden Levels

Exposure to oil does not always result in population- or community-level changes. Therefore it is advisable to measure hydrocarbon levels in the tissue of select organisms. The methods of preparation and chemical analyses should be EPA-approved as described in the mussel watch and subtidal bioaccumulation elements.

As in the subtidal environment, first-order consumers (grazers) will be the first species of choice for bioaccumulation analysis in the intertidal. A second-order consumer will also be targeted in the two more costly programs. Because there are several different, but equally important, intertidal habitats, different species will be targeted at different groups of stations. Every effort should be made to limit the number during the first survey and to continue sampling the same species in subsequent years. Potential target species in the rocky intertidal include periwinkle snails (*Littorina* spp.) and various limpets (*Collisella* = *Lottia* spp.). In sandy intertidal habitats the hard-shelled clam *Macoma balthica* will be the first target and *Protothaca* sp. will probably be second.

It is uncertain what first-order consumers will be targeted on mudflats or in salt-marshes. Likewise, the second-order target species in all four habitats will be selected and suggested during preparation of the final project report.

Population/Growth Studies

Potential target species for the determination of size frequency data and growth rates include the same primary targets as the bioaccumulation element: periwinkle snails (*Littorina* spp.), various limpets (*Collisella* = *Lottia* spp.), and hard-shelled clams (*Macoma* and *Protothaca*).

One or two species will be selected at each site and each of the two tidal elevations. One hundred or more randomly selected individuals of each will be collected from areas adjacent to but outside the permanently marked transects and quadrats. Individual length and weight measurements will be made of the sample in order to provide an index to correlate with the bioaccumulation levels for the same size

APPENDIX D.

For years air pollution scientists have defined and described the effects of air pollution on plants. Generally, the detrimental effects of airborne contaminants have been defined in terms of plant injury or damage (Koppe 1973). Plant injury is usually detected by the presence of visible symptoms or discolorations, and can be described as acute or chronic depending on the concentration of the pollutant and the duration of exposure. Severe or acute injury may result from a short exposure to a high pollutant concentration. When plants are exposed to continuous or repeated concentrations of pollutants, injury is very slow to develop. It is often referred to as chronic injury and is not always readily visible. For example, chronic injury may resemble normal plant senescence. When an area is exposed to acute or chronic levels of pollutants for prolonged periods, the entire plant community may be affected, permanently altering the ecosystem.

Attempts have been made to correlate the extent of plant injury with the concentration of pollutant causing the injury and to use plants as a substitute for air monitoring instruments. However, using plant condition by itself as an environmental indicator of air quality is difficult due to the synergistic effects of air pollutants and the interaction of environmental factors that influence plant growth and development. Plant condition as an indicator of air quality must thus be used in concert with measures of pollutant concentrations in the environment.

Field Surveys

Vegetation over a wide area should be visually inspected for air pollution injury. Field surveys have been used for observing the effects of sulfur dioxide near various sources, in assessing episodes of photochemical smog and the spread of photochemical pollutants, and in quantifying the effects of heavy metals on plant communities. Field surveys may be developed into a surveillance program where a wide range of plant species in defined areas are periodically inspected to continually assess plant health. This assessment includes both the identification of injury and its severity.

When field surveys are combined with information on the concentration of pollutants in sediments in the area, several evaluations may be possible.

1. The determination that the injury observed resulted from a specific pollutant or from some other causative agent.

2. A determination of the meteorological and topographical characteristics of the area, the source of the pollutant and the dispersion and distribution of the pollutant source.

3. A comparison of the species in the area and the numbers of plants injured within a species.

4. A description of the type of injury present and the frequency of new injury development.

5. The susceptibility of the terrestrial ecosystem to the pollutants.

Transects will be placed in a radiating pattern form the facilities at Nikiski and at Drift River. The transects will be positioned to account for prevailing wind patterns, and local topography and plant communities. Each transect will have 5 stations along its length: one as close to the source as possible and one every mile from one to four miles from the source. At each station, three replicate quadrats ($2m^2$) will be selected at random and permanently marked. Surface sediment samples will be taken at each quadrat and analyzed for hydrocarbons using gas chromatography, and for lead, cadmium, and arsenic using acid extraction methods.

The terrestrial surveys for the 200, 500, and 800K programs will involve simply increasing the number of transects that are studied. In the 200K survey, three transects will be monitored annually: two at Nikiski and one at Drift River; in the 500K survey, six transects will be monitored: four at Nikiski and two at Drift River; and in the 800K survey, nine transects will be monitored: six at Nikiski and three at Drift River.

The transects will be monitored annually in the spring when vegetation is most susceptible to pollution. Although some contaminants do not accumulate in sediments and therefore can not be analyzed in the proposed element, it is assumed that atmospheric deposition will be similar for all chemical species. Thus, the effects of a variety of chemical contaminants will be recorded.

Each quadrat will be photographed and the vegetation will be visually inspected for signs of pollution damage.

The results will be compared to atmospheric analyses of the refinery effluent conducted by the Tesoro refinery and state and federal agencies. Contaminant levels will be discussed in light of distance from the refinery, prevailing wind patterns, and the physical appearance and health of the vegetation.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

RPWG
Y

DATE: June 17, 1992

MEMORANDUM FOR: Heidi Sickles

FROM: John Strand

SUBJECT: RFP - Coordination and Development of a Comprehensive and Integrated Monitoring Plan for the *Exxon Valdez* Oil Spill Area

Pursuant to our recent telephone conversation, please find enclosed the subject RFP and supporting information for use in requesting the services of a qualified contractor. Hopefully, this will allow you to begin the process. I also initiated with WASC's Finance Division the process to establish a cost account for this procurement. Finally, I am including in the package a numerical rating form that incorporates evaluation factors and award points that will be used by an Evaluations Committee in grading and ranking each proposal. A Procedures for Evaluation of Technical Proposals is also available. Give me a call if there is need to review this document. Thank you.

Enclosures: RFP
IAG - EPA/NOAA (copy)
Form CD-435
Form SEC-970 and attachment
Form DAO 216-13
Proposal Rating Form (numerical)

CC: Byron Morris
RPWG (w/o attachments)

Barbara:
CC: RPWG members
thanks
Jo

RPWG
Y

FINAL PROJECT PLAN
PRINCE WILLIAM SOUND
REGIONAL CITIZENS' ADVISORY COUNCIL
ENVIRONMENTAL MONITORING PROGRAM

Prepared for:

Prince William Sound
Regional Citizens Advisory Council
Scientific Advisory Committee
601 West 5th Ave. Suite 500
Anchorage, AK 99501-2254
(907) 277-7222

Prepared by:

Kinnetic Laboratories, Inc.
403 West 8th Ave.
Anchorage, AK 99501-3515
(907) 276-6178

FINAL PROJECT PLAN
PRINCE WILLIAM SOUND
REGIONAL CITIZENS' ADVISORY COUNCIL
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REGIONAL CITIZENS ADVISORY COUNCIL
ENVIRONMENTAL MONITORING PROGRAM

1.0 INTRODUCTION

The purpose of the proposed project is to identify present and potential future adverse impacts on the ecosystems of Prince William Sound (PWS) and the Gulf of Alaska (GOA) represented by the Regional Citizens' Advisory Council (RCAC) as a consequence of oil transportation. The program concentrates its effort on determining hydrocarbon concentrations and accumulations in intertidal biota and nearshore sediments. The program covers the areas of Port of Valdez, Prince William Sound, and the Gulf of Alaska to document the full geographical extent of any present and potential future impacts due to oil transportation.

The program consists of two specific tasks that combine chemical and biological assessment tools to help determine present conditions and potential future impacts of oil transportation on ecosystems within the project area. These tasks are as follows:

- Chemical Assessment of Sediment - determine the existing hydrocarbon concentrations and characteristics in sediments from nearshore subtidal areas

- Biological - assess potential bioaccumulation of hydrocarbons in intertidal organisms by determining hydrocarbon levels in mussel tissue.

These two tasks form a basic approach that has proved extremely successful for other marine monitoring programs such as the National Oceanic & Atmospheric Administration's (NOAA) National Status and Trends Mussel Watch Project. By employing these tasks in a quantitative and statistically rigorous manner, Kinnetic Laboratories Inc. (KLI) will provide to RCAC quality products identifying present and potential adverse impacts of oil transportation that can be used to recommend mitigation measures for the future.

The study plan incorporates likely sources of hydrocarbon contamination in the study area and includes both historical or long-term inputs and the major release of petroleum into the ecosystem of the study area by the T/V *EXXON VALDEZ* in 1989. Contaminant inputs will be evaluated through analysis of samples collected from areas considered pristine as well as those known to be impacted by petroleum contaminants through point-source inputs. For example, sampling will be conducted in Port Valdez to provide information on hydrocarbon contamination which may be attributed to the Alyeska Pipeline Service Company's Ballast Water Treatment Plant, as well as in areas impacted by the *EXXON VALDEZ* oil spill (EVOS). Point Sources of detected hydrocarbons will be determined by hydrocarbon fingerprinting techniques. Control areas will also be sampled for statistical comparison and to provide baseline information. In the event of another oil spill or similar incident in the project area, project data will be invaluable in providing baseline data, allowing the prediction and evaluation of potential impacts, and providing information concerning recovery from potential impacts.

It is envisioned that the study would be conducted over a long-term period to establish both spatial and temporal variations between sampling locations. Sampling would be performed semi-annually during the winter (March) and summer (July-August) months.

2.0 STUDY DESIGN AND APPROACH

This project is designed to determine both recent and long-term effects of oil transportation and provide information on potential future impacts in the study area. As indicated above, a basic "mussel watch" monitoring approach that incorporates both chemical and biological components will be used to meet project objectives. The project will utilize state-of-the-art analytical methods for hydrocarbon analyses and fingerprinting and proven environmental monitoring techniques. Sampling and analytical methodologies will be consistent and comparable to those utilized in NOAA's National Status and Trends Mussel Watch Project and in *EXXON VALDEZ* assessment studies that have been conducted and some of which are currently ongoing. Sampling sites for the collection of sediment and biota will be located throughout the study area to help define hydrocarbon concentrations, characteristics, and effects in both impacted and non-impacted (control) areas.

The ecological monitoring program is designed to determine present impacts, baseline conditions, and potential impacts of future oil transportation in terms of:

- Hydrocarbon concentrations and characteristics (degree of weathering) in nearshore subtidal sediments from the study area, including impacted and control sites

- Bioaccumulation of hydrocarbons in the tissue of mussels collected intertidally from the study area.

As described in the sections that follow, a proven scientific approach will be used to accomplish these objectives. The proposed project is designed to be flexible in nature so that data from the initial survey can be used to tailor subsequent project activities. This approach allows control of project scope and costs while providing high quality results that are specific to RCAC's needs.

2.1 Statistical Design

The main purpose of the proposed project is to identify present and potential future impacts of oil transportation on the ecosystems of Prince William Sound, Port Valdez, and Gulf of Alaska. To meet the above objective, a sampling program will be conducted that is designed to provide data sufficient to test the following four overall null hypotheses:

H_o1: There are no changes in biological (bioaccumulation), chemical, or physical, variables with time at various monitoring sites.

H_o2: Observed changes in biological, chemical, or physical variables at various monitoring sites are not correlated with oil transportation activities.

H_o3: There are no differences in biological, chemical, or physical variables between monitoring sites (affected and control sites).

H_o4: Observed differences between monitoring sites are not correlated with oil transportation activities (Alyeska Marine Terminal, EVOS, or other tanker activities).

The first two hypotheses examine temporal variations and trends at individual monitoring sites. The last two hypotheses examine spatial differences and address existing impacts or impacts that may occur over the duration of the sampling program. These four null hypotheses incorporate all essential features necessary to address the objectives of the program. We feel that these particular hypotheses are the simplest possible answers to the critical study objectives and are both testable and falsifiable, with the fewest possible unknowable explanatory factors.

Rejection of the first null hypothesis and acceptance of the alternative hypothesis, H_a1, will demonstrate at a specified significance level that annual or longer-term temporal variation in one or more environmental variables does exist at one or more of the monitoring sites. Testing of this hypothesis can be performed with reference to each biological, chemical, or physical parameter of interest. Although we will be testing a hypothesis of no change, it is expected from previous experience that biological parameters, in particular, will vary with time.

Rejection of the second null hypothesis and acceptance of the alternative hypothesis, H_a2, will demonstrate, if corroborated by hydrocarbon fingerprinting analysis, that the observed temporal variation was an impact caused by oil transportation activities. We will attempt to determine the causality of observed biological changes by looking at concomitant chemical or physical changes that are linked to specific oil transportation activities. Hypotheses H_o3 and H_o4 will be treated similar to the first two previously described. In essence, we are combining a "dose response" approach with hypothesis testing as an overall method for detection of environmental impact.

As Green (1979) has stated, controls in both space and time are two necessary ingredients in the design of an "optimal impact study", since evidence for impact effects on the biological community must be based on changes in the impact area that did not occur at the control area. If spatial control is missing and only before and after impact samples from a potentially affected area are available, one runs the risk that a significant change may be unrelated to the impact. Statistical inference methods against which the above hypotheses will be tested will be as conservative, powerful, and robust as possible to minimize Type I errors, Type II errors, or violations of assumptions regarding the nature of the data.

In order to achieve a scientifically defensible product, statistical power must be maximized in an appropriate fashion and beta error (incorrectly accepting a null hypothesis) must be minimized. Unfortunately, even when the most appropriate statistical procedure is applied to a data set, there is no guarantee that it will detect real differences. Factors such as natural variability, sampling bias, improper station location, inadequate replication, inappropriate or unrealistic null hypotheses, inherent limitations (e.g. lack of power) in statistical procedures, etc., may lead to beta error. Some of them cannot be controlled, but a properly designed study can reduce their effects upon the conclusions.

In order to avoid many of these problems, two approaches will be utilized. First, for the mussel tissue analyses, a large number (30) of individual mussels will be collected from each station and each replicate composited in the laboratory. The three tissue samples will then be analyzed from the composited replicates. This procedure is commonly used in bioaccumulation programs and is the standard protocol for NOAA's Mussel Watch Project (Shigenaka and Lauenstein 1988, Boehm et al. 1987). By compositing and analyzing the replicates within a station, the natural variability as well as the mean of the population can be analyzed for each station.

A second approach will be utilized for the sediment analyses. KLI proposes to conduct power analyses on the available databases in the region prior to finalizing the sampling design. Data will include the following historical databases: National Status and Trends Mussel Watch data from Port Valdez and Prince William Sound, Alyeska's NPDES monitoring data, and available data from the various *EXXON VALDEZ* oil spill monitoring programs. In addition, a Pilot Study is planned for the first sampling effort which would include obtaining ten replicates from two of the stations in order to perform an accurate power analysis. The stations would include a site from the eastern part of PWS that was not impacted by the EVOS and another site that was heavily impacted and where higher variability would be expected such as Sleepy Bay. There are two main purposes of the power analysis: (1) to establish realistic criteria and null hypotheses for subsequent statistical analyses, and (2) to determine how many replicates need to be analyzed to meet those criteria.

A power analysis would permit us to state with some certainty how many replicates would need to be analyzed to meet these or other criteria. If natural variability were very high or the values were not normally distributed, more replicates might need to be analyzed or criterion "softened" as described above (e.g. 100% differences in means, or 90% confidence limits) to comply with cost limitations. Since the budget is restricted, the results of the power analysis will directly affect the number of sites that can be examined. If a higher number of replicates per site must be examined to test the main null hypothesis (to differentiate satisfactorily between means), it might be necessary to restrict the number of sites that can be compared. Following the initial power analysis, the study design could be modified for subsequent sampling efforts in order to maintain the most rigorous standards and defensible products.

2.2 Sampling Design

Field surveys will take place twice each year, during late winter (March) and during the summer months (July or August). Samples will be collected at nine locations. Individual mussel (*Mytilus edulis*) samples will be collected from the mid-intertidal zone as three replicates from within each station, composited, and analyzed for polynuclear aromatic hydrocarbons (PAH) and aliphatic hydrocarbons (AHC) and unresolved complex mixture (UCM). Three replicate sediment chemistry samples will be collected in the nearshore area adjacent to each of the intertidal mussel stations and analyzed for PAH, AHC, UCM, particle grain size (PGS), and total organic carbon (TOC). At two of the stations, an additional seven replicate sediment chemistry samples will be collected on the first survey to perform the power analyses previously discussed.

This basic sampling approach is consistent with NOAA's National Mussel Watch Project where native populations of sedentary organisms are utilized as bioindicators of chemical contamination (NOAA 1989). Another method that is sometimes employed, particularly with point source pollutants (e.g. an NPDES effluent discharge), is to transplant mussels or other bivalves from an uncontaminated control area and cage them at the monitoring site. The caged mussel approach has several disadvantages with respect to RCAC's program: (1) caged mussels should be monitored at least quarterly in order to service moorings, (2) caged mussels cannot be utilized for intertidal applications and need to be moored in a subtidal area, (3) since caged mussels are only exposed to water in the water column and not to surface water, they have much less of a chance of coming in contact with hydrocarbons and therefore of detecting any impact. Since the use of natural *in situ* mussels is not directly or statistically comparable to caged mussels, these two approaches cannot be mixed in the same study. Therefore we have opted for the use of natural intertidal mussel populations which will more readily display bioaccumulation of hydrocarbons and are more representative of what is actually taking place in environment.

Data analysis from the first survey (winter - year 1) will be used to direct the sampling and analysis for subsequent surveys. For example, it may be determined that sampling should be increased in intertidal locations to more fully characterize the extent of contamination or that more replicates are needed. The annual project reports will present results and provide recommendations for subsequent sampling and analysis which is needed to meet project objectives. It is expected and desired that RCAC project personnel and KLI scientists be interactive to determine the best sampling and analytical approach for continuation of the program.

2.3 Site Selection and Station Locations

Uptake and accumulation processes are subject to many influences which cannot always be controlled in field environments. To use indigenous organisms from the field to assess bioaccumulation, an assumption must be made that factors which affect bioaccumulation do not vary significantly at different sites. Detailed knowledge and measurement of these factors is desirable in order to accurately assess whether different accumulation rates are due to environmental variables or are the result of contaminants. Before samples taken at different sites can be compared, it is critical to determine that the local environmental variables do not differ enough between sites to effect the hydrocarbon concentrations of the target organism. The variables affecting growth are particularly important. Because environmental growth factors may indirectly affect hydrocarbon uptake, populations at different locations may have hydrocarbon chemistries that are related differently to the chemistry of local water and sediment.

It is possible to eliminate several variables (e.g. season, age, size and weight of individuals, and sampling position in the intertidal zone) by the use of rigorous sampling techniques. Other variables such as salinity, pH, turbidity, light, sediment type, water temperature, or wave exposure can be eliminated by the use of carefully selected control or reference stations. Final station locations will be selected for similarities in sediment characteristics, size of mussel populations, water quality parameters, and exposure to wind and waves. Control sites will be selected to match the environmental characteristics at the impacted sites. Since a large geographic area covering Port Valdez, PWS, and GOA will be sampled, control sites need to be located in each of the areas for valid comparisons.

Nine locations will be sampled for mussel (tissue) bioaccumulation and sediment chemistry (Figures 1 and 2). Mussel (*Mytilus edulis*) collection for bioaccumulation analysis will take place at a suitable rocky intertidal area. Sediment stations will be located in the offshore adjacent to each mussel station.

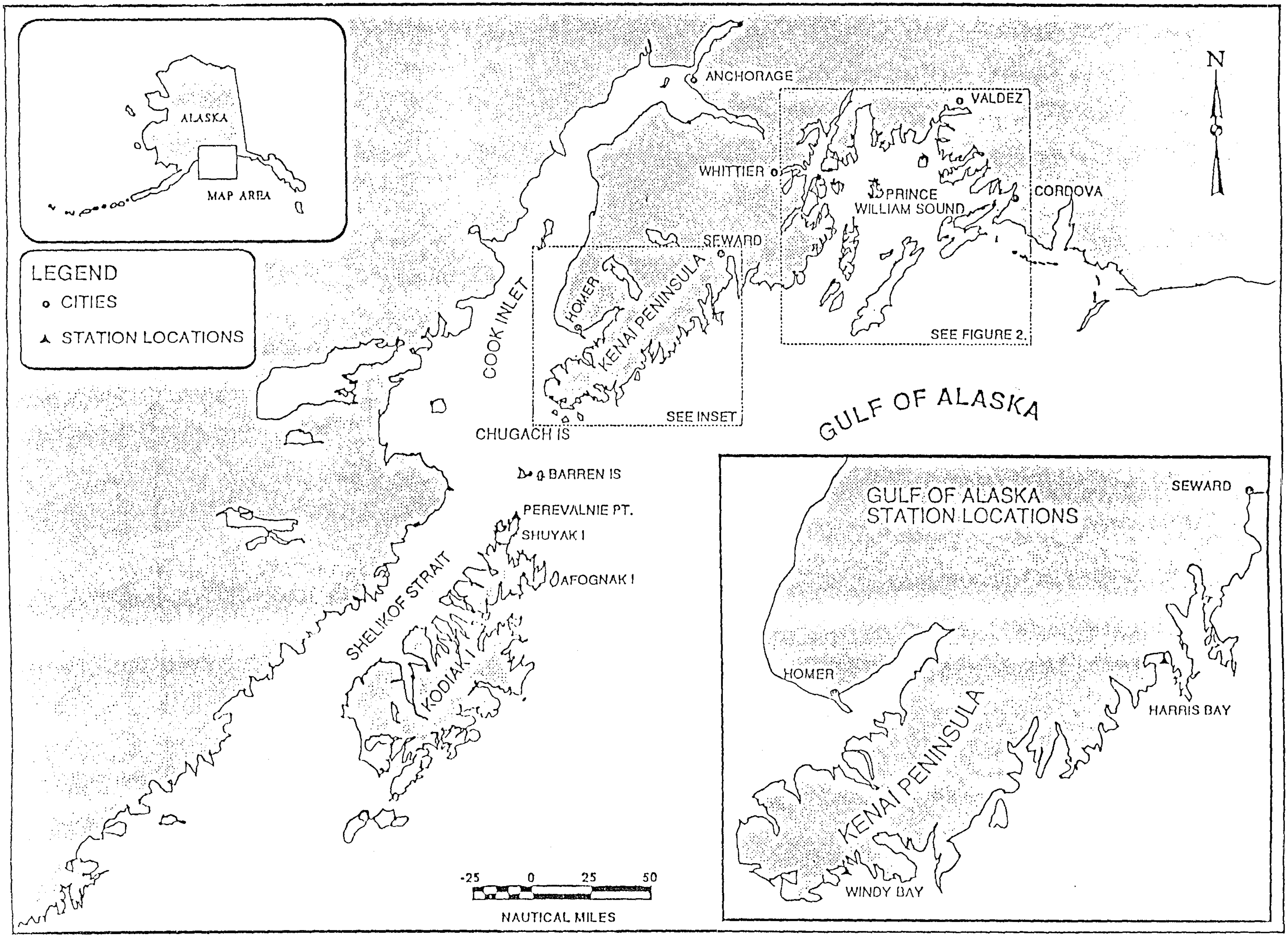

Figure 1. General Study Area and Gulf of Alaska Station Locations.

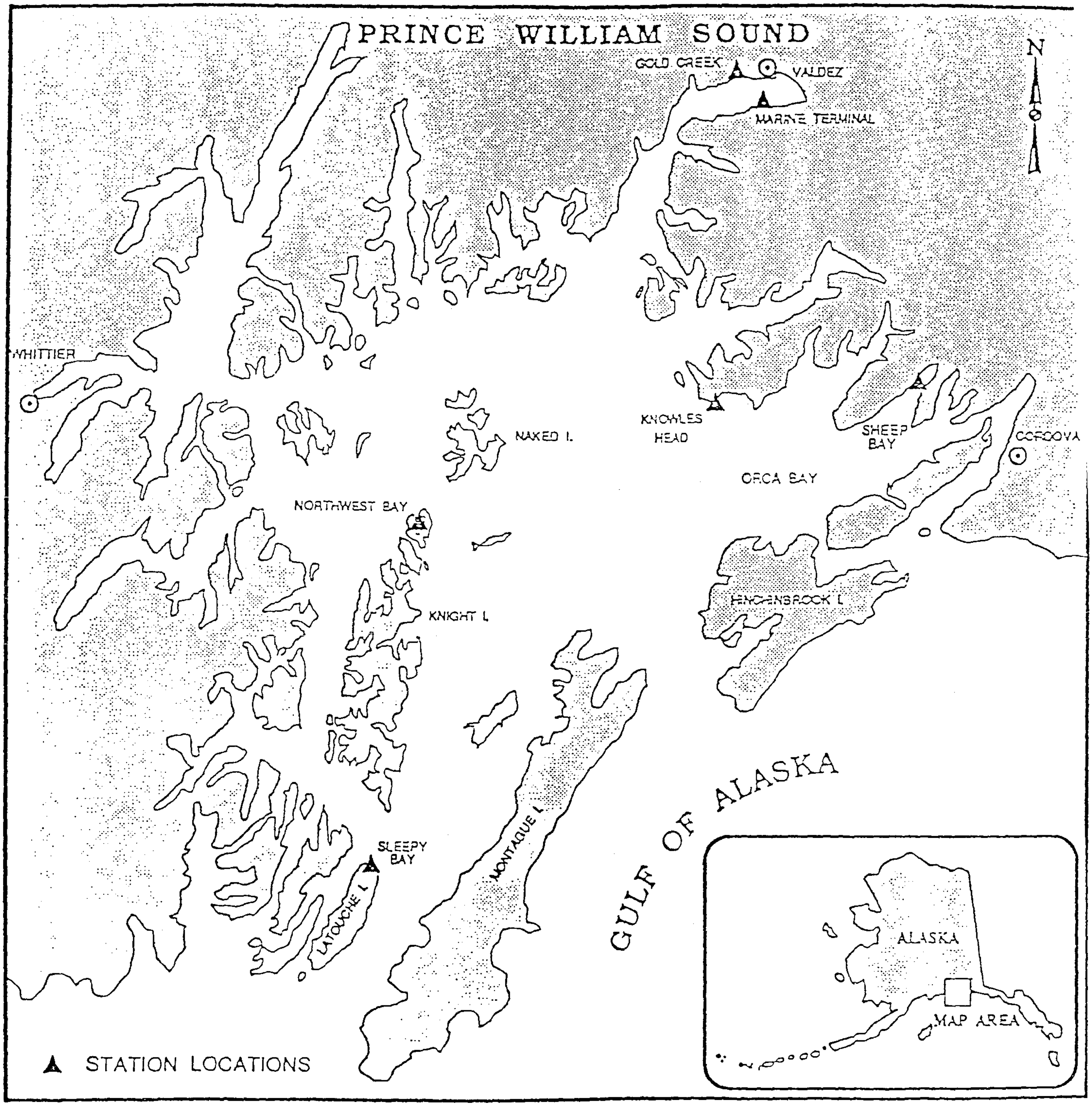

Figure 2. Prince William Sound Study Area and Station Locations.

Sampling stations will be located in areas known to be impacted by petroleum hydrocarbon inputs to the study area (near the BWTP discharge or shorelines impacted by the EVOS) and in control areas (areas that are considered to be unimpacted). Final location of each sediment station will depend on the bathymetry of the individual locations and the substrate type as judged by grab success during the first survey. If possible, stations will be located within depositional areas where petroleum hydrocarbons may have settled during natural or man-induced beach cleaning activity. If possible, intertidal sampling for impacted areas will occur at a site where visible oiling still exists, particularly at the subsurface level.

Hydrocarbon-impacted stations include one in Port Valdez, in the vicinity of the BWTP outfall, at a location within the mixing zone at approximately 80 m water depth (Station D-51) as identified in the NPDES Permit (USEPA, 1989) and previously sampled (Shaw et al. 1986; Feder and Shaw 1987, 1990). This location will be selected in consultation with Dr. Feder and an Alyeska representative, or other appropriate persons, to avoid disturbing existing sampling sites and programs. Sampling at this station will allow comparison of new results with permit-required studies. An additional station (control station) will be designated within Port Valdez, but at a suitable distance away from the outfall and the marine terminal berths. Past studies have indicated that sediments over 1 km from the discharge have remained unaffected (Shaw et al., 1985). This station will be located on the other side of the Port, at either Gold Creek or Mineral Creek, both of which have historic data from either the National Mussel Watch Project (Mineral Creek) or Alyeska's Monitoring Program (Gold Creek).

Two stations will be located in the Orca Bay area. One station will be located in the vicinity of the Knowles Head anchorage area for oil tankers. A second station that will serve as the Prince William Sound control station will be placed east of this site, within Sheep Bay. The remaining two Prince William Sound study sites will be located based on EVOS impact areas. These stations will be located within embayments heavily impacted by the spill and subsequently subject to extensive cleanup efforts: Northwest Bay (Eleanor Island) and Sleepy Bay (Latouche Island)(Owens, 1991; Houghton, 1991).

In addition to the six sites in PWS and Port Valdez, three stations will be located in the Gulf of Alaska on the Kenai Peninsulaand in the Kodiak Island area. Two of the stations will be located in EVOS impacted areas and third station will serve as a control or reference site that was not affected by the EVOS. EVOS impacted stations as shown by Owens (1991) and Gundlach et al. (1991) will be located at Windy Bay and on Shuyak Island. The control station will be located in Harris Bay.

3.0 METHODOLOGY

3.1 Field Methods

3.1.1 Sediment Collection and Handling

Sediment samples will be collected using a Teflon-coated Smith-MacIntyre or modified Van Veen grab. These types of grabs allow the collection of undisturbed surface sediments in most sediment types and have been used successfully by KLI in Prince William Sound. Grabs will be considered successful if the surface of the sediment appears largely undisturbed, water is overlying the sediment in the grab, and the grab contains a sufficient volume of surficial (0-2 cm) sediment to provide material for the full sample suite to be collected. Three replicate chemistry grab samples will be collected at each station for each analysis type (PAH, AHC, PGS, and TOC), requiring three successful drops of the grab.

After a successful grab, overlying water will be removed from the grab either by slightly opening the grab jaws to allow water to drain or by siphoning off with a piece of pre-cleaned Teflon tubing. Sediment samples will be collected from the top 0-2 cm of sediment within the grab using solvent-rinsed stainless steel utensils. Hydrocarbon chemistry samples will be collected from the inner portions of the grab; that is, from areas that have not come in contact with the grab's surface. Sufficient sample material will be collected for quality assurance/quality control purposes as described in Section 4.3. Samples will be placed in labeled precleaned glass jars (PAH, AHC, and TOC analysis); or Whirl-pak plastic bags (PGS analysis); as required by analytical protocols. PAH, AHC, and TOC samples will be frozen or placed on ice immediately after collection. Sediments collected for the analysis of PGS will be refrigerated or otherwise cooled aboard the vessel prior to shipment to the laboratory. Sample handling information is summarized in Table 1.

Table 1. Sample Handling Information.

Parameter	Matrix	Type of Container	Preservation	Analytical Lab
PAH/AHC	Sediment	250-ml Glass Jars	Freeze	GERG
PAH/AHC	Tissue	Foil/Plastic Bag	Freeze	GERG
TOC	Sediment	250-ml Glass Jars	Freeze	ToxScan
PGS	Sediment	Plastic Bag	Refrigerate	ToxScan

Grabs and stainless steel utensils will be decontaminated between each replicate or each failed replicate which brings up some sediment. Decontamination procedures include cleaning out by rinsing with seawater to remove sediment and then rinsing with high-purity distilled water to remove traces of seawater. The grab or utensil is then rinsed with acetone, to remove residual water, and hexane, which removes hydrocarbons. The gear is allowed to briefly air dry before redeployment. Care is taken during the rinsing procedure to contact all interior surfaces of the grab and all surfaces of the utensil which will come into contact with the sediment. Quality control samples, including equipment blanks and field blanks, will be collected as described in Section 4.1.1. After the collection of an equipment blank, the grab will be subject to decontamination prior to use. All solvent wastes are collected and returned to land for proper disposal.

3.1.2 Mussel Collection and Handling

Samples of the mussel *Mytilus edulis* will be collected at intertidal locations adjacent to the sediment sampling locations; one composite sample of at least 30 mussels will be collected at each station for chemical analysis. In addition, sufficient individuals at each station will be collected to determine the populations' gonadal index. The gonadal state of population is important to confirm that non-spawning mussels are being used for analysis, since spawning individuals release lipids that could contain lipophilic organics thereby skewing the degree of contamination. The exact number of mussels needed to ensure adequate tissue volume for replicate chemical analyses will vary depending on size class, however, previous studies have shown that between 30 and 40 individuals is usually more than adequate (Houghton, Lees, Teas and Ebert 1991). All mussels will be collected from the mid-intertidal zone and no mussels smaller than 20 mm in shell length will be collected for tissue analysis. Mussel sampling protocols will follow those outlined in the national Mussel Watch Program (Shigenaka and Lauenstein, 1988; Boehm *et al*, 1987). Mussel samples will be collected by hand, using a stainless steel knife to cut byssal threads if necessary. The individual mussels will then be separated and scrubbed with a nylon brush to remove any detritus. Cleaned mussels (whole shell and animal) will be placed intact in precleaned squares of aluminum foil and placed in polyethylene bags. Latex surgical gloves will be worn by collection personnel. Mussel samples will be properly labeled and placed on ice or frozen immediately after collection. The exception to this will be the mussels collected for gonadal state which will be shucked and preserved in the field. Mussel tissue sample handling information is provided in Table 1.

3.1.3 Sample Documentation and Chain of Custody Procedures

Proper documentation for sample custody includes keeping records of all materials and procedures involved in sampling. Sample documentation will be maintained throughout the course of this project through the use of project-specific pre-printed Sediment Station Logs, Effort Logs, Sample Identification/Chain of Custody Forms, and sample labels. The Field Leader is responsible for the completion, review, and approval of all field documentation. Completed field logs are retained in project files for future reference.

Sediment Station Logs provide information about the station, including cruise designation, station designation, visit number, date, time, station depth, navigational information, weather and sea-state conditions, observations of sediment characteristics, redox potential measurements, and names of sampling personnel. Observations which may be recorded on this form include appearance of the sediment and evidence of oiling, such as the presence or absence of oil droplets or tarballs. An example of a Sediment Station Log is provided in Figure 3; logs tailored specifically to this projects will be generated prior to the first survey.

Effort Logs are used to record each drop of a grab, including the time of drop, navigational information, and success or failure of each attempt. This type of information can be used to describe bottom type in specific areas, help determine sampling locations, and provide estimates of time needed to successfully sample in a given area, as well as allowing the evaluation of equipment performance.

Sample identification and integrity are ensured by a rigidly-enforced chain of custody program. Sample Identification/Chain of Custody Forms (COCs) provide specific information concerning the identification, handling, and shipment of samples; a generic example of this form is provided in Figure 4. After sample collection, pertinent information from the sample label is transferred onto the COC, along with other information as required. COC forms are signed off, copied, and the originals packed into coolers with the samples by field personnel prior to shipment to the laboratory. The Field Leader retains a copy of each form for the field records and for tracking purposes should a shipment become lost or delayed. Upon receipt of the samples at the analytical laboratory, the Laboratory Sample Custodian signs the samples in by checking all sample labels against the COC information and noting any discrepancies, as well as sample condition (e.g., samples broken during shipment). The laboratory may also assign a laboratory sample identification number at this time, that is also entered on the COC form.

Pre-printed labels, including project identification, analysis type, a pre-assigned sample identification number, and other information such as date of collection, station designation, replicate number, etc., are also provided to the field crew prior to departure of the cruise. Use of standardized labels with pre-assigned numbers eliminates last-minute labeling problems that can result in improperly identified samples and unusable results.

3.1.4 Navigation

Navigation and station location will involve the use of nautical and topographic charts, radar, and a Global Positioning System (GPS). This satellite-based system is ideal for use in PWS, where Loran-C coordinates are often inaccurate because of the rugged topography of the area.

Station locations (longitude and latitude) will be recorded on Sediment Station Logs as described in Section 3.1.3. In addition, visual triangulation will be used where necessary to pinpoint each station location. Station locations will be plotted on National Oceanic and Atmospheric Administration (NOAA) nautical charts, and range and bearing to fixed landmarks will be recorded where appropriate.

Intertidal stations will be permanently located with marker stakes placed above the intertidal zone. Tidal zonation within the intertidal will be carried out using standard land survey techniques. Station locations will be backed up by noting prominent landmarks on the field logs and sketching maps of station location with respect to the landmarks. Depending on substrate type and mussel bed density, stations may also be marked using stainless steel bolts driven into the substrate. Sampling locations will also be documented through the use of still and/or video photography.

SEDIMENT CHEMISTRY LOG

PROJECT RCAC ECO/ENV MONITORING PROGRAM							DATE		
STATION				SAMPLE TYPE		CHEMISTRY	NAV TYPE		
REP	CONSISTENCY	ORGANISMS	COLOR	ODOR	SHELLS	DETRITUS	PARAMETERS SAMPLED	X POS	Y POS
REP 1									
REP 2									
REP 3									
REP 4									
REP 5									
STATION				SAMPLE TYPE		CHEMISTRY	NAV TYPE		
REP	CONSISTENCY	ORGANISMS	COLOR	ODOR	SHELLS	DETRITUS	PARAMETERS SAMPLED	X POS	Y POS
REP 1									
REP 2									
REP 3									
REP 4									
REP 5									
STATION				SAMPLE TYPE		CHEMISTRY	NAV TYPE		
REP	CONSISTENCY	ORGANISMS	COLOR	ODOR	SHELLS	DETRITUS	PARAMETERS SAMPLED	X POS	Y POS
REP 1									
REP 2									
REP 3									
REP 4									
REP 5									
STATION				SAMPLE TYPE		CHEMISTRY	NAV TYPE		
REP	CONSISTENCY	ORGANISMS	COLOR	ODOR	SHELLS	DETRITUS	PARAMETERS SAMPLED	X POS	Y POS
REP 1									
REP 2									
REP 3									
REP 4									
REP 5									
COMMENTS:									

Figure 3. Example of a Sediment Chemistry Log.

KINNETIC LABORATORIES, INC.
CHAIN OF CUSTODY RECORD

LABORATORY:			FROM:		
			KINNETIC LABORATORIES, INC. 403 WEST 8th AVENUE ANCHORAGE, AK 99501 PHONE: (907) 276-6178 FAX: (907) 278-6881		
REQUIRED COMPLETION DATE:			KLI PROJECT #:		P.O. #:
RELINQUISHED BY	DATE/TIME	TRANSPORTER	RECEIVED BY	DATE/TIM	
RELINQUISHED BY	DATE/TIME	TRANSPORTER	RECEIVED BY	DATE/TIM	
RELINQUISHED BY	DATE/TIME	TRANSPORTER	RECEIVED BY	DATE/TIM	

SAMPLE NUMBER	SITE/ SAMPLE ID	NO. OF CONTAINERS	SAMPLE DATE/TIME	PRESERV-ATIVE	ANALYSIS TYPE	DETECTION LIMIT	CONDITIO UPON RECEI

DATA REPORTS MUST INCLUDE THE FOLLOWING: SAMPLE NUMBER, ANALYTICAL METHOD, DETECTION LIMIT, DATE OF EXTRACTION IF APPLICABLE, DATE OF ANALYSIS, ANALYTICAL RESULTS, AND SIGNATURE OF QA REVIEWER.

COMMENTS: PLEASE REPORT QA/QC DATA.

SAMPLED BY (NAME/SIGNATURE) ______________________

Figure 4. Example of a Chain of Custody Form

3.1.5 Logistics

The sampling station locations have been broken into two distinct geographical areas (Section 2.3), Prince William Sound (PWS) and Gulf of Alaska (GOA). The field effort will consist of mobilizing two different cruises to address each geographical area. The PWS and Port Valdez cruise will use Valdez as the home port and the GOA cruise will depart and return to Seward. Both cruises, however, will utilize very similar vessels. The vessel of choice will be a 35-50 foot seiner or equivalent capable of 12+ knots, with a minimum range of 400 nautical miles and provisions for one week at sea. The vessel will have adequate hydraulics (e.g. capstan, winch, crab block) and rigging (e.g. "A" frame, davit) to safely deploy and retrieve both a benthic grab and skiff. The vessel will berth at least three scientists and one observer plus crew. Additionally both vessels will include a full complement of safety gear, including exposure suits for all personnel, Flares, E-PIRB, VHF radio, RADAR, Color Depth Sounder (for grabs), Loran-C etc.

Intertidal sampling will be conducted utilizing a Zodiac Mark III skiff equipped with a 25 horse power outboard motor to shuttle scientific personnel to and from the main vessel. All small boat operations will be conducted in accordance with KLI's Vessel Safety Plan.

Cruise durations could vary depending on weather conditions or equipment problems. Under ideal circumstances, however, the anticipated duration for the PWS cruise is five days with one day on each end for mobilization/demobilization. The GOA cruise will last three days with one day on each end for mobilization/demobilization. Additional days would have to be taken into account if the Shuyak Island station is unreachable during the GOA cruise, and has to be sampled as a seperate operation mobilized in Kodiak. This contingency is based on the problems associated with crossing both the Kennedy and Stevenson Entrances, in order to reach Shuyak Island.

3.2 Laboratory Methods

Sediment samples will be analyzed for a variety of parameters which have been chosen to meet project needs in determining sediment and tissue hydrocarbon concentrations and characteristics. Sediment chemistry parameters include polynuclear aromatic hydrocarbons (PAH), aliphatic hydrocarbons (AHC), particle grain size (PGS), and total organic carbon (TOC). Bioaccumulation and environmental risks to biota will be evaluated through the analysis of hydrocarbon levels (PAH, AHC) in mussel tissue.

Samples will be analyzed at the Geochemical and Environmental Research Group (GERG) laboratory of Texas A & M University (PAH, AHC,); and at ToxScan, Inc., owned by KLI (TOC, PGS).

Table 2 provides the analytical methods and limited descriptive information for each parameter to be analyzed. Quality control samples are processed as described in Section 4.3.

Table 2. Analytical Procedures.

Parameter	Matrix	Type of Method
PAH	Sediment Tissue	GC/MS in SIM Mode
AHC	Sediment Tissue	GC/FID
TOC	Sediment	Combustion/Infrared Detection
PGS	Sediment	Dry Sieving/Pipette

3.2.1 Mussel Tissue Processing

Mussel tissues will be analyzed by GERG for PAH and AHC according to internal Standard Operating Procedures (SOP's 8903, 8904, and 8905) that were prepared in accordance with EPA and National Status and Trends Mussel Watch protocols.

Mussels will be shucked and thoroughly macerated (with 100 ml CH_2Cl_2 and 50 g Na_2SO_4) and homogenized (Tekmar; Polytron homogenizer or equivalent, fitted with titanium blades to eliminate metals contamination)

The homogenized bivalve tissue is extracted for organic analysis using EPA Method 3630. The extensive lipid content of the shellfish will be extracted with the organic extracting solvent and will be removed prior to any analysis. Alumina column chromatography cleanup procedures will be applied to the extract to accomplish this removal. There is a concern that the saturated aliphatic components of the petroleum hydrocarbons would be removed in the cleanup process and analysis for these compounds would probably not yield quantitative or representative results. That measurement has been eliminated from the bioaccumulation testing requirements of the US Army Corps of Engineers dredged material testing program for just that reason.

Once cleanup procedures have been completed, the PAHs and the synthetic organic compounds will be analyzed using the methods discussed in sections 3.2.2 and 3.2.3.

3.2.2 Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons will be determined using a gas chromatograph/mass spectrometry (GS/MS) technique in the selected ion monitoring (SIM) mode. This method was used extensively for the determination of PAHs and their alkylated homologues in sediment, and tissue samples collected during various scientific studies in response to the EVOS. The use of GS/MS allows fingerprinting of aromatic hydrocarbons, while the SIM mode provides greater sensitivity than full range mass spectral data (National Research Council, 1985). The method is designed for the analysis of PAH at part-per-billion levels in sediments and tissues.

Prior to analysis, samples of sediment, or mussel tissue are extracted using methylene chloride, concentrated, and passed through an alumina column to remove polar interferences. An additional cleanup step may be used for tissue samples. Samples are spiked with surrogate material during the extraction procedure. Extracts are stored both prior to and after analysis with sufficient solvent to prevent dryness.

Gas chromatographic (GC) separation is accomplished on a fused-silica capillary column with a DB-5 bond phase. The GC column feeds directly into the ion source of the mass spectrometer (MS) operating in the SIM and electron-impact ionization mode. A computer system interfaced with the MS continuously acquires and stores all mass-spectral data and performs initial data manipulations. Tissue and sediment results are reported in ng/g (wet weight). Percent moisture will also be ascertained so that dry weights can be obtained if desired.

3.2.3 Aliphatic Hydrocarbons

Aliphatic hydrocarbon (AHC) concentrations will be determined in sediments and tissues utilizing high resolution capillary gas chromatography using flame ionization detection (GC/FID). The method is used for the analysis of environmental samples for normal alkanes, and pristane and phytane, and details the unresolved complex mixture (UCM).

Samples are extracted using the same procedures described for PAH analysis (Section 3.2.2). GC separation is also similar to that described for PAH and uses a column that provides baseline resolution of alkanes (n-C_{10} to n-C_{34}), pristane/n-C_{17}, and phytane/n-C_{18}. The flame ionization output is collected and processed by a data acquisition package. Tissue and sediment results are reported in ng/g (wet weight). Percent moisture will also be ascertained so that dry weights can be obtained if desired.

3.2.4 Particle Grain Size

Particle grain size will be determined using methods adapted from Plumb (1981). Measurements of grain size are important because it has been shown that varying particle sizes and types within a given sediment have different hydrocarbon compositions (Thompson and Eglinton, 1978).

Dry sieve techniques are used to determination the sand and gravel fractions. Silt and clay fractions are determined by pipetting. Results are reported in percent gravel, sand, silt, and clay on a weight basis.

3.2.5 Total Organic Carbon

Total organic carbon analysis will be performed using an induction furnace to burn samples in an oxygen atmosphere. Gases produced by the combustion are processed and put through an infrared detector for quantification of carbon dioxide. Total organic carbon is determined after sample acidification. Carbonate carbon is determined as the difference between total carbon and total organic carbon. Results are reported in percent organic carbon on a dry weight basis.

3.3 Data Analysis and Reporting

3.3.1 Statistical Analyses

The main purpose of the proposed project is to identify present and potential future impacts of oil transportation on the ecosystems of Prince William Sound and Port Valdez. To meet the above objective, KLI will conduct a sampling program designed to provide data sufficient to test the following four overall null hypotheses as discussed in Section 2.1:

> H_o1: There are no changes in biological, chemical, or physical variables with time at various monitoring sites.

> H_o2: Observed changes in biological, chemical, or physical variables at various monitoring sites are not correlated with oil transportation activities.

> H_o3: There are no differences in biological, chemical, or physical variables between monitoring sites (affected and control sites).

> H_o4: Observed differences between monitoring sites are not correlated with oil transportation activities (Alyeska BWTP, EVOS, or other tanker activities).

The first two hypotheses will examine temporal variations and trends at individual monitoring sites. The last two hypotheses examine spacial differences and address existing impacts or impacts that may occur over the duration of the sampling program. These hypotheses will be addressed by a variety of statistical methods discussed below (Figure 5).

The replicated design of this study will allow a rigorous parametric analysis of the data that has been collected. All replicates (3-10) at each station will be used to calculate summary data for tissue and sediment hydrocarbon concentrations, TOC, and for four sediment texture categories, gravel, sand, silt, and clay. Measures of dispersion (mean, standard deviation, etc.) will be calculated for each parameter. The graphical methods of Folk (1980) will be used to calculate these statistics for the data. Tables and graphs that include the summary statistics will be generated as well as plots of appropriate data analyses.

Monitoring studies are usually designed mainly to avoid Type I (alpha) errors, i.e. describing differences that are not real. A Type I error is avoided when a null hypothesis is rejected ($p > 0.05$, for example). Unfortunately, applied environmental studies rarely pay sufficient attention to avoiding Type II (beta) errors, i.e. missing differences that are, indeed, real.

Statistical significance for all testing will be conducted at two levels of probability: (1) Type I error (α) = Type II error (β) at the 95 percent confidence level for hypotheses testing and (2) Type I error (α) = 0.05 and Type II error (β) = 0.20 (or $1-\beta = 0.80$) for the evaluation of the ANOVA F-value result (power analysis). These values will be presented together in all tables.

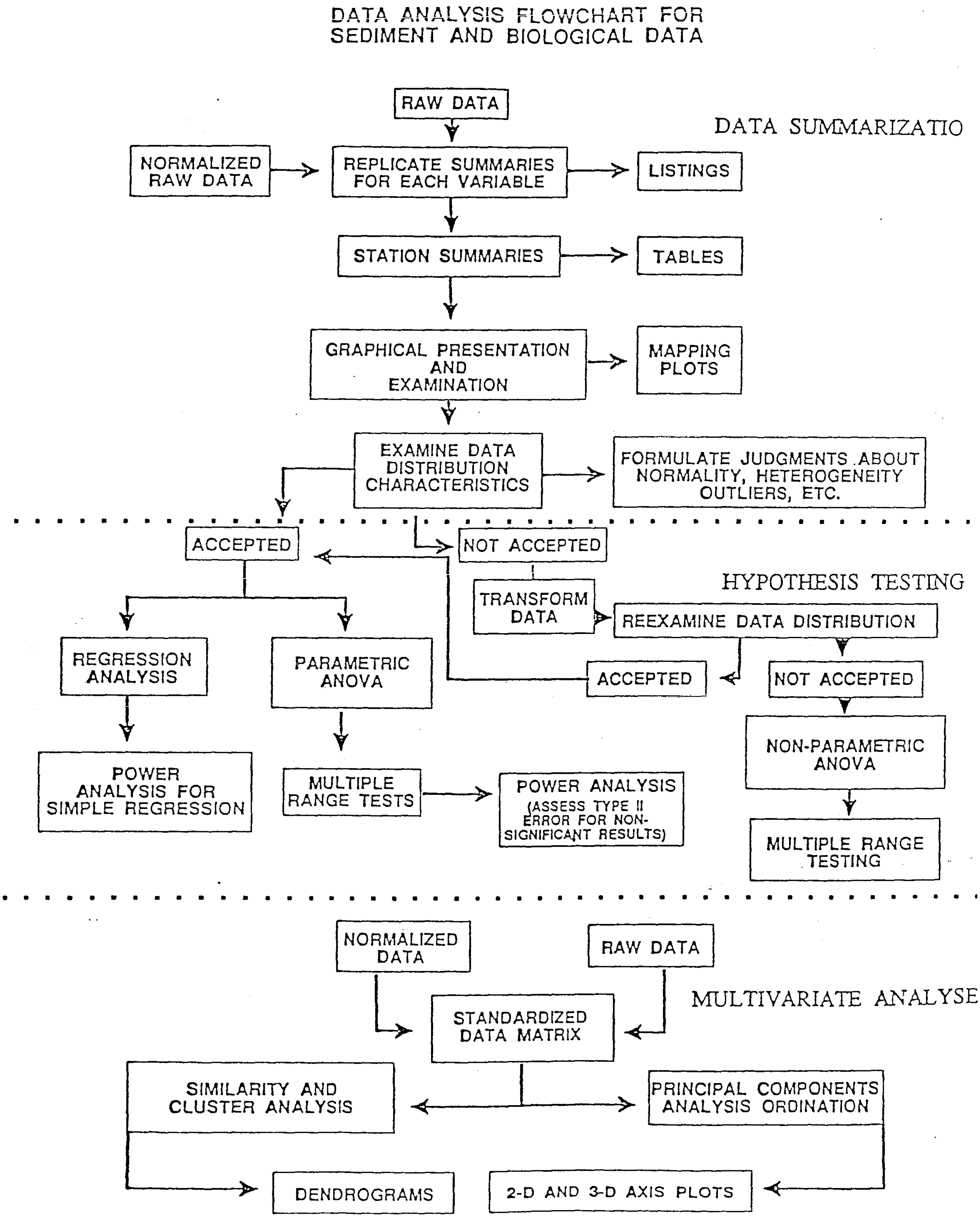

Figure 5. Statistical Flow Chart

KINNETIC LABORATORIES

Analysis of variance (ANOVA) will be used for the general testing of the various parameters. A one-way or two-way layout will be used depending on whether temporal differences are being examined. Both analyses will assess the spatial differences among stations, however the power of a two-way design that incorporates time is often lower than a one-way design due to typically greater variability in the data.

Non-normal data, and data with heterogeneous variance violate the basic assumptions of parametric ANOVAs. For this reason, the raw data will be examined using Lillefor's test for normality and Bartlett's test for homogeneity of variance if the normality of the data is not seriously violated (Zar 1984). If normality is a problem with the data set, Hartley's F_{max}-test (Sokal and Rohlf 1981) for homogeneity of variances, which is less influenced by non-normal data, will be use instead of Bartlett's test, however it is a less powerful test for assessing variance violations. Data passing these tests can be used directly in a parametric ANOVA in either a one-way or two-way design. Raw data failing either or all test combinations will be transformed using a procedure that is based on Taylor's power law (see Elliott 1971) and then re-examined for violations of the ANOVA assumptions as was performed for the raw data. Transformed data passing these tests can then be used in a parametric ANOVA. Data failing this rigorous handling even after transformation will then be analyzed nonparametrically by a standard one-way Kruskal-Wallis ANOVA or a modified version of this test applied specifically to a two-way design for temporal considerations.

Statistically significant ANOVAs ($\alpha = 0.05$) will trigger a-posteriori or ad-hoc multiple range tests, which will be used to determine differences in mean values among all stations for a given parameter. This procedure is not necessarily essential to rejecting or accepting the null hypotheses (this is handled by the ANOVA at the specified alpha level), it simply determines in an ad-hoc manner what station mean values are different when a significant ANOVA result is found ($\alpha = 0.05$). Tukey's HSD, Student-Newman-Kuels (SNK), and Duncan's MRT are suggested multiple comparison tests for parametric ANOVAs. The Dunn's test is suggested for nonparametric ANOVAs. These tests are robust, versatile, and appropriate for this data, especially for the balanced sampling design being proposed here.

We propose using power analysis to assess Type II error (β) for parameters used in the parametric ANOVAs (which assesses Type I error (α)). Power Analysis ($1-\beta$), discussed here in an a-posteriori sense, evaluates the ANOVA's ability to detect significant statistical results when real differences actually exist for a given monitoring parameter (EPA 1987). Highly variable data often requires large numbers of replicates to show statistically significant differences, even when drawn from different populations. The fixed design parameters for power analysis can encompass a number of factors. For this study these will be $\alpha = 0.05$, $\beta = 0.20$ (or $1-\beta = 0.80$), the number of stations equals 9, and the number of replicates per station equals 3. The estimated variance will vary and come from each parameter data set that is analyzed by ANOVA. The power curves for each parameter will show the power of the ANOVA result versus the number replicates needed ($1-\beta$ vs replicates). The power curve could also reflect $1-\beta$ versus the minimum detectable difference among station means as a percent of the overall mean of stations.

3.3.2 Data Management

Nearly all of KLI's database handling and statistical analysis procedures are performed with the use of PRODAS software running on a 386 based IBM PC-clone computer system. This software is well documented and thoroughly tested, and has been programmed and customized by KLI to facilitate analysis of environmental data sets of virtually any size. File formats designed for PRODAS are also compatible with various popular database and spreadsheet programs including Macintosh based software as required by the RCAC.

Graphics for reports and data interpretation can be produced either on an Apple Macintosh or IBM PC-clone based computer system using one of a variety of software packages (ie. Cricket Graph, Delta Graph, Excel, or Lotus software for the MacIntosh, or PRODAS, Grapher, Graftool, Excel, or Quattro Pro software for the PC). Digitizing and scanning hardware and software for mapping of data are available as well as computer software like Surfer that can handle detailed contour plotting needs. As required, KLI has the capability to provide all data in variety of formats that are compatible with Macintosh based software (Excel, ASCII Macintosh format, etc.). The final selection of the format will be made with input from RCAC to ensure that data will be compatible with their Macintosh software.

3.3.3 Deliverables and Reporting

Project deliverables will include monthly progress reports, survey reports, annual project reports, data submissions, oral presentations before RCAC, presentations to national conferences, and publications in scientific journals. Progress and budget reports will be delivered to RCAC on a monthly basis. These will include a review of project activities and approximate expenditures during each month and information concerning upcoming tasks.

A field survey report will be prepared within one month of the completion of each field survey. This report will include a description of the survey, the number of stations successfully sampled, station location information, etc. It will also include descriptions of weather-related contingencies, problems encountered during sampling, if any, and recommendations for subsequent surveys.

Comprehensive project reports will be submitted on an annual basis. These will include all sample and QC data, statistic analyses, and a detailed discussion of methods, results, and conclusions. The annual reports will be in a format acceptable to RCAC. The reporting task will include the submittal of annual reports for peer review and publication in scientific journals as specified by RCAC. Data submittal will also take place on an annual basis and will be in the form of both hard- and soft-copies. Soft-copy data will be compatible with Macintosh-based software.

Oral presentations will be provided to RCAC at the end of each project year, including our recommendations for subsequent sampling and analysis. Presentations will be given by key personnel to national conferences at RCAC's request.

4.0 QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The project will include a comprehensive quality assurance/quality control (QA/QC) program administered by the Quality Assurance (QA) Manager and designed to provide RCAC with technically-defensible and high quality products. The QA/QC program will encompass all aspects of the project, from initial sample collection through laboratory analysis and data analysis to reporting. The program is designed to allow the data to be assessed by the following parameters:

- Precision
- Accuracy
- Comparability
- Representativeness
- Completeness

These parameters are controlled by adhering to documented methods and procedures and by the analysis of quality control (QC) samples on a routine basis. A detailed description of all the QA/QC program parameters are contained in Section 4.2.

KLI's QA/QC program maintains high standards designed to provide control over all aspects of the proposed project work plan. The result is data and reports representing scientifically valid, legally defensible products that are of known accuracy, precision, representativeness, and comparability. KLI's responsibility for implementing the QA/QC program begins with the initial planning of all activities affecting data quality. It continues through data collection and analysis, and ends with the turnover of reports and files to the client upon successful completion of the program. The QA/QC program specifies the quality assurance (QA) and quality control (QC) procedures that will ensure that the data generated during the sampling program are accurate, precise, complete, comparable and representative of actual conditions. The program assures that data are produced within specified error tolerances and that all measurements will be made so that the results are representative of both the media (sediment, and tissues) and of the conditions being measured.

Kinnetic Laboratories Inc. insures that QA/QC objectives are met through the use of a Sample Control Department staffed by personnel knowledgeable in methods selection, control of samples and records, chain of custody requirements, and proper sampling methods. Their responsibilities include diagnosing quality defects and resolving problems associated with the acquisition of quality measurements and data generated from the field. A Quality Assurance officer is responsible for periodic performance audits, summarizing field sampling procedures and data, noting significant QA problems and correcting them. The QA officer also reviews, verifies, and validates data. Both the sample control department and the QA officer will be responsible for adherence to the principles of good laboratory practice, consistent use of standard operating procedures, adherence to protocols for specific measurement programs, maintaining equipment records, calibration and reliability.

In addition, Standard Operating Procedures (SOPs) and project-specific protocols will serve to document both field (sampling) and laboratory (analytical) procedures. Field SOPs, for example, describe mussel handling and collection and sediment collection procedures. Laboratory SOPs describe in-house sample tracking procedures as well as analytical methods, including proper sampling handling and storage, use of quality control (QC) samples, acceptable limits for the analytical results of QC samples, and data reporting. Adherence to laboratory and analytical SOPs will ensure that analytical results are properly obtained and reported.

4.1 Field and Laboratory QA/QC

The foundation of any QA/QC program is documentation. As described in Section 3.1.3, sample documentation begins in the field using pre-printed logs, chain of custody forms, labels, and pre-determined sample identification numbers that have been designed specifically for use on this project. This extensive field documentation provides a paper trail that exists for each sample or field measurement (e.g., mussel size) and therefore ensures credibility of the data.

4.1.1 Field Sampling

Proper documentation for sample custody includes keeping records of all materials and procedures involved in sampling. Project specific field data sheets will be used to record field data. All information on the station, respective samples and replicates collected at each site, including positions of each station, will be recorded by the field crews. All data is to be reviewed by the field crew leader before leaving the station. Completed field logs will be kept on file for any QA/QC checks. In addition, special instructions for handling and preservation of the samples during transfer or shipping will also be included.

Sample integrity and identification are assured by a rigidly enforced chain of custody program. The chain of custody procedure documents the identity and handling of a sample from the time the sample is collected to the arrival of the sample at the lab. Each time a sample is transferred to a different custodian, both the relinquishing and receiving person must sign, date, and record the time on the chain of custody. When the samples are transferred to the designated laboratories, a photocopy of the chain of custody is kept by the field personnel and the original accompanies the samples to the laboratory.

At the time of sample transfer to the laboratory, the lab will assign the sample a discrete log number which is attached to the sample container and entered on the chain of custody form into the lab's sample log book. This provides a cross reference between field and laboratory sample identification. The logging-in process also provides verification of sample integrity. Lab and field personnel will inspect the sample to ensure that:

- The sample is clearly marked and dated
- The sample was collected in an appropriate container
- The sample is properly preserved and temperature controlled, if necessary
- There is sufficient volume to do all the analyses
- The sample is in good condition
- Chain of custody form information matches the description of the sample and the information on the label

All sample labels and containers will be prepared in advance, with each label including the project name, date, analysis to be performed, preservative, station identification, sample number, and collector. This information will also be recorded on both the field data log sheets and on the chain of custody form. Duplicate samples will be collected and labeled using dummy field sample numbers and locations. The dummy locations and sample numbers will be cross-referenced in the field log and sample summary form. Labels will be waterproof and not easily removed from the sample container. Each grab sample will be assessed for sediment surface disturbance. If the grab appears to have been overly disturbed on the sediment surface, the sample will be taken over. Sediment samples will be cooled to 4°C and packed in coolers along with the chain of custody and analysis request forms, for shipment to the laboratories for analysis. Coolers will be securely packed with blue ice and sealed with fiber tape and custody seals for transfer.

Data measured in the field will be reviewed by the field crew leader and final validation will be performed by senior personnel. Data validation will be completed by checking procedures utilized in the field and comparing the data to previous results. Data that cannot be validated will be documented as such.

Field sampling corrective actions include procedures to follow when data results are not within the acceptable error tolerance range. These procedures include:

- Comparing data readings being measured with readings previously recorded
- Recalibration of equipment
- Replacing or repairing faulty equipment
- Resampling when feasible

4.1.2 Laboratory Analyses

Analytical QA/QC for this program includes adherence to documentation, the internal QA/QC performed by the laboratory, and assessment of field duplicates.

Documentation for this program starts in the field with sampling logs, proper labelling, and initiation of the chain-of-custody and sample request form. Documentation in the laboratory includes finalizing the original chain forms and generating the internal documents that track samples through the lab and records the various steps of analysis, including calibrations and maintenance of equipment, weighing standards preparations, preparations and analyses of samples, and storage conditions (refrigerator logs, etc.).

Both contract analytical laboratories (ToxScan, GERG) operate under a QA program described in a laboratory specific QA Plan. For each lab this program involves the use of qualified and trained personnel; the use of standard operating procedures for analytical methodology; a rigorous GLP like system of documenting measurements, use of standards, maintenance and calibration of instruments, and the analysis of blanks, spikes, duplicates, and check samples for precision and accuracy tracking. The specific measurements that will be performed for this program include the use of surrogate compounds for organic analyses (introduced into each sample), the use of matrix spikes and spike duplicates, the use of sample replicates for selected analyses (those not appropriate for spiking), the use of method blanks, the use of standard reference materials where available, and the use of standard curves (3, 4, or 5 point) with continuing calibration verifications.

Analytical reports to be produced for this program will include a case narrative, analytical results of submitted samples, results of surrogates (organic analyses), results of blanks, results of spikes, results of sample replicates, and results of any SRMs used.

The contract laboratories conducting the analyses have specific procedures to follow when the data results are not within the acceptable error tolerance range. The corrective action may be one of several forms listed, but not limited to those below:

- Repeat the analysis
- Check the calculations
- Examine sample for non-homogeneity or unusual interferences
- Check and/or repeat calibration
- Check the laboratory control standard
- Check instruments for proper performance
- Verify that standard solutions are properly prepared and fresh
- Assure purity of reagent water and/or gases
- Observe the analyst to check that no procedural errors are occurring
- Resample

Bioaccumulation

All of the quality assurance measures just described are applied to the bioaccumulation portion of the program. For comparability assurance, standard reference materials, will be used for analytical testing. For each testing event references, controls and baseline tests will also be run. Equipment used to homogenize the tissue samples will be cleaned according to an SOP. This has proven to minimize the chance of sample cross-contamination. Samples are triple-wrapped and frozen when not being used. All tissue handling and processing is done at the laminar flow bench to minimize chances of contamination. All paperwork, field logs, Chain of Custody forms, labels, analysis request forms will be filled out completely at the appropriate times. All protocols and records for tissue samples used in bioaccumulation will be strictly maintained.

Data Validation

Data collected during individual investigation tasks are appropriately identified, validated, and included in an investigation memorandum or report. Where test data have been reduced, the method of reduction will be described in the text of such reports. The data validation process includes specific procedures used for evaluating precision, accuracy, and completeness of the chemical data.

Prudent laboratory procedures require multiple levels of data review prior to acceptance. The contract labs will assign an individual from within the organization to act as quality assurance officer for the project. This individual must have no other role in any phase of the program, and must fulfill the function of assuring that all protocols and SOP's are adhered to, that all data meet strict standards for acceptance, and that all data quality objectives (both internal and external) are met. The project QA officer will also summarize the field sampling procedures and data, and note significant QA problems that have occurred during the field investigation. The final field survey report will contain copies of the laboratory data packages, summary sampling log, sampling alteration check list, chain of custody forms, sample analysis request, and corrective action lists. The QA information will be included in the annual report that summarizes the results of the data quality review, including the results of system audits, assess data accuracy, precision, and completeness and discuss any significant problems and recommendations.

Data will be verified by doing complete comparisons of all final data against the original documentation. Any discrepancies will be fully documented in the project files. Data derived from the investigation will be validated according to accuracy, precision and completeness for both the analytical laboratory and field sample collection programs. The primary goal of these procedures is to ensure that the data reported during the investigation are representative of conditions in the study area. Statistical procedures and qualitative evaluations will be used to check the quality of the chemical and field data. Implementing these procedures will verify that data generated during the investigation are representative of sample station site conditions.

Sample data will be subjected to a QA review upon receipt from the laboratory. Items reviewed during data validation will include sample holding times, results for laboratory method blanks, matrix spike/spike duplicates (MS/SD), check standards, field and laboratory duplicates, and laboratory performance (i.e., ability to achieve method detection limits and adherence to QA/QC criteria established for this project). An estimation of data quality (precision and accuracy) based on sample results will also be provided.

Despite all efforts to achieve the objectives of the QA/QC program, the potential for error exists. Every reasonable effort is to be made to compare and double-check information reported from the field, the laboratories, and subsequently the data reported in project reports. This validation process is a standard procedure and includes checks for proper identification, transmittal errors, internal consistency and checks for temporal and spatial consistency.

Should poor laboratory performance be documented from the precision or accuracy evaluations, the QA Officer will notify the laboratory and ensure the laboratory initiates appropriate corrective action.

4.2 Quality Assurance

Samples will be analyzed with strict adherence to established analytical methods for the matrix and analyte being tested. Method detection limits are established for each method in accordance with EPA requirements.

Precision is the measure of variability of two measurements taken under similar conditions and usually expressed in terms of either the relative standard deviation, the relative percent difference or as a range. Field precision will be evaluated by taking field duplicates and submitting them blind to the laboratory for sediment analysis. Analytical laboratory precision will be evaluated through the use of laboratory replication and calculation of the relative percent differences. Precision of the data will be reported in the quality control report. Comparisons of matrix spike/spike duplicate analyses will be calculated to provide an estimate of laboratory precision.

Accuracy is the degree of agreement a measurement has with an accepted reference or certified true value. Accuracy is usually expressed as percent recovery, which is the difference between the mean and the true value expressed as a percentage of the true value. The accuracy of sediment, and tissue quality will be determined through the assessment of the recovery of matrix spike, surrogate compounds, check standards and Standard Reference Materials (SRM's) (Tissue and sediment will be evaluated through the use of Mytilus edulis SRM 1974 and estuarine sediment of known and certified values available from the National Research Institute of Canada (HS 4)). Reanalysis will be required for samples in which recoveries are outside established control limits. All corrective actions taken for samples requiring reanalysis will be reported with sample results.

Comparability is a qualitative characteristic expressing the confidence with which one set of data can be compared with another. Comparability assurance will be provided by the use of standard techniques to collect and analyze representative samples and by reporting analytical results in appropriate units.

Representativeness is how well a sample or group of samples reflect the characteristic of the media at the sampling point. It also includes how well the sampling point represents the actual parameter variations which are under study. Representativeness of the data is ensured by following proper sample collection, preservation, and shipping procedures. Method blanks will also be used to evaluate representativeness by providing information on contamination introduced by field sampling methodology. If contamination is found the QA officer and test leaders will evaluate and correct sampling procedures.

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected by the sampling design. Completeness will be evaluated by comparing the number of valid measurements obtained with the number of measurements planned.

Quality assurance/quality control objectives and their validation procedures were designed to ensure that problems will be identified and corrected quickly. Quality assurance audits have been included to insure the integrity of the data and that all work performed by individuals trained in the objectives and methods specific to this project. Audit results will be reported to the task manager who will then implement any necessary corrective actions.

4.3 Quality Control Samples

Quality control samples are used to address QA/QC issues and will be analyzed in the same manner as regular samples. The different types of QC samples used for this project are described below. A schedule of QC sample analysis for each of the parameters is provided in Table 3.

Table 3. Schedule of Quality Control Sample Analysis.

	PAH/AHC in Sediments, and Tissue	TOC (Sediment)	PGS (Sediment)
Field and Equipment Blanks	1 in 20	NA	NA
Duplicates	NA	1 in 20 or 1 per batch	1 in 20 or 1 per batch
MS/SD	1 in 20 or 1 per batch	NA	NA
Method Blank	1 in 20 or 1 per batch	1 in 20 or 1 per batch	NA
Surrogate Material	Each sample and QC sample	NA	NA
Reference Material (When available)	1 in 20 or 1 per batch	As available	NA

NA = Not Applicable

Field blanks will be collected at a minimum of once in twenty grab samples for analysis of PAH and AHC. Field blanks consist of HPLC-grade de-ionized (DI) water poured from the DI dispenser into the appropriate sampling container. Field blank analysis helps determine the accuracy of the data. For example, analysis of field blanks will help determine if contaminants are present during sampling that may affect analytical results (such as stack gases, impure DI water, or contaminated sample containers).

Equipment banks will also be collected at a minimum of once in twenty grab samples for the analysis of PAH/AHC. Equipment blanks consist of a DI water rinse of the grab after it has been decontaminated using the procedures described in Section 3.1.1. These blanks help assess accuracy of the data, providing information to determine if the grab and sampling utensils are being adequately cleaned by the decontamination process.

Sufficient material will be collected for the analysis of matrix spike/spike duplicate (MS/SD) or duplicate samples as required for the various parameters. MS/SD samples are regular samples that are split in the laboratory and spiked with known quantities of analytes and analyzed. Accuracy is assessed by comparing the percent recovery (result) to the original spike amount. Reproducibility and comparativeness are assessed by comparing spike duplicate (SD) results with matrix spike results (MS). MS/SD samples are run for PAH and AHC once in twenty samples or once per sample batch, whichever is more frequent.

Duplicate samples are samples that are split by the laboratory, and each portion of the sample is analyzed separately. This type of QC sample is analyzed for the parameters of TOC and PGS (one in twenty samples or once per batch). This type of QC sample also provides information on the reproducibility of results.

Method blank samples will be analyzed for the parameters of PAH, AHC, and TOC on the schedule of one in twenty samples or one per sample batch. These types of blanks help assess method interferences from contaminants in glassware, solvents or reagents, and instruments in the laboratory.

Deuterated surrogate compounds will be used to spike all samples and QC samples designated for PAH and AHC analysis. These compounds are spiked into the samples prior to extraction and are used to measure sample matrix effects associated with sample preparation and analysis. Recovery of the surrogates is monitored in each sample, and corrective actions are taken if surrogate recovery is outside acceptable limits for the method.

When available, standard reference materials will also be run for PAH and AHC on a schedule of one in twenty samples or once per sample batch. Standard Reference Material (SRM), such as those issued by the National Institute for Standards and Technology (NIST), are certified for specific chemical properties and are issued with certificates that report analytical data and indicate proper use of the material. These materials may be used by the laboratory as a measurement of both accuracy and reproducibility. Reference material, if available, may also be run for TOC analysis (e.g., standard sediment provided by the National Bureau of Standards).

The objectives of the Quality Assurance/Quality Control (QA/QC) program are to fully document the field and laboratory data collected, and to maintain data integrity from the time of field sampling to the data's storage at the end of the project.

5.0 PROJECT MANAGEMENT

Details concerning project organization, management, scheduling, and key project personnel are provided in this section of the Study Plan.

5.1 Project Organization

The organization of the project is depicted in Figure 6. All aspects of the project will be overseen by the Project Manager/Principal Investigator with support from the Assistant Project Manager. Individual tasks will be managed by Task Leaders. The project is comprised of five major tasks:

- Quality Assurance/Quality Control
- Field Sampling
- Laboratory Analysis
- Data Management
- Reporting

5.2 Project Management

The Principal Investigator and Project Manager, Dr. Patrick Kinney, will be responsible for the overall study design, adherence to schedule, production of deliverables, cost and manpower tracking, coordination of all project tasks, and be point-of-contact for RCAC. The Project Manager will be supported by an Anchorage-based Assistant Project Manager, Ms. Janet Kennedy, who will be also involved in the above tasks and serve as secondary point-of-contact for RCAC.

The Task Leaders will be responsible for the completion of each of the individual technical tasks and are identified in Figure 6. Integration and communication between tasks will be maintained throughout the course of the project.

5.3 Key Personnel

Kinnetic Laboratories' team has been carefully assembled. The Project Manager, Assistant Project Manager, and individual Task Leaders have been chosen because of their proven ability to meet project objectives on time and within budget. All members of the project team have experience in environmental monitoring projects of this type; in addition, most of the team members have considerable Alaskan experience to their credit. The qualifications of key personnel of the project team are summarized below.

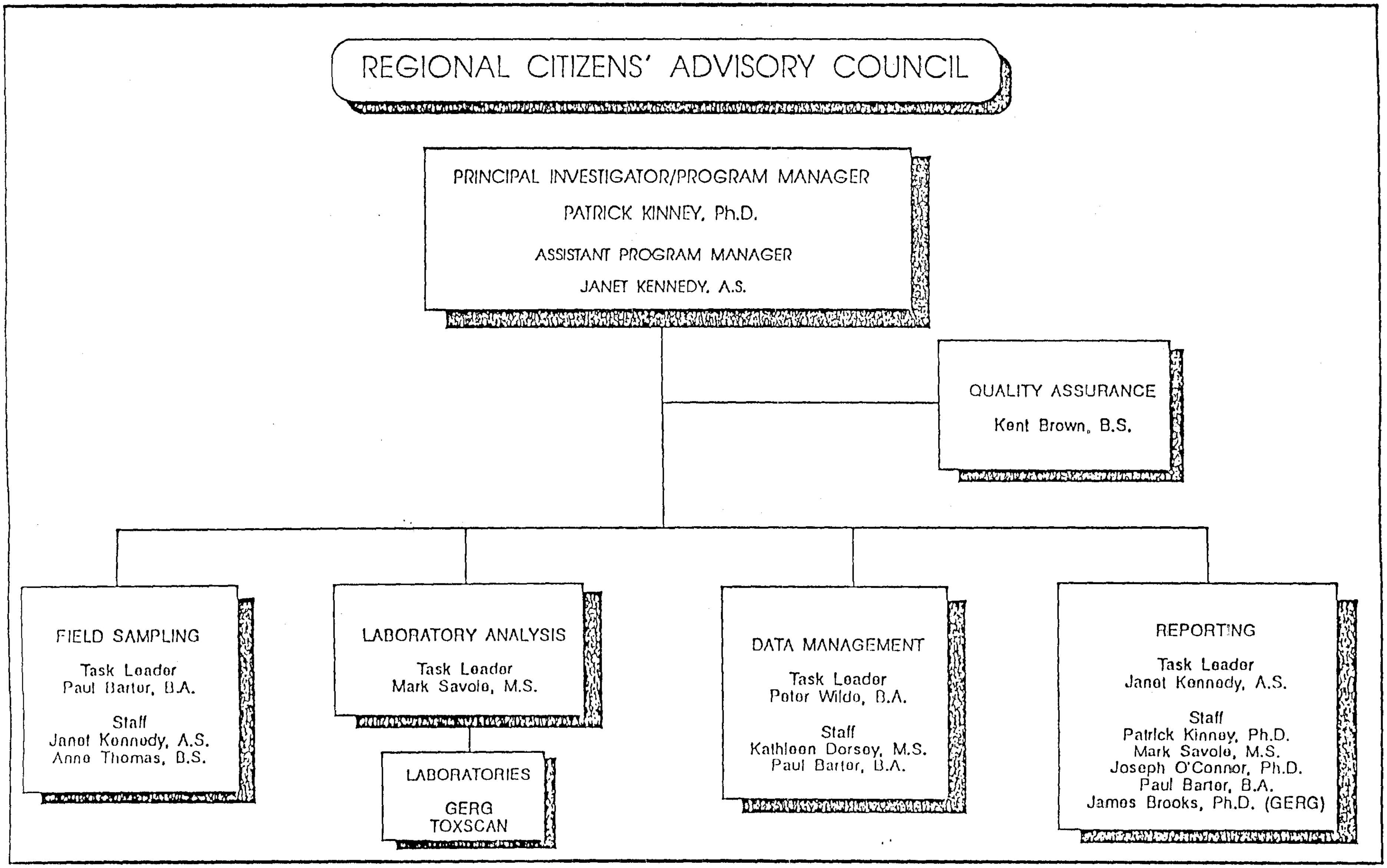

Figure 6. Project Organization Chart.

KINNETIC LABORATORIES INCORPORATED

Patrick Kinnev, Ph.D., will serve as Principal Investigator and Project Manager and will coordinate all project tasks, monitor progress, and oversee budgets and invoicing.

Dr. Kinney is a founding Principal of Kinnetic Laboratories, Inc. and has over 25 years experience in environmental studies. He received his Ph.D. in Chemical Engineering from Iowa State University and a Post-doctorate in Oceanography from Scripps Institution of Oceanography. Dr. Kinney has served as a tenured faculty member at the University of Alaska, Institute of Marine Sciences, where he initiated the University's oceanographic research efforts in the Arctic Ocean and along the Beaufort Sea coast. He has also served as a visiting professor at the University of California, Santa Cruz.

In recent years, Dr. Kinney has relinquished some of his business responsibilities to return to technical work. He is involved in both Alaskan and California projects, with approximately 20-30 percent of his time in recent years spent in Alaska. Dr. Kinney has extensive Alaskan experience, including experience in the Arctic, Bering, Beaufort, and Chukchi Seas, Prince William Sound, and Port Valdez. In 1971, while at the University of Alaska, he served as the Principal Investigator in baseline studies of Port Valdez hydrocarbon concentrations.

Dr. Kinney has over 25 years of experience in interdisciplinary marine programs, many of which were in Alaska. This experience has ranged from program design through implementation to final interpretation of results. He has actively participated in over 50 large applied programs designed to quantitatively assess impacts on the marine environment. His education and experience have combined engineering with oceanography, biology, and chemistry, with emphasis on applied problems in nearshore and estuarine areas.

Dr. Kinney has designed and/or acted as Principal Investigator on over 75 NPDES monitoring studies involving effects of point source discharges. He has extensive experience with non-point source discharges as well as spills of hazardous materials, most recently the *EXXON VALDEZ* oil spill.

Janet Kennedv, A.S., will act as Assistant Project Manager and lead the Reporting Task. Ms. Kennedy is an environmental scientist holding a degree in Marine Biology and Oceanography. She is currently serving as the Regional Manager of KLI Alaska Operations and has ten years of experience in marine studies, primarily revolving around monitoring and assessment projects pertaining to the oil industry. She has participated in numerous multi-disciplinary long-term monitoring programs as well as NRDA programs for both industrial and government clients. Her involvement in these programs has included management of scientific programs; field sampling; development of sampling protocols for water, sediment, and biological collections; data analysis and reporting; proposal and report writing; taxonomy of benthic organisms; and training and supervision of personnel.

Ms. Kennedy has extensive field experience in the Atlantic and Pacific Oceans, Prince William Sound, and the Gulf of Alaska. She has been a participant or field leader of over 50 research cruises involving the collection of samples for the determination of chemical, physical, biological, microbiological, and toxicological parameters. Her experience includes intertidal programs and shallow-water, nearshore efforts as well as deep water cruises involving sampling in water depths of up to 3000 m.

From April 1989 to March 1991, while employed by Battelle Ocean Sciences, Ms. Kennedy served as the Assistant Science Manager/Field Leader for scientific programs associated with the EVOS. She was Field Leader for many fate and effect study surveys in 1989/Spring 1990 and Chief Scientist for the 1990 Bioremediation Monitoring Program, a five-month study funded by EPA, ADEC, and EXXON. Prior to April 1989, Ms. Kennedy was heavily involved in several long-term U.S. Minerals Management Service (MMS) programs monitoring the effects of oil drilling on benthic communities in the U.S. Pacific Ocean off California and in areas of the U.S. Atlantic stretching from Georges Bank (New England) to the southern Atlantic states. Ms. Kennedy was also involved in the study of environmental effects of the *PAC BARONESS* oil and copper ore spill which occurred off the coast of California in 1988.

James Brooks, Ph.D. will provide technical assistance to the project and assist in hydrocarbon fingerprinting and data interpretation. Dr. Brooks is Director and Senior Research Scientist at the Geochemical and Environmental Research Group (GERG) at Texas A & M University. He holds his Ph.D. degree in Chemical Oceanography from Texas A & M University. His specialties include environmental chemistry, petroleum geochemistry, and project management, and he offers additional expertise in marine geochemistry and environmental assessment.

Dr. Brooks has 16 years of experience, 14 of which have been spent at GERG. He has authored or contributed to more than 120 publications, mostly concerning petroleum in the marine environment. His extensive work has been conducted in areas around the U.S. as well as internationally, including studies conducted in Chesapeake Bay, the Gulf of Mexico, offshore California, New Zealand, the Antarctic, and Alaska. Dr. Brooks has been heavily involved in the analytical efforts for EVOS impact assessment for NOAA, U.S. Fish and Wildlife Service, and the State of Alaska as well as EXXON's scientific contractors. In addition, GERG was selected by the National Science Foundation (NSF) to perform environmental assessment of the *BAHIA PARISO* oil spill which occurred in the Antarctic in 1989. Dr. Brooks and GERG are currently involved in large-scale programs such as NOAA's National Status and Trends Mussel Watch Program (Gulf of Mexico region), EPA's Environmental Monitoring and Assessment Program - Near Coastal (EMAP-NC, Gulf of Mexico and Virginia Province) and National Estuary Program (Galveston Bay, Boston Harbor, and Maine's Casco Bay).

Joseph O'Connor, Ph.D. will serve as a Senior Scientist on the project and will contribute to the evaluation of hydrocarbon data with respect to biological and toxicity considerations. Dr. O'Connor has over 25 years of experience in estuarine environmental studies, focused primarily on sediments, sediment chemistry, and sediment-biological interactions in urban/industrial estuaries.

Dr. O'Connor is a nationally recognized scientist in environmental toxicology and chemistry. He has carried out pioneering studies to establish sediment/biological relationships as affected by dredging and dredged material disposal in estuaries. He has served as Principal or Co-Principal Investigator on research and monitoring studies of the effects of sediments and sediment associated chemicals in Chesapeake Bay, Delaware Bay, Hudson River, New York Bight, and San Francisco Bay. He also has been a key participant in studies of storm drain contribution to sediment contamination in New York Harbor and San Francisco Bay.

Dr. O'Connor has directed and managed the preparation of the Status and Trends reports on both Pollutants and Dredging in San Francisco Bay. As former Senior Scientist at the San Francisco Bay Aquatic Habitat Institute, he was a key participant in the design and implementation of the Regional Monitoring Program to assess sediment and water quality in San Francisco Bay. He also organized a major workshop for the State of California Water Resources Control Board on establishing sediment quality criteria for the state. He designed and interpreted results from studies of urban stormwater runoff to San Francisco Bay from watersheds within Santa Clara County.

Dr. O'Connor was a U.S. Delegate at the Japan/U.S. experts conference on dredging and dredged material disposal. He also has been a research Professor at New York University Medical Center, Institute of Environmental Medicine, where he still retains Adjunct Professor status, and where he also served as Director of Aquatic Toxicology. He has served as a Research Advisor to 12 Ph.D. students, now active in academic, governmental, regulatory, and industrial settings. He also serves as an Editorial Board Member for two major international journals; Marine Environmental Research and Chemistry and Ecology.

Mark A. Savoie, M.S. will lead the laboratory chemical analyses task and provide technical interpretation on the sediment quality and hydrocarbon fingerprinting aspects of the project. Mr. Savoie has a M.S. degree in physical oceanographer/coastal engineering and serves as the vice president for Kinnetic Laboratories, Inc. (KLI). He has over 12 years of experience in conducting environmental monitoring studies and has an extensive background in water and sediment quality, physical oceanography, and coastal engineering. Mr. Savoie recently relocated to California after having spent 10 years in Alaska working for KLI.

From the Spring of 1989 through mid-1991, Mr. Savoie managed a large segment of the scientific studies being carried out on the *EXXON VALDEZ* oil spill for EXXON. In addition to scientific interpretation and input, Mr. Savoie was involved in field operations, budgeting, and database management associated with these extensive studies. He was also involved in interpretation of hydrocarbon fingerprinting information for both water and sediment samples.

Mr. Savoie has been involved in a large number of water and sediment quality related studies that KLI has performed for federal agencies, municipalities, and industrial clients. In Alaska, Mr. Savoie was either the project manager or principal investigator for a number of National Pollutant Discharge Elimination System (NPDES) permit monitoring efforts including: Municipality of Anchorage's 301(h) secondary treatment waiver monitoring studies, EPA/ADEC's investigations of pulp processing discharges into Ward Cove near Ketchikan, Kuparuk Seawater Treatment Plant's (STP) discharge monitoring, Prudhoe Bay STP discharge monitoring, and the Endicott STP discharge monitoring. Mr. Savoie has also been involved in a number of federal studies funded by NOAA and MMS that examined the effects of offshore oil development including baseline studies in the Chukchi and Beaufort Seas. He was also the Principal Investigator for the physical oceanographic and water quality aspects of a large MMS-funded 5-year California OCS environmental monitoring program that examined the effects of offshore drilling and associated discharges into the region.

Paul Barter, B.A. will lead the Field Sampling task. Mr. Barter currently serves as Alaska Field Operations Manager for KLI. He holds a degree in Biology with marine emphasis from the University of California, Santa Cruz. In addition to his operations responsibilities, Mr. Barter performs data analysis and is conversant with a wide variety of conventional software appropriate for use in environmental studies.

Mr. Barter has worked extensively off the coast of Northern and Southern California and in Prince William Sound, Shelikof Strait, Cook Inlet, and the Beaufort Sea. He has experience in environmental monitoring using a wide range of equipment and analytical methods. For the studies initiated by EXXON in response to the grounding of the *EXXON VALDEZ*, Mr. Barter served as the principal Field Leader for the water and sediment quality monitoring projects and held other positions of responsibility on many other fate and effects programs, as well as serving as Divemaster/Diver on cruises in both the Kodiak Island/Shelikof Strait areas and Prince William Sound. In 1990, Mr. Barter acted as KLI's Field Leader for the Bioremediation Monitoring Program, a joint EPA, ADEC, and EXXON study.

Prior to his move to Alaska, Mr. Barter performed field studies out of KLI's Santa Cruz, California office. His field operations history includes work on numerous NPDES programs and MMS-sponsored benthic and physical oceanographic studies. He has experience in the design and implementation of field studies; diver-supported sampling; soft- and hard-bottom sampling techniques for biota and sediments; the design and deployment/retrieval of oceanographic moorings; the use of Remotely Operated Vehicles (ROV) sampling and equipment retrieval; and water and sediment quality monitoring techniques.

Peter Wilde, B.A., will be lead the Data Management task and be responsible for the data management and statistical analysis aspects of the project. Mr. Wilde is the Data Systems Manager and has served as computer analyst and physicist at Kinnetic Laboratories since 1979. He holds a B.A. in Physics and Information Sciences from the University of California, Santa Cruz.

As computer analyst, Mr. Wilde is responsible for all data processing, programming, and statistical analyses for environmental programs, including physical, chemical, and biological studies. His responsibilities include computer system and data file management, computer processing, statistical analyses, time series analyses, and graphical presentation of results. He is skilled in working with a wide range of computer hardware, from micro- and mini-computers to large mainframe systems. Using his expertise in analyzing sophisticated data sets, he designs the software required to address and simplify complex physical and biological problems. He has developed and written all of the specialized software used in KLI's oceanographic data analyses, data processing, and computer modeling efforts. He has participated in numerous projects along the coasts of California and Alaska, including studies in the Beaufort and Chukchi Seas, Resurrection Bay, and Cook Inlet.

Mr. Wilde's long history at KLI has included work on oceanographic projects for the oil industry; evaluation of dredge disposal sites for the U.S. Corps of Engineers; fate and effects studies for industrial discharges; and MMS-sponsored offshore oil development monitoring programs, rocky intertidal ecological studies, and drilling mud disposal effects studies.

Kent Brown, B.A. will serve as Quality Assurance/Quality Control Task Leader for this project. Mr. Brown is a Marine Scientist and serves as an internal QA/QC Officer for Kinnetic Laboratories, Inc. As KLI's QA/QC officer, Mr. Brown has primary responsibility for ensuring the quality of samples through proper collection, storage and analysis. He has extensive training and experience in QA/QC requirements and procedures and was a key participant in design and implementation of KLI's QA/QC program.

Mr. Brown holds a B.A. degree in marine biology for California State University, Stanislaus. His marine biological experience includes benthic community evaluation and nearly all aspects of benthic, water quality, and sediment sampling from marine waters. Mr. Brown also has broad experience with nonpoint source (urban runoff) studies, sediment sampling, and dredging studies. His practical experience combined with his QA/QC training and expertise make him particularly well-qualified to perform his QA/QC duties.

Ann Thomas, B.S. will assist in the field sampling, logistics, sample handling and tracking, and reporting. Ms. Thomas holds a B.S. degree in biology from Humbolt State University, Arcata. She functions as a marine scientist at KLI in the laboratory as well as in the field. Her duties have included sorting and taxonomy of various invertebrates (specifically crustacean groups), data analyses, computer graphics, and field sampling and support.

Ms. Thomas was a team leader with a Non-Point source project conducted for Alameda County. She led a team of field researchers in sampling water to be analyzed as well as measuring field parameters. Prior to her experience with Kinnetic Laboratories, Ms. Thomas conducted research on the feeding strategies of *Pisaster ochraceus* as it preys upon *Mytilus califorianus*. This research included both laboratory techniques as well as observations in the field and data analysis. As an undergraduate, Ms. Thomas worked on a botanical project which tested various methods of stopping an encroaching, introduced, opportunistic beach grass. Other experience during her time as an undergraduate included working for a chemist on a groundwater pollution project.

Kathleen Dorsey, M.S. will assist in the data management and analyses tasks. Since coming to Kinnetic Laboratories in 1989, she has been responsible for data analysis of the large biological data sets. These have included the hard-substrate benthic studies of the offshore Santa Maria Basin area conducted for Minerals Management Service, the hard-substrate benthic field studies for the Texaco Platform HARVEST monitoring, and three rocky intertidal studies performed for Minerals Management Service. Her responsibilities have also included analyses of the hard-substrate and soft-bottom benthic assemblages and water quality for the Watsonville and Santa Cruz outfall discharge monitoring programs. She also has responsibility for sediment particle-size analysis for all of our outfall monitoring studies and for our San Francisco Corps of Engineers' open contract, and for water column profiling for all of the Santa Cruz office's projects.

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7.0 ESTIMATED COSTS

Breakdown of proposed project costs for Year 1 and Year 2 is provided as an attachment to this project plan.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

March 19, 1993

RPWG
Y

Ms. Mary Sue Brancato
Parametrix, Inc.
5808 Lake Washington Blvd. N.E.
Kirkland. WA 98033

Dear Mary Sue:

RE: Draft Outline - Conceptual Monitoring Plan

I believe there is still some confusion on how the terms "recovery" and "restoration" are being used. Pete Peterson picked-up on this in his review of the preliminary draft materials. Please review Pete's comments which were forwarded to Tracy on or about March 5th. Pete says, and I agree with him, "that it is recovery that requires monitoring, not restoration (except in certain cases where effectiveness is uncertain). Recovery can occur naturally, whereas restoration is intervention in natural processes to promote recovery. To be explicit, it is recovery that needs to be defined in the conceptual plan, not restoration." Please feel free to call Pete if any of his comments in this regard are unclear.

I also am enclosing some additional comments offered by Chris Swenson (RPWG/ADF&G). I think his first comment, in particular, has merit. Clearly, monitoring will be undertaken for different purposes: 1) to assess the rate of unassisted recovery for injured resources and services, 2) to evaluate the effectiveness of specific restoration activities, to identify where additional restoration activities may be appropriate, and to determine if delayed injury occurs 3) to follow long-term trends in the distribution and abundance of injured resources and the quality and quantity of services, and to detect residual spill effects and provide ecological baseline information to assess the impacts of future spills and other disturbance. Accordingly, the different components of the monitoring program may have different goals, objectives and strategies.

I hope our comments are of some help. Thanks.

Yours very truly,

John Strand, ~~Ph.D.~~
Restoration Manager

Enclosure

cc: Byron Morris
Pete Peterson
RPWG

MEMORANDUM

State of Alaska
Department of Fish & Game
Habitat and Restoration Division

TO: John Strand

DATE: March 12, 1993

FILE NO.:

TELEPHONE NO.: 278-8012

SUBJECT: Conceptual Monitoring Plan and Phase 2 RFP

FROM: Chris Swenson CS

The following are my comments on the outline of the conceptual monitoring plan and the RFP for phase 2 of the monitoring plan. I don't have any major problems with either document, and I have no comments on the RFP. However, the outline often wasn't specific enough to give me a real understanding about what is being proposed.

With that in mind, the following points should either be added or clarified in the outline:

1. Section 4.1.5: Emphasize that components of the monitoring program, and thus the goals and objectives, will vary across alternatives. In fact, the goals and objectives of each component are sometimes different.

2. Section 4.2.1: Presumably, the lack of baseline data and strategies for dealing with this problem will be addressed here.

3. Section 4.3: It should be emphasized that the data must be interpreted and presented in such a way as to provide guidance for agency management and the overall course of the restoration process. Also, is it the job of those in the monitoring program to interpret and present data for general public consumption?

4. Section 7.0: This seems to be the place to emphasize the need for centralized management of research and data analysis to avoid the problem of each agency using monitoring money to go off in their own, separate directions. This is perhaps the most serious potential problem I see with the monitoring program. There needs to be some sort of binding agreement (perhaps an MOA?) and governance of the process, if the data is to be effectively integrated and disseminated over the long term.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Office of Oil Spill Damage
Assessment and Restoration
P.O. Box 210029
Auke Bay, Alaska 99821

RPWG
Y

FILE
1991 SCIENCE STUDIES PROGRAM

DATE: January 15, 1991

MEMORANDUM FOR: Stan Senner

FROM: John Strand

SUBJECT: Adjustments to RPWG's 1991 Science Studies Program Budget

Based on the results of the recently held NRDA Program Review, I think that we can now make some additional adjustments to RPWG's proposed 1991 Science Studies Program budget, at least as it pertains to the original seven monitoring studies proposed by NOAA. Three of these proposed studies have been approved under the NRDA Program. Two others (Recovery of Juvenile Salmon, Recovery of Epibenthic Prey of Juvenile Salmon) have been withdrawn because recently analyzed 1990 field data indicated that there were few or no lasting measurable effects of the oil spill on these resources. There are, however, elements of the two remaining studies (Recovery of Intertidal Sediment Resources, Natural recovery of Marine Mammals) that should remain as part of RPWG's Restoration Program and should be included in RPWG's 1991 Science Studies Program budget. The status of these two studies is described in some detail below. The status of all seven originally proposed NOAA Natural Recovery Monitoring studies is summarized in TABLE 1.

Study No. 4 (Recovery of Intertidal Sediment Resources) was submitted by the Auke Bay Laboratory. As originally proposed, there were two objectives. The first was to continue sampling historically established sites in Prince William Sound for residual hydrocarbons. The second objective measured recovery and recolonization rates of key ecosystem components (mussels, barnacles, other epibenthos and algae) at sheltered rocky and mixed-soft intertidal substrates for two conditions of oiling and treatment. Objective 1 will be funded under the NRDA Program, although at a reduced level ($152K). Objective 2, as proposed under the Restoration Program, will be conducted at 12 sites at a funding level of $267K. Objective 2 was never proposed under the NRDA. The original funding request submitted to RPWG to conduct both Objectives 1 and 2 was $462K. These funding levels include the costs of hydrocarbon analyses.

The original proposal for Study No. 6 (Natural Recovery of Marine Mammals) was prepared by the National Marine Mammal Laboratory and requested $500K. Of this proposed amount, $268K was approved under the NRDA Program ($100 for trend counts of harbor seals; and $168 for photo-identification of killer whales). The remainder of the work, as originally proposed, will determine important habitat for harbor seals and killer whales, and assess trends and important habitats for harbor porpoise and Dall's porpoise. This unfunded portion is estimated to cost $265K ($125k for harbor seals; and $140k for cetaceans). This will not add-up to the originally requested $500K because now the studies are split and "piggy-backing" of vessels etc., will be more difficult. Please also note that ADF&G will perform the harbor seal studies.

To confirm our conversation of January 10th, it is NOAA's recommendation that both the intertidal sediment and marine mammal recovery studies remain in RPWG's 1991 Science Studies Program budget. Although I initially estimated the total cost of both programs to be $450K, the actual cost may be closer to $532K. We may have to reduce scope; although, we perhaps can wait for peer review before making this decision.

cc: Byron Morris

TABLE 1

	STUDY TITLE	PROPOSAL NO.	STATUS	$(K)
1)	Monitoring Recovery of Juvenile Salmon Exposed to Hydrocarbons	FS-2	Withdrawn	0
2)	Monitoring Recovery of Epibenthic Prey of Juvenile Salmon	-	Withdrawn	0
3)	Natural Recovery Monitoring of Selected Fish Species	FS-3	NRDA	0
4)	Recover Monitoring of Intertidal Sediment Resources	CH-3	Restoration	267
5)	Natural Recovery Monitoring of Subtidal Sediment resources	CH-2	NRDA	0
6)	Natural Recovery of Marine Mammals	M-1	Restoration	265
7)	Near Shore Seawater Quality Using Sediment Traps and Caged Mussels	CH-5	NRDA	0
				$532