RPWG

United States Department of Agriculture | Forest Service | Alaska Region

Date: NOV 6 1989

Subject: Detailed Study Plans

CONFIDENTIAL

To: All P.I.'s

Enclosed are Draft Detailed Study Plans for all damage assessment studies. These remain confidential and are not to be circulated by you to anyone besides persons working directly for you on your project without prior authorization from your representative on the Trustee Council Legal Team.

Michael R. Mangan
MANAGEMENT TEAM

Enclosures

VOLUME 1

DETAILED OPERATIONAL PLANS FOR STUDIES

IN THE

STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT PLAN FOR THE EXXON VALDEZ OIL SPILL

DRAFT

CONFIDENTIAL

Coastal Habitat

Air/Water

I. COVER PAGE

Title:
Coastal Habitat Injury Assessment-Phase I

Study ID Number:
Coastal Habitat Study Number 1

Project Leader:
Kimbal A. Sundberg

Lead Agency:
Alaska Department of Fish and Game

Cooperating Agencies:
U.S. Forest Service
Environmental Protection Agency
U.S. Department of Interior
National Oceanic and Atmospheric Administration
Alaska Department of Environmental Conservation
Alaska Department of Natural Resources

Cost:
$ 536,000

Study Plan Date:
September 29, 1989

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II. INTRODUCTION

The purpose of the Coastal Habitat Injury Assessment (CHIA) is to document and quantify injuries to biological resources found in the shallow subtidal, intertidal, and supratidal zones throughout the shoreline affected by oil from the Exxon Valdez. This includes areas where oil has persisted, areas where oil has not persisted, and areas where oil did not come ashore. This study will investigate the invertebrates, fishes, algae, and vascular plants that regularly inhabit these areas. Animals that make occasional or casual use of coastal habitat (e.g. mammals, birds, commercially important fishes) are not being addressed by the CHIA but are being addressed by other injury assessment studies. Data from the CHIA will be valuable for assessing injuries to higher trophic level organisms that depend, in part, on coastal habitats in the study area.

The CHIA uses a stratified random sample design to select basic experimental units called study sites (Figure II-1). Study sites are selected from U.S. Geological Survey 1:63,360 maps containing shorelines that were affected by the oil spill. The shoreline is sub-divided into fifteen strata; five geomorphologic types called habitats multiplied by three oiling types called oil impacts. The study sites are grouped by strata within three geographic regions; Prince William Sound (PWS), Cook Inlet/Kenai Peninsula (CIK), and Kodiak Archipelago/Alaska Peninsula (KAP). For each region, four replicate study sites are sampled per habitat type in the heavy/moderate oil impact category and three replicate study sites are sampled per habitat type in the light/very light and none (control) oil impact categories.

Measurements of the quality, quantity, and composition of biological attributes at each study site (e.g. standing crop, diversity, biomass, growth rates, recruitment rates, reproductive condition) are used to develop mean study site values. These values are then averaged to derive mean values for a given strata. Strata values, in turn, are used to produce regional injury values. The regional injury values are then used to produce overall injury values.

The CHIA is divided into two phases. Phase One a reconnaissance study, is tasked with establishing statistically valid study sites. Phase Two, a comprehensive study is tasked with measuring the biological attributes of the study sites. The selection of study sites and extrapolation of injury values uses a Geographic Information System (GIS) developed under Technical Services Study Number 1.

III. OBJECTIVES

1. Establish a statistically valid study site selection strategy and identify potential study sites using existing map-based coastal habitat and oil impact classification schemes.

2. Ground-truth potential study sites to evaluate map-based habitat and oil impact classifications.

3. Describe and mark approximately 150 study sites.

IV. METHODS

Study sites are randomly selected from a GIS data base called GEO with probability proportional to size. GEO uses ARCINFO (ESRI) software to combine four primary data bases:

1. Environmental Sensitivity Index (ESI);

2. Oil Spill Impact Maps;

3. U.S. Geological Survey Shoreline; and

4. Upland Land Status

Data base numbers one, two, and three are used for selection of study sites. These data bases are described as follows:

Environmental Sensitivity Index
The ESI is a digital reproduction of five map atlases (Hayes and Ruby, 1979; RPI, 1983a; RPI, 1983b; RPI, 1985; and RPI, 1986,) which classifies the shoreline of the study area into nineteen geomorphologic types following the shoreline classification system described by Gundlach and Hayes, 1978 and Hayes, et.al., 1980. For the purposes of this study, the nineteen ESI shoreline types are consolidated into five functionally similar habitat types pursuant to CHS#1 SOP-1. The habitat types are:

1. **Exposed Rocky Shores;**

2. **Fine Textured Beaches;**

3. **Coarse Textured Beaches;**

4. **Sheltered Rocky Shores;** and

5. **Sheltered Estuarine Shores.**

Oil Spill Impact Maps
The oil spill impact maps are a GIS data base maintained by the Alaska Department of Environmental Conservation (ADEC) for the Exxon Valdez oil spill (ADEC, 1989). This data base is being developed under Air/Water Study Number 1. The oil spill impact maps classify the shoreline into five oiling types: heavy, moderate, light, very light, and no observed oil. For the purposes of this study, the five oil spill impact classifications were consolidated into three oil impact types:

1. **Heavy/Moderate;**

2. **Light/Very Light;** and

3. **No Observed Oil (Control).**

U.S.Geological Survey Shoreline
The shoreline used in GEO is a digitized reproduction of the shoreline depicted on U.S. Geological Survey topographic maps at a scale of 1:63,360. This shoreline is the approximate line of mean high water.

Site Selection
Using GEO, the primary data bases are combined to classify the shoreline into fifteen strata; five habitat types multiplied by three oil impact types. For study site selection, these strata are subdivided into segments (arcs) ranging in size from 100 to 600 meters in length. Arcs less than 100 meters are rejected from study site selection because they are too small to capture the natural variance of species composition, distribution, and abundance within a strata. Arc lengths are limited to 600 meters to ensure that the intertidal zone within a study site can be efficiently sampled during a low tide event. Following this process, each arc is given a unique identification number.

Using a random number generator, arc numbers are selected and ranked within each strata with probability proportional to size according to the following equation (Cochran, 1977):

$$\text{Probability } i\text{th arc is selected} = Pi = \frac{lij}{L.j}$$

where: $L.j = \sum_{i} lij$ = total arc length in jth strata

lij = length of ith arc in jth strata

After arc numbers are selected, the top ranked arc center points are plotted on maps at a scale of 1:63,360.

Reconnaissance Survey

Study sites are field checked by a reconnaissance survey to ground-truth the habitat type and oil impact classifications and to mark the boundaries of the study site for Phase II sampling.

Reconnaissance surveys are performed during low to mid tide levels. Tides in the study area are mixed, semi-diurnal. For the purposes of this study, the shallow subtidal zone is defined as -20 meters (referenced to Mean Lower Low Water) up to Mean Lower Low Water; the intertidal zone is defined as Mean Lower Low Water through Mean Higher High Water; and the supratidal zone is defined as Mean Higher High Water through the upland extent of visible oiling (generally Extreme Higher High Water).

The center point of each study site is located on the ground using topographic maps, visual references, and compass bearings. A study site where the slope is found to be greater than 35 degrees in 50 percent or more of the intertidal zone is determined to be inaccessible due to human safety considerations and is rejected. The arc length of accessible study sites is measured from the center point using a meter tape along the upper intertidal zone (generally above the Fucus line). The end points of the study site are marked with fixed monuments (iron stakes, paint on rocks, flagging, etc.). Each accessible study site is surveyed and photographed using a 35mm camera with time/date imprint noting the habitat type(s) and oil impact type in the intertidal and supratidal zone over the entire study site. If more than one strata is found within a study site, each strata is measured separately. Habitat types are rated by visually assessing the surficial and shallow subsurface grain size of beach sediments, visually assessing the degree of wave exposure, and referencing CHS#1 SOP-1. Oil impact types are determined using the rating system provided by the ADEC (CHS#1 SOP-2). Beach slopes are determined using a hand-held clinometer. Information is recorded on field forms (CHS#1 SOP-5).

Surficial sediment and/or oil samples from each study site are collected from the intertidal zone using CHS#1 SOP-3 provided by the National Marine Fisheries Service, Auke Bay Fisheries Laboratory.

V. Data Analysis

Data collected during Phase I are used to determine the study sites that will be sampled in Phase II. Sites are reclassified to strata other than the strata classified on the original site selection maps if more than 50 percent of the study site is determined to fit a strata other than the original classification. Measurements of habitat types and oil impact types are used to classify study sites into the appropriate strata and to provide baseline information for

measuring future changes. Linear measurements of strata at each study site are used to determine the number and placement of transects for sampling in Phase II. Photographs are used to record the site location, land marks, and visible site characteristics. Analysis of sediment and oil samples are used to document the presence of Exxon Valdez oil at the oiled study sites and to determine whether hydrocarbons are present or absent at the control study sites.

VI. Schedule and Planning

Data Submission Schedule

Figure VI-1 identifies the major activities and milestones for this project.

Special Reports

Reports containing maps and summarized field data will be provided to the Phase II principal investigators to enable them to begin comprehensive sampling of study areas as soon as possible. Lists of approved study sites are provided to the GEO group (TSS #3) for preparation of study site maps.

Visual Data

Photographs of the study sites are sorted, labeled, and cataloged in bound volumes for use by the Phase II principal investigators and others.

Sample and Data Archival

All sediment and hydrocarbon samples are transferred to National Marine Fisheries Service, Auke Bay Fisheries Laboratory through EQM&LO Chain-of-Custody Procedures (CHS#1 SOP-4) for archival and analysis. Field notes, data summaries, maps, correspondence, analysis, photographs, and other documents pertinent to the study are maintained in a locked file cabinet under the custody of the principal investigator.

Management Plan

Figure VI-2 shows the management structure for the project. The principal investigator is responsible for all products, reports, and publications pertaining to Phase I of the CHIA. The University of Alaska, Institute of Marine Science and Institute of Arctic Biology, and the University of Wyoming, Department of Statistics are among the principal investigators for Phase II of this project and are providing technical support for Phase I.

Logistics

Reconnaissance surveys will be accomplished using charter vessels, skiffs, and helicopters. The following is a summary of logistical needs:

KAP Region

One crewed vessel, 80+ feet in length with two skiffs, outboards, fuel, provisions	23-30 days
One helicopter, single engine	92-120 hours
Fixed-wing, single engine	10 hours
Helicopter fuel	47-61 drums

PWS-CIK Region

One crewed vessel, 60+ feet in length with two skiffs, outboards, fuel, provisions	28-35 days
One helicopter, single engine	96-112 hours
Fixed-wing, single engine	20 hours
Helicopter fuel	49-57 drums

VII. Budget

All costs are in $1,000.

	LINE					
	100	200	300	400	500	TOTAL
Projected Expenditures to 12/30/89	47.2	9.0	368.2	16.3	3.4	444.1

Line 100-Salaries

Class	Name	PCN	Mo.Salary & Benefits	Months		Total
HB IV	Sundberg	6028	5.8	3.0		17.4
HB I	Byersdorfer	N384	2.5	5.5		13.8
HB I		N428	2.5	1.5		
CART III	Barnhill	6118	3.4	2.0		6.8
CT III	Voelker	6053	2.4	3.0		7.2
					OT	2.0
				Total		47.2

Line 200-Travel

Includes per diem

2 RTs, Anchorage-Cordova @ $.2/trip	0.4
4 RTs, Anchorage-Kodiak @ $.3/trip	1.2
1 RT, Laremy, WY-Cordova (McDonald)	1.2
1 RT, Columbia, SC-Kodiak (Sexton)	2.0
1 RT, Tampa, FL-Cordova (Gibeaut)	1.7
4 RTs, Anchorage-Juneau @ $.5/trip	2.0
2 RTs, Anchorage-Valdez @ $.2/trip	0.4
4 Goldstreaks @ $.028	0.1
Total	9.0

Line 300-Contractual

E-Tech Inc.	J. Gibeaut 38 days @ $.2 50 hours @ $.025 J. Sexton 36 days @ $.41 E. Gundlach 2 days @ $.5 Misc. expenses	25.0
Vessel Charter	28 days X $4.0/day 24 days X $3.75/day	112.0 90.0
Fixed-Wing	3 hours X $.5/hour	1.5
Helicopter	220 hours X $.5/hour	110.0
Air Freight	RT, Anchorage-Cordova RT, Anchorage-Kodiak	1.5
GIS Mapping	USGS-EROS, ADNR-DM	25.0
Advertising	Contracts-Legal Notices	0.2
Photo-repro.	Drafting, photo duplicating	1.0
Office	Phone, xerox, fax	2.0
	Total	368.2

Line 400-Commodities

Jet A Fuel	100 drums @ $.1	10.0
Film & Processing	Slides	1.0
Rebar stakes	500 #6 X 4 feet	0.6
Mustang suits	2	0.6
Maps and charts	USGS topos and NOAA charts	0.3
Field supplies	Hand tools, meter tapes, markers	1.0
Groceries		0.8
Office supplies	Includes drafting supplies	1.0
Miscellaneous		1.0
	Total	16.3

Line 500-Equipment

Cameras	2 Nikons w/zoom, data back, acces.	2.0
Radios	3 hand-held VHF	1.4
	Total	3.4

Principal Investigator Statement of Qualifications

Kimbal A. Sundberg has been employed as a Habitat Biologist with the Alaska Department of Fish and Game since 1975. Mr. Sundberg graduated from the University of Washington with a B.S in Biological Oceanography in 1975. He has worked extensively on coastal zone management projects including mapping the biophysical boundaries for the coastal zone of Alaska, completing a detailed coastal habitat evaluation for the City and Borough of Sitka, and assisting with developing the standards and guidelines of the Alaska Coastal Management Program.

In 1976-77, he served as project leader of a study to determine the distribution and relative abundance of post-larval king crab in Lower Cook Inlet. This study, among others, was used for the state buy-back of oil and gas leases in Kachemak Bay. Mr. Sundberg has been closely involved with evaluating Federal and state oil and gas leasing in Alaska. He has reviewed and commented on numerous documents and studies concerning the effects of major energy facility developments on fish and wildlife resources. He frequently assists and advises other state and federal agencies in evaluating the effects of coastal developments on fish and wildlife habitats. Currently, he leads the department's participation in planning efforts on state and federal lands in Southcentral and Western Alaska.

I. CITATIONS

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Environmental Systems Research Institute (ESRI). ARCINFO geographic information system software. Version 5.0. Redland, California.

Gundlach, E.R. and M.O. Hayes. 1978. Vulnerability of coastal environments to oil pollution. Marine Technology Society Journal, Vol. 12, pp 18-27.

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_____. 1983b. Sensitivity of coastal environments and wildlife to spilled oil, Shelikof Strait Region, Alaska, and atlas of coastal resources. Prepared for National Oceanic and Atmospheric Administration, Office of Oceanography and Marine Services, Seattle, Washington, 98115. 43 leaves.

_____. 1985. Sensitivity of coastal environments and wildlife to spilled oil, Cook Inlet/Kenai Peninsula, Alaska, an atlas of coastal resources. Prepared for National Oceanic and Atmospheric Administration, Office of Oceanography and Marine Assessment, Seattle, Washington, 98115. 64 leaves.

_____. 1986. Sensitivity of coastal environments and wildlife to spilled oil, Southern Alaska Peninsula, an atlas of coastal resources. Prepared for National Oceanic and Atmospheric Administration, National Ocean Service, Alaska Office and U.S. Department of Interior, Minerals Management Service, Alaska OCS Region. 69 leaves.

IX. Other Information

List of Figures

Figure II-1	Coastal Habitat Injury Assessment
Figure VI-1	Milestone Chart
Figure VI-2	Coastal Habitat Injury Assessment-Phase I Management Structure

List of SOPs

CHS#1 SOP-1	Consolidation of Shoreline Types for Coastal Habitat Injury Assessment 6/13/89
CHS#1 SOP-2	Alaska Department of Environmental Conservation Rating System
CHS#1 SOP-3	Procedural Guidance: Sampling and Sampling Equipment
CHS#1 SOP-4	EQM&LO Chain-of-Custody Procedures
CHS#1 SOP-5	Coastal Habitat Injury Assessment Reconnaissance 7/89

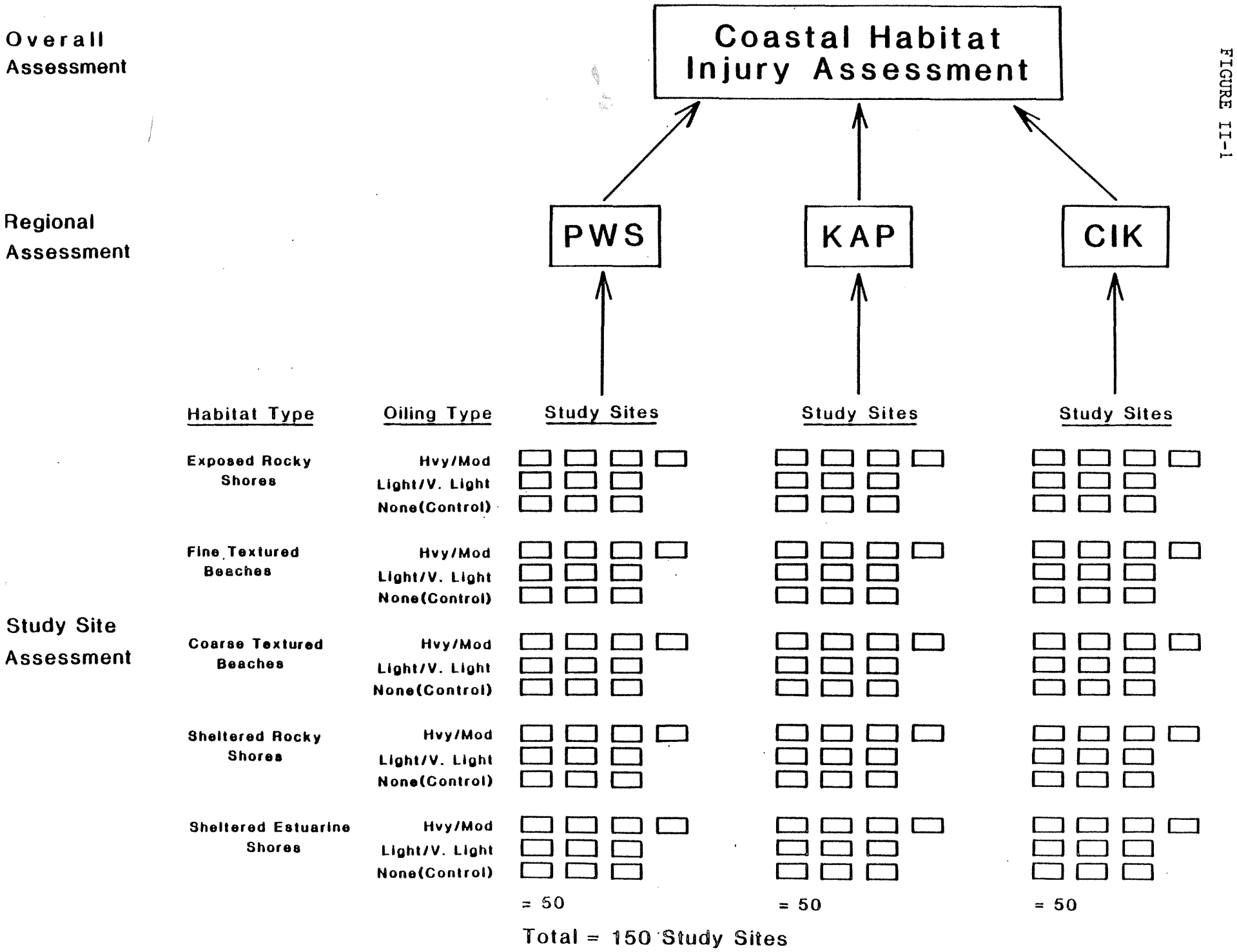

Overall Assessment
Coastal Habitat Injury Assessment
Regional Assessment
PWS
KAP
CIK
Habitat Type
Oiling Type
Study Sites
Study Sites
Study Sites
Exposed Rocky Shores
Fine Textured Beaches
Coarse Textured Beaches
Sheltered Rocky Shores
Sheltered Estuarine Shores
Hvy/Mod
Light/V. Light
None(Control)
Study Site Assessment
= 50
= 50
= 50
Total = 150 Study Sites

FIGURE II-1

FIGURE VI-1

M I L E S T O N E C H A R T

Planned Completion Date △

Actual Completion Date ▲

SP #: Coastal Hab #1 PI: Kimbal A. Sundberg

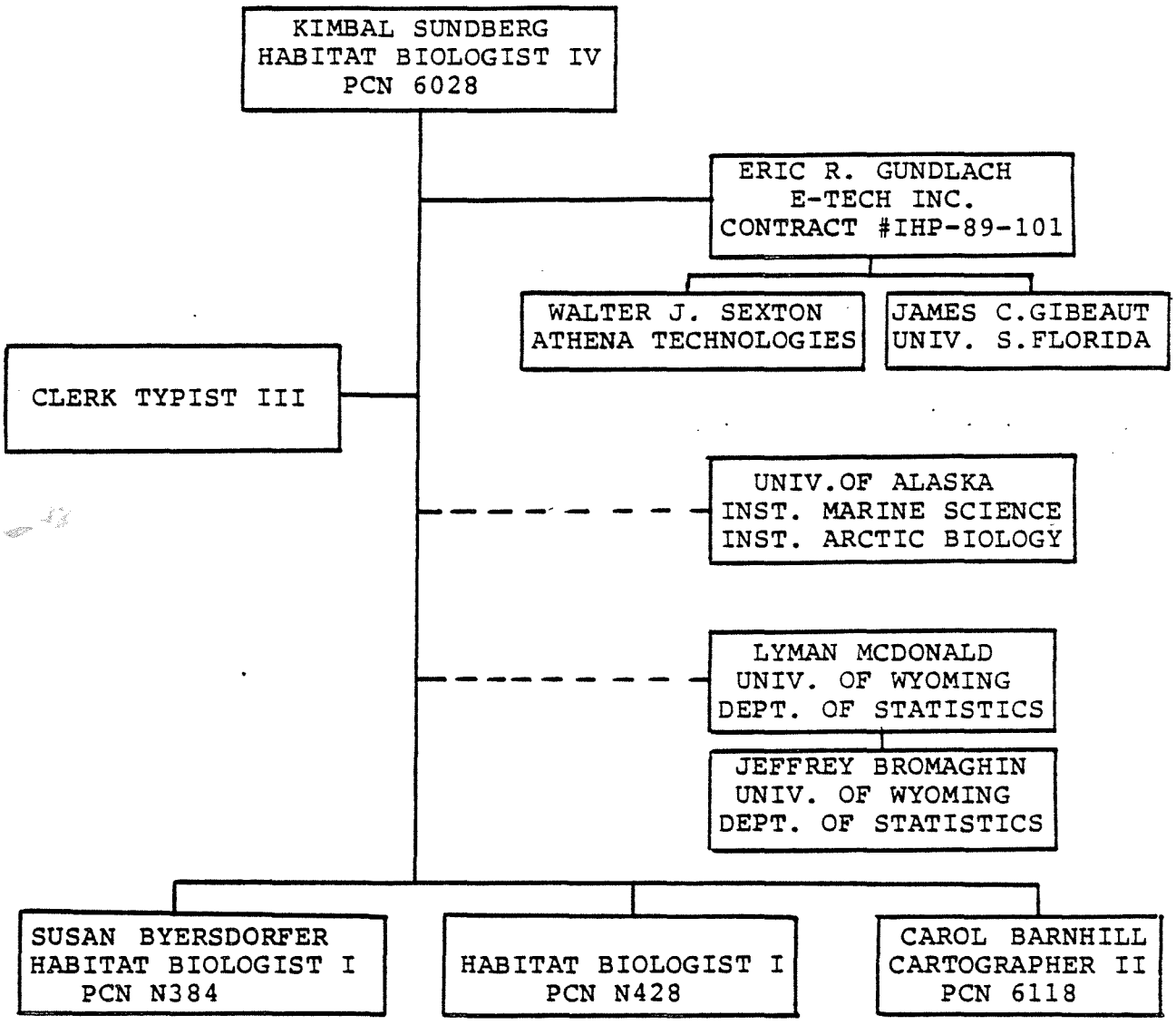
Major Milestones: Reports, cruises, field effort, data management, workshops, significant contractual requirements, etc.

MAJOR MILESTONES	1989									1990			
	A	M	J	J	A	S	O	N	D	J	F	M	A
Combine data bases and generate site selection maps				▲									
Conduct field orientation cruise				▲									
Complete reconnaissance survey cruise in PWS				▲									
Complete reconnaissance survey cruise in CIK					▲								
Complete reconnaissance survey cruise in KAP					▲								
Complete study site selection for '89 Phase II sampling						▲							
Complete Phase I report									△				

FIGURE VI-2

COASTAL HABITAT INJURY ASSESSMENT-PHASE I

MANAGEMENT STRUCTURE



CHS#1 SOP-1

CONSOLIDATION OF SHORELINE TYPES FOR COASTAL HABITAT INJURY ASSESSMENT 6/13/89

ESI #	SHORELINE TYPE	HABITAT TYPE
1	Exposed rocky headlands	1. EXPOSED ROCKY SHORES
1	Exposed rocky shores	
2	Wave-cut platforms	
2	Exposed wave-cut platforms	
3	Fine/medium grained sand beaches	2. FINE TEXTURED BEACHES
3	Fine grained sand beaches	
4	Coarse grained sand beaches	
5	Exposed tidal flats	3. COARSE TEXTURED BEACHES
5	Mixed sand and gravel beaches	
5	Exposed tidal flats (low biomass)	
6	Mixed sand and gravel beaches	
6	Gravel beaches	
7	Gravel beaches	
7	Exposed tidal flats	
7A	Exposed tidal flats (mod. biomass)	
7	Exposed tidal flats (mod.-high biomass)	
8	Sheltered rocky shores	4. SHELTERED ROCKY SHORES
9	Sheltered tidal flats	5. SHELTERED ESTUARINE SHORES
10	Marshes	

Alaska Department of Environmental Conservation (ADEC) Rating System

Beach impacts are evaluated solely on the amount of area covered or penetrated by oil between the mean high tide and mean low tide lines. The ADEC rating system is as follows:

Amount of Oil

Less than 1 m wide band on beach = very light
1 to 3 m wide band = light
3 to 6 m wide band = moderate
Over 6 m wide band = heavy

OR

Percent of Total Beach Area Covered or Penetrated

Less than 1% coverage/penetration = very light
1 to 10% coverage/penetration = light
10 to 50% coverage/penetration = moderate
More than 50% coverage = heavy

2. Procedural Guidance: Sampling and Sampling Equipment

The method of collection should not contaminate the samples. Surface slicks must be avoided during sub-surface sampling. Collecting fish or other animals for whole animal samples with oil-fouled equipment, such as nets, is unacceptable.

Sample collection and storage devices shall be cleaned with soap and water and rinsed in methylene chloride or alternatively, a rinse with acetone followed by a rinse with hexane. Glass jars may be cleaned by heating to 440°C for a minimum of 1 hour.

All sample containers shall be chemically clean glass with teflon-lined lids or chemically clean aluminum foil. All equipment that comes in contact with the sample such as dredges, dissecting equipment or water bottles must be solvent-rinsed between each sample.

Sample container volume must be appropriate to sample size to minimize head space and desiccation. Do not overfill or underfill.

All samples shall be held in a secure place under chain-of-custody until the Trustees indicate otherwise.

2.1.1 Water - Samples must be taken using chemically-clean inert samplers (such as glass, teflon or stainless steel). All samplers must be cleaned and solvent-rinsed between samples. Recommended sample size is 1-4 liters.

Water samples for volatiles analyses should be taken in 40 ml amber vials with no head space or bubbles.

2.1.2 Sediment - Any accepted methods of collecting undisturbed surface sediment samples such as box cores, hand corers, or grabs may be used. The methodology must be specified. Recommended sample size is 10-100 grams (an 8 oz. jar).

Suggested reference:
National Status and Trends Program Cycle III Field Manual NOS OMA 28 Procedures for Handling and Chemical Analysis of Sediment and Water Samples. EPA/CE 81-1.

2.1.3 Tissue

Bird eggs collected in the field can be transported by any convenient means that will prevent breakage. If the eggs cannot be opened within a few days of collection, the eggs should be refrigerated. Eggs can be opened by cutting them with a scalpel or by piercing the air cell end and pouring/pulling the contents out. The latter technique is easier for someone not experienced with the scalpel method. Care must be taken to avoid including pieces of egg shell with the contents and to avoid contamination of the contents by using uncleaned instruments or by touching the contents with your hands. Total weight, volume (measured or calculated), length, width and contents weight must be recorded for each egg.

Animal tissues to be analyzed for petroleum hydrocarbons must be processed before decomposition occurs. The whole carcass can be frozen until samples are taken for analysis. Where there is risk or evidence of oil contamination on collecting equipment or collected organisms, only internal organs may be sampled. Dissections must be performed in such a manner that no cross contamination of internal organs by external oil can occur. In all cases, instruments used for exterior dissection must not be used for internal dissection.

Bile shall be collected by removing the gall bladder, puncturing it with a clean, sharp instrument, and collecting the contents in 4 ml amber glass vials.

2.2 Sample Identification, Labelling and Chain-of-Custody

Sample identification and chain-of-custody ensure that the quality and integrity of environmental samples are maintained during their collection, transportation and storage. Sample identification documents must be carefully prepared so that identification and chain-of-custody can be maintained and sample disposition can be controlled. Study managers and/or sample collectors are responsible for implementing the identification and chain-of-custody procedure.

2.2.1 Field Identification Procedure - The method of identification of a sample depends on the type of measurement performed. An in-situ measurement is one in which the sample is collected or measurement is performed in its natural place and the data are recorded directly in logbooks, together with the location at which the measurement was made and other identifying information. Examples of in-situ measurements are temperature and salinity.

Samples for which in-situ measurements are not performed are identified by a sample tag or sample label attached to or folded around the sample container. A tag or label identifying the sample must be completed and attached to each sample. Waterproof (indelible) ink must be used on the tag or label. Included on the tag are the sample identification number, the location of the collection site, the date of collection and signature of the collector. Additional information will include preservative used and any remarks. The information above shall be recorded in a bound logbook. Field sample data sheets or photographs, along with any pertinent in-situ measurements and field observations, are options, and also must be recorded in the logbook.

The location of the sampling site is to be determined with the aid of navigation systems such as LORAN or USGS grid maps. A descriptive location will be recorded and the location must also be recorded as latitude and longitude.

After collection and identification, the sample is preserved, if required, and maintained under the chain-of-custody procedure.

2.2.2 Field Chain-of-Custody Procedure - Due to the evidentiary nature of sample-collecting investigations, the possession of samples must be traceable from the time the samples are collected until they are introduced as evidence in legal proceedings. To maintain and document sample possession, chain-of-custody procedures must be followed.

The field sampler will be personally responsible for the care and custody of the samples collected until they are transferred.

All samples will be accompanied by a chain-of-custody record or field sample data record (see Attachment 2 for an example). When samples are transferred from one individual's custody to another's the individuals relinquishing and receiving will sign, date and note the time on the record. This record documents the transfer of custody of samples from the sampler to another person or to a specified analytical laboratory.

Shipping containers will be custody-sealed for shipment. This procedure includes use of a custody seal such that the only access to the package is by breaking the seal. The seal shall be signed before the sample is shipped. The chain-of-custody record will be dated and signed to indicate any transfer of the samples. The original record will accompany the shipment, and a copy will be retained by the sample collector. Whenever samples are split, a separate chain-of-custody record will be prepared for those samples and marked to indicate with whom the samples are being split.

If samples are sent by common carrier, copies of all bills of lading or air bills must be retained as part of the permanent documentation.

2.3 Sample Preservation and Holding Time

All samples shall be maintained on ice until prepared for final disposition. Samples that are to be frozen shall be kept on ice until frozen and shall be kept in a frozen state until extracted or prepared for analysis. We recommend the rapid and timely freezing of any samples that are to be maintained frozen and the storage of frozen samples at -20°C or less.

If extracts are stored prior to analysis, changes in extract volume due to solvent loss are possible. The initial extract weight must be recorded and the weight measured and recorded before analysis.

2.3.1 Water - All water samples must be immediately extracted with methylene chloride or preserved with HCl to pH<2. If preserved, water samples shall be stored in the dark at 4°C and extracted within 7 days. All extracts shall be stored in the dark in air tight chemically cleaned containers until analysis. If extracts are stored frozen at -20°C or less, they must be analyzed within 90 days. Otherwise analysis must take place within 40 days.

2.3.2 Sediment - Samples have been held for up to 5 years continuously frozen at -20°C or less with no loss of data quality for high molecular weight aromatic hydrocarbons. If there is a lag between sample extraction and sample analysis, extracts may be stored for up to 40 days in air tight containers kept in the dark at 4°C. We recommend that all sediment samples be analyzed within 1 year of collection.

2.3.3 Tissues - Samples have been held for over 5 years continuously frozen at -20°C or less with no less of data quality for high molecular weight aromatic hydrocarbons. If there is a lag between sample extraction and sample analysis, extracts may be stored for up to 40 days in air tight containers kept in the dark at 4°C. We recommend that all tissue samples be analyzed within 1 year of collection.

2.4 Sample Shipping

All samples, except water samples, shall be maintained in a frozen state throughout the shipping process. Samples shall be packaged to prevent breakage (i.e., bubble wrap). It is the responsibility of the sample collector to inform the receiver that the shipment has been initiated. To insure that samples are not compromised, we recommend shipments not be initiated later in the week than Wednesday. After analyses, any remaining sample and all sample tags or labels shall be returned to the submitter to be held until the Trustees indicate otherwise.

3. Analytical Methodology

We are not specifying any analytical methodologies as it has been demonstrated that the specification of methodology does not ensure comparable data. Instead, all analytical laboratories will use their "best" technology and the ACG will provide each laboratory with appropriate calibration standards and control materials and conduct frequent evaluation exercises to enhance accuracy and determine the extent of data comparability. This approach has been demonstrated to be cost effective and to provide data of similar, if not better, quality than the specification of methodologies.

3.1 Analytes

The petroleum hydrocarbon compounds which are to be identified quantified in water, tissue and sediment are listed below. The volatiles include benzene, toluene, xylene and various alkyl substituted benzenes.

Polynuclear Aromatic Hydrocarbons	Aliphatic Hydrocarbons
Naphthalene	n-dodecane
2-Methylnaphthalene	n-tridecane
1-Methylnaphthalene	n-tetradecane
Biphenyl	octycyclohexane
2,6-Dimethylnaphthalene	n-pentadecane
Acenaphthylene	nonycylohexane
Acenaphthene	n-hexadecane
2,3,5-Trimethylnaphthalene	n-heptadecane
Fluorene	pristane
Phenanthrene	n-octadecane
Anthracene	phytane
1-Methylphenanthrene	n-nonadecane
Fluoranthene	n-eicosane
Pyrene	
Benz(a)anthracene	
Chrysene	
Benzo(b)fluoranthene	
Benzo(k)fluoranthene	
Benzo(e)pyrene	
Benzo(a)pyrene	
Perylene	
Indeno(1,2,3-c,d)pyrene	
Dibenz(a,h)anthracene	
Benzo(g,h,i)perylene	

3.2 Recommended analytical methodologies include but are not limited to:

Matrix	Analyte	Method	Methodology
Water			
	WSF	NMFS F/NWC-111	GC/MS
	Volatiles	EPA 624	GC/MS
Sediments/ Tissues			
	Extractable Organics		
		NMFS F/NWC-153 (used with) NMFS F/NWC-92	HPLC All Steps
		EPA SW 846	All Steps
Bile	Aromatics	NMFS F/NWC-153	HPLC

3.3 Other - Methodologies other than those employed for the identification and quantification of petroleum hydrocarbon compounds may be employed in these studies. Examples of analytical or measurement methodologies that may be used include the determination of aryl hydrocarbon hydroxylase (AHH) activity in fish liver as described; (Collier et al., 1986. Comp. Biochem. Physio. 84C). Postlabeling of DNA adducts with P^{32} in fish liver as described; (Varanasi et al., 1989. Cancer Res. 49).

Specific analytical methods to "fingerprint" or identify mixtures of petroleum hydrocarbons observed in sediment or water samples as being the result of direct input from the EXXON VALDEZ are not currently performed by any of the Trustee Agencies. It is anticipated that throughout the course of this project a number of these comparisons will be made.

Suggested References:

U.S.C.G. Report #D-52-77. "Oil Spill Identification System."
EPA-R2-73-221. "A Multiparameter Oil Pollution Source Identification System".

EQM&LO CHAIN-OF-CUSTODY PROCEDURES

Chain-of-Custody is necessary if there is a possibility that the conclusions based upon analytical data will be used in litigation. The components of chain-of-custody are : sample seals, a field log book, chain-of-custody record, and the Request for Laboratory Services (RLS); the procedures for their use are described in the following sections.

Due to the evidentiary nature of samples collected during enforcement investigations, possession must be traceable from the time samples are collected until they or their derived data are introduced as evidence in legal proceedings. To maintain and document sample possession, chain-of-custody procedures are followed.

Admissibility of Analyses as Evidence. To be admissible as evidence, samples must be proved conclusively to be in an appropriate person's possession until the analyses resulting therefrom have been introduced as evidence. Rigid controls must be maintained to establish a chain-of-custody for the samples from the time of sampling until ultimate disposition of the particular case.

CUSTODY DEFINITION

A sample is under custody if:

If it is in your possession, or
It is in your view, after being in your possession, or
It was in your possession and you locked it up, or
It is in a designated secure area.

1. Evidence tape or sample seals are used to detect unauthorized tampering of samples following sample collection up to the time of analysis. The seal must be attached in such a way that it is necessary to break it in order to open the container. Seals must be affixed to containers before the samples leave the custody of sampling personnel.

2. Samples must be kept in such a manner that they cannot be altered wether deliberately or accidentally. Until the samples can be sent to the laboratory they should be kept in a cool, dark, dry place. Refrigeration, freezing or other chemical method of preservation are usually required. Chemical preservatives are added at the laboratory.

   Any indication that a sample has been subjected to tampering or physical alteration could disqualify it as evidence for possible legal action. Therefore, the instructions given herein must be followed strictly.

opening. A evidence tape is placed on the openings of the shipping container, signed and dated.

Sample tags and custody forms must be legible and filled out using waterproof, non-fading ink. Secure individual sample containers or group of sample containers using tamperproof evidence tape or seals.

4. Maintain an up-to-date Field Data Record Logbook. Record field measurements and other pertinent information necessary to refresh the sampler's memory if, later on, he/she takes the stand to testify regarding his/her actions during the evidence gathering activity. Maintain a separate set of field notebooks for each survey; store them in a safe place where they can be protected and accounted for at all times.

5. The field sampler is responsible for the care and custody of the collected samples until they are properly dispatched to the receiving laboratory, or turned over to an assigned custodian. The field sampler should verify that each container is in his/her physical possession or in his/her sight at all times, or is locked so that no one can tamper with it.

6. Colored slides or photographs are often taken to show the outfall sample location and any visible water pollution. Written documentation on the back of the photo should include the photographer's signature, and the time, date and site location. These photographs can be used as evidence, and are handled by chain-of-custody procedures to prevent alteration.

TRANSFER OF CUSTODY AND SHIPMENT

1. Samples are accompanied by a Request for Laboratory Services which has a chain of custody section. When transferring the possession of samples, the individual relinquishing and receiving the samples will sign, date and note the time. This record documents sample custody transfer from the sampler, often through another person, to the laboratory Sample Custodian.

2. Ensure that samples are properly packed in shipping containers (for example, ice chests) to avoid breakage. Ensure that shipping containers are sealed for shipment to the laboratory.

3. If the package is sent by the US mail, ensure that it is sent with a return receipt. If the package is hand-delivered, note that it was hand carried in the method of shipment block in the chain of custody record. Send field receipts from the post office and bills of lading to the laboratory custodian for retention as part of the permanent chain of custody documentation.

CHS#1 SOP-5

COASTAL HABITAT INJURY ASSESSMENT-RECONNAISSANCE 7/89

REGION: A. PWS B. CIK C. KAP

DATE: _____ ,1989 3. TIME: ___ ___ ___ ___

OBSERVERS: _____ _____ _____

_____ _____ _____

TIDE STAGE:
- A. HIGH
- B. MID
- C. LOW

CURRENT:
- A. FLOODING
- B. EBBING
- C. SLACK

a. STRONG
b. MODERATE
c. SLOW
d. NONE

SITE ID NO: ___ ___ ___ ___ ___

SITE TYPE NO.: ___ ___ A. OK B. MISTYPED

OIL OBSERVED:	a. YES	b. NO	c. UNDETERMINED
A. SUPRATIDAL	_____	_____	_____
B. H-INTERTIDAL	_____	_____	_____
C. M-INTERTIDAL	_____	_____	_____
D. L-INTERTIDAL	_____	_____	_____
E. SUBTIDAL	_____	_____	_____

SITE APPROVAL: A. OK B. REJECT

Reason: _____

_____

_____

10. SITE MONUMENTS: Describe

A. Flagging _____

B. Stakes _____

C. Other _____

11. SITE DESCRIPTION:

A. Freshwater influences _____

B. Clean-up impacts _____

C. Kelps & seagrasses _____

D. Subtidal substrate a. Coarse b. Soft c. Mixed d. Undetermined

E. Other _____

_____

_____

_____

_____

_____

_____

12. PHOTOS:

A. NUMBER	B. DESCRIBE
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

COASTAL HABITAT INJURY ASSESSMENT-RECONNAISSANCE 7/89

Continuation Sheet

1. REGION: A. PWS B. CIK C. KAP

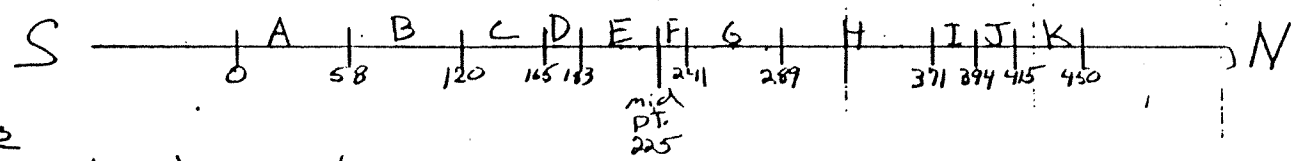
2. DATE: _____ ,1989

3. SITE ID NO.: ___ ___ ___ ___ ___

4. ADDITIONAL COMMENTS:

Segment # 149 Time Observed: 1330, 25 July 1989

Total Length: 450m Code = 135 Lat = Long = Quad = Seward C3 General Location: SE Perry Isl



Units

A = exposed rocky, 15° slope

B = exposed rocky, 40 - 90° slope

C = coarse texture, 7° slope, rounded granular pebble cobble small boulder pocket beach, 2 upper berms clast size decreases to the south

D = exposed rocky, 25° slope,

E = exposed rocky, 45° slope.

F = exposed rocky, 25° slope

G = coarse textured, 8° slope, pebble gravel w/ scattered boulders 2 berms deep oil penetration, pocket beach

H = Coarse texture, 8° slope, cobble gravel w/ scattered boulders, high intertidal pebbles, pocket beach

I = exposed rocky, 15° slope, boulder veneer.

J = exposed rocky, 80° slope,

K = exposed rocky, 8° slope, boulder veneer w/ infilling cobbles.

% > 35° = 28%

% exposed rocky = 61% for < 35° = 33%

% coarse texture = 39% for < 35° = 39%

Profiles: none

Geologic Description: This segment is mostly exposed rocky with 2 coarse-textured pocket beaches. The pocket beaches are pebble gravel and the other cobble gravel. Both have scattered boulders and upper berms that are deeply oiled. The clasts are well-rounded. An alongshore decrease in grain size is evident in one of the pocket beaches indicating a southerly net littoral transport direction. The rocky shoreline units

CHS#1 SOP-5 EXAMPLE

COMPREHENSIVE ASSESSMENT OF INJURY TO COASTAL HABITATS

PHASE II

STUDY PLAN

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CONFIDENTIAL

L COVER PAGE

Study Title: Comprehensive Assessment of Injury to Coastal Habitats Phase II

Study ID No.: Coastal Habitat Study Number I, Phase II

Project Leaders:

David Gibbons, USFS
Will Barber, UAF, SFOS
John Bryant, UAF, IAB
Howard Feder, UAF, SFOS
Lewis Haldorson, UAF, SFOS
Raymond Highsmith, UAF, SFOS
Stephen Jewett, UAF, SFOS
Lyman McDonald, Univ. Wyoming
Peter McRoy, UAF, SFOS
Joshua Schimel, UAF, IAB
James Sedinger, UAF, IAB
Mike Stekoll, UAS
Robert White, UAF, IAB

Lead Agency: U.S. Forest Service

Cooperating Agencies: University of Alaska Fairbanks, University of Wyoming, ADF&G, DEC, DNR, EPA, NOAA, USDI

Cost: $4900.0 through February 28th 1990.

Dates: July 1 1989 - March 1 1992.

SIGNATURES

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II. INTRODUCTION

The coastal habitat is a unique area of high productivity supporting a diverse array of organisms including many commercially and ecologically important species. Coastal habitats are particularly vulnerable to oil spill impacts because of the grounding of oil in the intertidal zone, the persistence of oil in intertidal and subtidal sediments, and the effects of associated clean-up activities.

Oil may affect coastal organisms directly by coating or ingestion, with toxic effects leading to death or reproductive failure. Indirectly oiling may cause decreased productivity of food organisms, accumulation of toxic effects through the food chain, and loss of microhabitat such as algae beds. Assessment of injuries to coastal habitat resources and determination of rates of recovery requires consideration of the various coastal geomorphologic types, the degree of oiling, the affected biota, and their trophic interactions. Coastal habitats consist of three interactive zones (supra-, inter-, and subtidal); animals may use multiple zones, necessitating coordinated study of the effects of oiling over the entire habitat. The complexity of this system requires expertise in many disciplines, and we have therefore put together an interdisciplinary team with the appropriate expertise, including plant and systems ecology, marine biology, and statistical analysis.

Study sites were selected and ground-truthed during Phase I (see Phase I Study Plan). The study plan for Phase II, an intensive evaluation of the study sites to determine the extent of injury to natural resources, is presented here. The overall objective of this study is to estimate the effects of various degrees of oiling on the quantity (abundance and biomass), quality (reproductive condition and growth rate), and composition (diversity and proportion of population) of key species in the critical trophic levels of coastal communities. These data will provide evidence of damage to the overall health and productivity of these critical coastal habitats, and provide information necessary to the more species-specific studies on the effects of the oil spill on commercially important mammals and fish that use these habitats.

III. OBJECTIVES

Initial field studies have been completed as of November 1, 1989. Processing of samples and data analysis will follow to determine the variance and magnitude of changes in parameter estimates between unoiled and moderately-heavily oiled sites.

For Winter 1989-90:

A. Based on data collected in 1989, estimate the necessary number of sites required to achieve required precision in the assessment of injury to coastal habitat. Required adjustments (deletions and additions) to the sample sites will be proposed.

B. Based on data collected in 1989, evaluate the subsampling being conducted within study sites for precision of estimates of parameters at specific sites. Adjustments in the subsampling of sites will be made prior to the 1990 field season.

For Field Sampling:

A. To estimate the quantity (abundance and dry wt biomass), quality (reproductive condition and growth rate), and composition (diversity and proportion of standing crop) of critical trophic levels (and subsequent impact on trophic interactions) in lightly and moderate-heavily oiled sites relative to non-oiled sites.

B. To estimate hydrocarbon concentrations in sediments and soils.

C. To establish the response of these parameters to varying degrees of oiling and subsequent clean-up procedures.

D. To extrapolate impact results to the entire spill affected area.

E. To estimate the rate of recovery of the habitats studied and their potential for restoration.

F. Provide linkages to other studies by demonstrating the relationships between oil, trophic level impacts, and higher organisms.

G. Determine levels of toxicity resulting from hydrocarbon contamination in sediment along the shoreline.

H. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

IV. METHODS

Phase I

Site selection procedures are given in the Phase I Study Plan and are briefly summarized here. Using a geographical information system, potential study sites were identified by overlaying shoreline impact maps on coastal morphology maps. From this universe of potential sites, the actual sites were chosen randomly by computer. Three replicate study sites were selected for each of 45 categories of coastline: 3 regions (Prince William Sound, Kenai Peninsula-Lower Cook Inlet, and Kodiak-Alaska Peninsula) X 5 habitat types (exposed rocky intertidal, fine textured beaches, coarse textured beaches, sheltered rocky, sheltered estuarine) X 3 degrees of oiling (none, light, moderate-heavy). One additional replicate per region per habitat type was added for the moderate-heavy oiling category, bringing the total number of planned study sites to 150. Candidate sites have been visited for ground-truthing purposes, marking of boundaries and descriptions.

Phase II

Vertical transects will be established at each of the sites selected in Phase I, in accordance with Standard Operating Procedure 1. Work will be conducted along these transects in the supratidal, intertidal, and subtidal zones. For this study, the subtidal zone is from -20 m to the 0 tide level, the intertidal extends from the 0 tide mark to mean high high water (MHHW), and the supratidal is from MHHW or where terrestrial vegetation begins (if below MHHW) to the highest extent of possible oil occurrence. At a subset of 12 sites per region, the transects will be extended into the subtidal. The subtidal combinations will be 2 habitat types (soft-bottom and hard-bottom) X 2 degrees of oiling (none, moderate-heavy) X 3 replicates. This gives a total of 36 subtidal sites. The intertidal transects will be extended into the supratidal at locations where coastal plant communities occur. Primarily, this will be in fine textured, coarse textured, and sheltered estuarine habitats. Thus, the supratidal combinations are expected to be 3 regions X 3 habitat types X 3 degrees of oiling X 3 replicates plus 9 extra moderate-heavily oiled locations for a total of 90 sites. Beach sediment texture will be determined as part of Phase I. Sediment samples will be collected for analyses of hydrocarbon composition and changes in concentration over time. Community composition, cover, and standing crop by trophic level will be estimated. Key species (dominant producers and food sources) will be determined and studied per Standard Operating Procedures listed below, to estimate the quantity, quality, and composition at each trophic level, and to collect samples for determination of hydrocarbon contamination. Using a geographic information approach, the impact by habitat type and degree of oiling over the entire area affected by the oil spill will be integrated and field verified.

Specific methods for each component of the study are given in Standard Operating Procedures. A list of SOPs follows:

Coastal

SOP 1.	Initial Site Survey
SOP 2.	Locating Transects
SOP 3.	Sample Identification and Chain of Custody

Supratidal

SOP 1.	Quadrat Location
SOP 2.	Determination of Plant Productivity
SOP 3a.	Analysis of Vegetation Nutrient Content
3b.	Analysis of In Vitro Digestibility
SOP 4.	Analysis of Soil/Sediment Microbial Activity
SOP 5.	Sampling of Soils and Sediments for Hydrocarbon Concentration

Intertidal

SOP	1.	Locating Quadrats
SOP	2.	Swath Surveys
SOP	3.	Reproductive Condition
SOP	4.	Growth and Survivorship
SOP	5.	Hydrocarbon Sampling Procedures
SOP	6.	Intertidal Fish
	6a	Locating transects
	6b	Locating quadrats
	6c	Sampling quadrats
	6d	Minnow trap sampling
	6e	Sample storage and identification.
	6f	Fish for hydrocarbon analysis

Subtidal

SOP	1.	Subtidal Sampling

V. DATA ANALYSIS

A. Tests.
Sample collection is complete, but sample analysis is still underway. All data analysis and statistical testing will be conducted with the assistance of Dr. Lyman McDonald of the University of Wyoming.

B. Products
The data from all of the component studies are being entered into the INGRES database management system. This system is widely used, and has good data security features. Use of this data base system will therefore maximize both internal integration and availability of the data to related damage assessment projects.

VI. SCHEDULES AND PLANNING

A. Data Collection Schedule:

	Start	Finish
Prince William Sound	Aug. 22	Oct. 6
Kodiak/Alaska Peninsula	Aug. 29	Oct. 6
Kenai/Lower Cook Inlet	Spt. 12	Oct. 6

Data Analysis Schedule:

Samples will be processed as rapidly as possible after they are returned form the field. We anticipate that sample processing and analysis will be complete by February 1990.

B. Schedule for 1990 (tentative):

Start field sampling- April
Finish field sampling- Sept. 30.

C. Sample and Data Archival:

All samples, log books, data sheets, etc. will be stored as appropriate (dried, frozen, etc.) under chain of custody procedures in secure storage facilities.

D. Management Plan:

The overall U.S. Forest Service project manager is David Gibbons. Under him are the various scientific contacts for each section of the study.

USFS Project Coordinator: David Gibbons

University of Alaska Contacts:

Institute of Marine Science:
(IMS)

Raymond Highsmith
Project Scientific Contact
(907) 474-7856

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(907) 474-7682

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(907) 474-7659

The scientific contacts are responsible for coordinating communications between USFS and the other investigators on the project, who are each responsible for the individual components of the overall integrated study. Coordination between components will be maintained by regular meetings and discussions among the investigators. The IMS and IAB institute executive officers are authorized to conduct negotiations.

The complete list of investigators is:

Will Barber, UAF, SFOS
John Bryant, UAF, IAB
Howard Feder, UAF, SFOS
Lewis Haldorson, UAF, SFOS
Raymond Highsmith, UAF, SFOS
Stephen Jewett, UAF, SFOS
Lyman McDonald, Univ. Wyoming
Peter McRoy, UAF, SFOS
Joshua Schimel, UAF, IAB
James Sedinger, UAF, IAB
Mike Stekoll, UAS
Robert White, UAF, IAB

VII. BUDGET

VIII. CITATIONS

All citations appropriate to the specific methods are cited in the pertinent SOP (See Section IX for SOPs).

IX. OTHER INFORMATION

STANDARD OPERATING PROCEDURES FOR COASTAL HABITAT SAMPLING.

Coastal

SOP	1.	Initial Site Survey
SOP	2.	Locating Transects
SOP	3.	Sample Identification and Chain of Custody

Supratidal

SOP	1.	Quadrat Location
SOP	2.	Determination of Plant Productivity
SOP	3a.	Analysis of Vegetation Nutrient Content
	3b.	Analysis of In Vitro Digestibility
SOP	4.	Analysis of Soil/Sediment Microbial Activity
SOP	5.	Sampling of Soils and Sediments for Hydrocarbon Concentration

Intertidal

SOP	1.	Locating Quadrats
SOP	2.	Swath Surveys
SOP	3.	Reproductive Condition
SOP	4.	Growth and Survivorship
SOP	5.	Hydrocarbon Sampling Procedures
SOP	6.	Intertidal Fish
	6a	Locating transects
	6b	Locating quadrats
	6c	Sampling quadrats
	6d	Minnow trap sampling
	6e	Sample storage and identification.
	6f	Fish for hydrocarbon analysis

Subtidal

SOP	1.	Subtidal Sampling

COASTAL STANDARD OPERATING PROCEDURE NO. 1

Initial Site Survey

A. When a site is first visited, compare the oil and habitat classification of the site with the general appearance of the site. However, note any discrepancies between the classification and appearance of the site.

B. Using the geologists notes identify any subhabitats and unworkable sections of beach present on the site. Unworkable sections of beach include sections with a general slope of greater than 35 degrees from horizontal and sections with mudflats deemed dangerous by crew leaders.

C. Measure the "beach length" of the main habitat, all subhabitats, and unworkable sections present on the site; similar sections will not necessarily be contiguous. All measurements should be made in meters (m). Lay the tape at the bottom of the Verrucaria zone and attempt to maintain a constant elevation through those areas where the Verrucaria is not well defined. The objective is to have the line, the starting point for all transects, at the same elevation on all sites. The accuracy with which this is done will have a direct effect on the location of the study quadrats!

D. Draw a sketch of the site, including the beach lengths and relative positions of the main habitat, all subhabitats, and all unworkable sections. Also include any unusual features of the site, such as freshwater streams, in the sketch.

COASTAL STANDARD OPERATING PROCEDURE NO. 2

Locating Transects

A. Three transects will be established in the main habitat present on a site. The number of transects to be established in subhabitats will depend on the beach lengths of the subhabitats. Place 1 transect in subhabitats with beach lengths less than 50 m; place 2 transects in subhabitats with beach lengths between 50 m and 100 m; place 3 transects in subhabitats with beach lengths greater than 100 m. Note: These rules apply to workable beach lengths, i.e., subtract the beach length of unworkable sections present within the habitat type from the total beach length of the habitat type before applying these rules.

B. Use the following procedure to locate transects within a habitat: Divide the total workable beach length of a habitat by the number of transects to be established in the habitat (according to A above). Call this number X. Essentially, this divides the habitat into intervals of equal length X; one transect will be located in each interval. Multiply X by a random number (the pocket calculator provided has a random number function). Call this number Y. The first transect will be located Y meters from the left end of the habitat (when facing the beach from the sea). If 2 or 3 transects are to be established in the habitat, they should be positioned X meters and 2X meters, respectively, to the right of the first transect. Note: The beach length of a habitat may occur in 2 or more disjoint pieces. When this is the case, make all measurements within a habitat as if the pieces were contiguous, i.e., skip over interspersed sections of other habitat types when locating transects within the habitat of interest. Repeat the above procedure for each habitat identified on a site.

C. Example:

A 445 m site is determined to be composed of 3 habitat types; sheltered rocky shore (main habitat), coarse textured beach, and fine textured beach. A section of the rocky shore is determined to be unworkable. The habitats are distributed as follows (from left to right): 50 m of rocky shore, 30 m of coarse beach, 40 m of fine beach, 50 m of coarse beach, 25 m of unworkable rocky shore, and 250 m of rocky shore.

Three transects are to be established in the rocky shore, since it is the main habitat. There are 325 m of rocky shore, but only 300 m are workable. Dividing 300 by 3, we obtain X = 100 m. Multiplying 100 by a random number, say 0.618, we obtain Y = 61.8 m. Therefore, the 3 transects will be located at 61.8 m, 161.8 m, and 261.8 m as measured within the workable rocky shore (or at 206.8 m, 306.8 m and 406.8 m as measured on the whole site).

Since there are 80 m of workable coarse texture beach, 2 transects will be established in this subhabitat. Dividing 80 by 2, we obtain X = 40 m. Multiplying 40 by a random number, say 0.088, we obtain Y = 3.52 m. Therefore, the 2 transects will be located at 3.52 m and 43.52 m as measured within the coarse beach (or at 53.52 m and 133.52 m as measured on the whole site).

Since there are 40 m of workable fine textured beach, 1 transect will be established in this subhabitat. Multiplying 40 by a random number, say 0.906, we obtain Y = 36.24 m. Therefore, the transect will be located at 36.24 m as measured within the fine beach (or at 116.24 m as measured on the whole site.

Note: All left/right directives are made from the orientation of facing the beach from the sea. All measurements should be made from the left to the right.

D. The starting point of the transect should fall along the tapeline made when the site was measured (see Coastal SOP 1-C). This should be done as carefully and consistently as possible as it will have a direct effect on the location of the study quadrats. In rocky habitats, the starting

point will be the bottom of the Verrucaria zone (>20% cover). At locations where Verrucaria is absent use MHHW or the lowest extent of terrestrial vegetation as the starting point.

E. The main objectives addressed by the orientation of transect lines are (1) the transects "cut across" the gradation of intertidal habitat exposed at low tide, and (2) all intertidal habitat exposed at low tide should have a chance of being sampled. When facing the beach from the sea, if the beach is extending out toward you, orient the transects perpendicular to the beach. If the beach is extending away from you, orient the transects toward the nearest water at low tide. Switch from one procedure to the other at "inflection points." See Figure 1 for an example.

COASTAL STANDARD OPERATING PROCEDURE NO. 3

Sample Identification and Chain of Custody

All samples collected in the field will be tracked by a full chain of custody.

Before the start of the study special sample tags (Fig. 2) will be prepared with spaces for noting site, transect, quadrat, type of sample, and name of collector. These tags will each have a unique sample number preprinted on them. There will also be a data sheet (Fig. 3) prepared for each transect to record the pertinent information for each transect (habitat, location, quadrat locations, etc.). As each sample is taken the tag is filled out and stored in the same container as the sample (except for hydrocarbon samples, for which tag and bottle will be stored together in a plastic bag). The same information is transferred to the transect sheet, including the sample number. Thus each sample may be identified in two ways to avoid error: by the quadrat and by the unique sample number. The sample container will be custody sealed by the person who took the sample and the relevant information recorded on a chain of custody form (Fig. 4). As soon as possible, all information is recorded in a bound logbook. Any photographs taken will also be logged into a bound notebook that is carried with the camera. All writing will be done in indelible ink.

The field sampler is personally responsible for the care and custody of samples collected until they are transferred. The chain of custody forms will accompany the samples. When samples are transferred from one person to another, the people relinquishing and accepting will sign, date, and note the location of transfer on the record. Whenever samples are subsampled or split, separate chain of custody records will be established for each subsample.

Shipping containers will be custody sealed, and the seal signed and dated. If samples are sent by common carrier, copies of all bills of lading or air bills will be retained with the chain of custody forms as part of the permanent documentation.

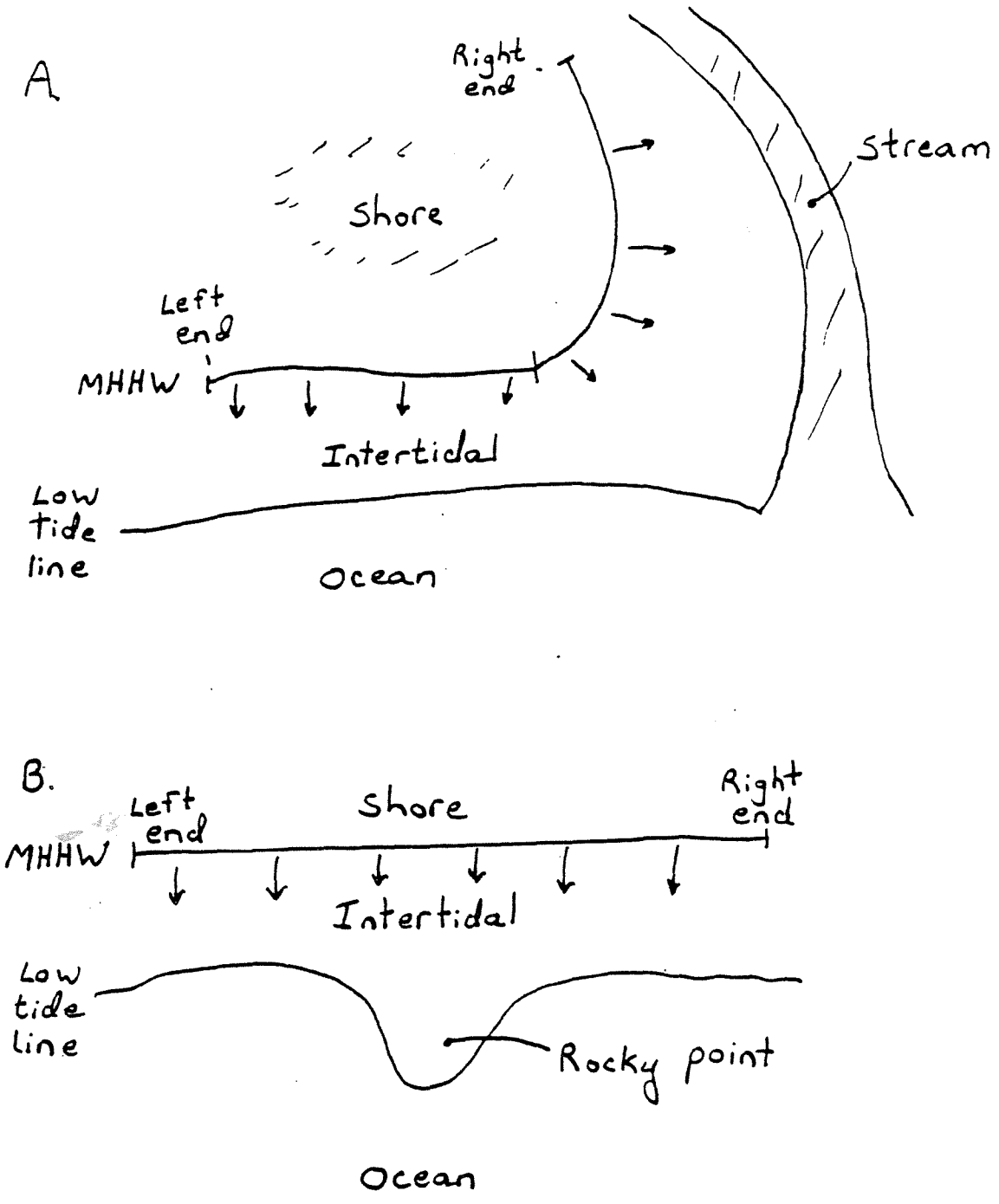


Figure 1. Arrow (↑) indicates recommended transect orientation. Two examples (A & B) of nontypical beaches are presented. + indicates a point of inflection.

Sample #	1001	Sample #	1007	Sample	1013
Site #		Site #		Site #	
Habitat		Habitat		Habitat	
Transect #		Transect #		Transect #	
Quadrat #		Quadrat #		Quadrat #	
Date		Date		Date	
Collectors		Collectors		Collectors	
Sample #	1002	Sample #	1008	Sample #	1014
Site #		Site #		Site #	
Habitat		Habitat		Habitat	
Transect #		Transect #		Transect #	
Quadrat #		Quadrat #		Quadrat #	
Date		Date		Date	
Collectors		Collectors		Collectors	
Sample #	1003	Sample #	1009	Sample #	1015
Site #		Site #		Site #	
Habitat		Habitat		Habitat	
Transect #		Transect #		Transect #	
Quadrat #		Quadrat #		Quadrat #	
Date		Date		Date	
Collectors		Collectors		Collectors	
Sample #	1004	Sample #	1010	Sample #	1016
Site #		Site #		Site #	
Habitat		Habitat		Habitat	
Transect #		Transect #		Transect #	
Quadrat #		Quadrat #		Quadrat #	
Date		Date		Date	
Collectors		Collectors		Collectors	
Sample #	1005	Sample #	1011	Sample #	1017
Site #		Site #		Site #	
Habitat		Habitat		Habitat	
Transect #		Transect #		Transect #	
Quadrat #		Quadrat #		Quadrat #	
Date		Date		Date	
Collectors		Collectors		Collectors	

Figure 2. Example sample tags. Note that they are prenumbered.

COASTAL HABITAT STUDY LOG SHEET

Site # ________ Code ________ Arc Length ________ m Date ________ Pg ___ of _

Habitat Type ____________ Length ________ m

Other habitat types at this site: ☐ 1) exposed rocky, ☐ 2) fine textured, ☐ 3) coarse textured, ☐ 4) sheltered rocky, ☐ 5) sheltered estuarine

Transect # ____ of ____ Time (start) ____ (finish) ____

Transect location: 0.____ (random #) x ________ (length (m) habitat) = ________ (location)

Names of collectors: ____________________

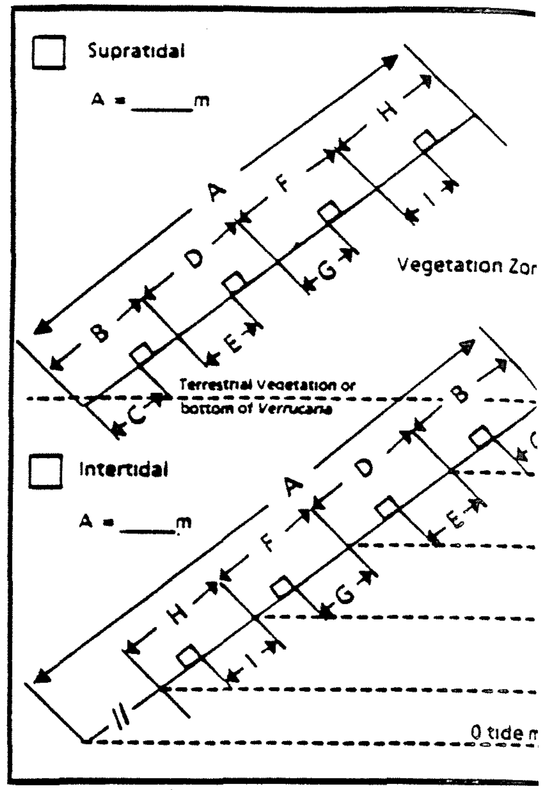
____

Signature of supervisor ____________________

NOTES: (Write additional comments and observations of animals using the beach on the back of this sheet.)

Swath along transect. Record: 1) type of seastar, 2) location of seastar along transect, and 3) horizontal distance from center of transect line.

1) ______	2) ____	3) ____	1) ______	2) ____	3) ____
1) ______	2) ____	3) ____	1) ______	2) ____	3) ____
1) ______	2) ____	3) ____	1) ______	2) ____	3) ____
1) ______	2) ____	3) ____	1) ______	2) ____	3) ____
1) ______	2) ____	3) ____	1) ______	2) ____	3) ____
1) ______	2) ____	3) ____	1) ______	2) ____	3) ____



Quadrat 1 Sample # ________
Location:
______ (distance B) - 0.5 m = ______ x 0.______ (random #) = ______ (location C) m
Comments: ____________________
Grazed: Y ☐ N ☐ Frame # ___ ___ ___ ___

Quadrat 2 Sample # ________
Location:
______ (distance D) - 0.5 m = ______ x 0.______ (random #) = ______ (location E) m
Comments: ____________________
Grazed: Y ☐ N ☐ Frame # ___ ___ ___ ___

Quadrat 3 Sample # ________
Location:
______ (distance F) - 0.5 m = ______ x 0.______ (random #) = ______ (location G) m
Comments:
Gra

Quadrat 4 Sample # ________
Location:
______ (distance H) - 0.5 m = ______ x 0.______ (random #) = ______ (location I) n
Comments: ____________________
Grazed: Y ☐ N ☐ Frame # ___ ___ ___ _

Quadrat 5 Sample # ________
Location:
______ (distance J) - 0.5 m = ______ x 0.______ (random #) = ______ (location K) n
Comments: ____________________
Grazed: Y ☐ N ☐ Frame # ___ ___ ___ _

Quadrat 6 Sample # ________
Location:
______ (distance L) - 0.5 m = ______ x 0.______ (random #) = ______ (location M) n
Comments: ______

Figure 3. Sample transect log sheet.

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INSTITUTE OF ARCTIC BIOLOGY
Fairbanks, Alaska 99775-0180 U.S.A.

EXXON VALDEZ OIL SPILL COASTAL HABITAT ASSESSMENT
CHAIN OF CUSTODY FORM

Project Region_____

Page_____of_____

Serial #_____

NOTE: Use ballpoint pen, waterproof ink or fine-tip waterproof marker

FOR INFORMATION CONTACT:
LORI MOILANEN (907) 474-7658
SUSAN COOPER

Date Collected	Site #	Transect #	Quad	Assigned #	Sample Type	Location Collected	Remarks

Continue on back of page

CHAIN OF CUSTODY

Samples collected by_____ (print name) of_____ (agency) _____ (signature) _____ (date)

Relinquished by_____ (signature) _____ (date) at_____ (place) _____ (comments)

Received by_____ (print name) of_____ (agency) at_____ (place) _____ (signature) _____ (date)

Relinquished by_____ (signature) _____ (date) at_____ (place) _____ (comments)

Received by_____ (print name) of_____ (agency) at_____ (place) _____ (signature) _____ (date)

Relinquished by_____ (signature) _____ (date) at_____ (place) _____ (comments)

Received by_____ (print name) of_____ (agency) at_____ (place) _____ (signature) _____ (date)

Based on ABL C of C 17/May/1989

CONFIDENTIAL - NOT FOR RELEASE

SUPRATIDAL STANDARD OPERATING PROCEDURE No. 1

Quadrat Location

1. Establish transects perpendicular to the beach from the vegetation line to the limit of the affectable supratidal zone; this is defined as either:
   a. 3 m into Elymus (beach rye) zone.
   b. Tree/shrub line.
   c. In extensive marshes- 0.5 m elevation range above Mean High High Water (MHHW).

In estuaries, vegetation frequently starts below MHHW, and so the vegetation line is in the intertidal zone; in this case "supratidal" sample collection still begins at the vegetation line.

2. Identify vegetation zones and measure the length of both the total transect and of each zone.

3. Locate one or more 50 cm by 20 cm quadrats in each vegetation zone according to the following scheme:

Zone Width	Number of Quadrats
< 1 m	1
1-5 m	2
5-25 m	1 per 5 m
> 25 m	As for 25 m, plus 1 every additional 25 m.

4. Locate quadrats:
   a. divide vegetation zone into the number of subzones described above, for the first 25 m. Additional quadrats go every additional 25 m if needed.
   b. locate quadrats: (Length of subzone-0.5 m)x random #. This is measured from the bottom of the subzone (the 0.5 is to prevent quadrats from overlapping into the next subzone). Use same RND for each of the quadrats in a zone. Place a stake and label the quadrat. Record all the information (including the random numbers) that relate to the location of the quadrat.
   c. Repeat b for each zone.
5. Locate 50 cm by 20 cm quadrat frame with the long axis against the transect line, lower left corner at the marker stake. If quadrat falls on the edge of a clump of vegetation or driftwood, put legs on quadrat frame and sample vertically below the frame. Photograph the quadrat.

6. After the first year, quadrats will be displaced first 0.5m left at each sampling date, then in the next year 0.5m right to avoid resampling the same quadrats too extensively.

SUPRATIDAL STANDARD OPERATING PROCEDURE No. 2

Determination of Plant Productivity.

1. Collect vegetation three times over the year, early spring, early summer, and late summer (at peak standing crop).

2. Collect vegetation in quadrats:
   The quadrats sampled in spring will be resampled at each sampling date to allow determination of the rate of plant productivity. Additional quadrats will be sampled from unclipped areas for peak standing crop.
   Count tillers of graminoid vegetation in each quadrat. If possible, count all tillers. Where there are too many, count the lower left 10 x 10 cm.
   Clip plants the root crown.
   For Graminoids the whole plant is considered to be in the quadrat if the tiller base is in the quadrat, while if the tiller base is outside, the whole plant is outside. For other types of vegetation, collect all and only the material that is actually inside the quadrat.
   If samples cannot be processes immediately, they are frozen.

3. Sort plant material into the following categories:
   1. Elymus; Live, Dead, Current senescence
   2. Other graminoid; Live, Dead, Current senescence
   4. Forbs; Live, Dead
   5. Shrubs; Live, Dead
   6. Other; Live, Dead

4. Samples are then dried at 60-65 C for 48 hours, or until constant weight.

5. Weigh each sample.

6. Estimate live standing crop for each vegetation zone along a transect by multiplying mean standing crop in sampled quadrats by the ratio of total area of zone/total area of quadrats in zone.

7. Estimate standing crop for entire site by determining biomass per vegetation zone and multiplying by the area of each zone in the site.

8. Total seasonal productivity will be estimated as the increase in plant biomass over the season as measured by the successive clippings.

9. Maximum standing biomass will be determined from the extra quadrat clipped at the time of peak standing biomass.

SUPRATIDAL STANDARD OPERATING PROCEDURE No. 3

Determination of Vegetation Forage Quality.

SOP Sp. 3a. Analysis of vegetation nutrient content:

After drying, randomly selected subsamples (250mg) from the quadrats for standing crop will be ground and analyzed for N & P concentration. N and P will be analyzed for after digesting plant material in selenous-sulfuric acid (Kjeldahl digest; Bremner and Mulvaney, 1982). Nitrogen in the digest will be analyzed by colorimetric analysis of NH_4^+ using the indophenol method (Bremner and Mulvaney, 1982). P will be analyzed by the molybdate procedure (Olsen and Sommers, 1982). Both N and P analyses will be performed on an autoanalyzer system using standard analytical methodologies (Lachat Quickchem methods 13-107-06-2-B and 13-115-01-B respectively; Lachat Instruments, Milwaukee, WI).

SOP Sp. 3b. Analysis of in vitro digestibility.

Samples for this analysis will be taken by collecting samples of the dominant vegetation in each zone along a swath 10 m from the primary transect. These sampling transects will be extended into the intertidal and will include samples of Fucus (a brown alga).

Vegetation samples will be analyzed for their potential digestibility by ruminant and non-ruminant animals by using two in vitro techniques.

Initially all vegetation samples will be freeze-dried for 24h to estimate dry-matter content and to prepare samples for grinding (Wiley Mill-20H sieve size, Agric. Handbook No. 379). A sub-sample will be used for estimation of Kjeldahl N and crude protein content (i.e. Nx6.25) (AOAC, 1980).

Non-ruminant dry matter and protein digestibility
Dried sub-samples (0.5 g) will be incubated in triplicate in a pepsin-HCl solution for 48h at 38 C, filtered and the dry matter residue determined by drying at 100 C for 24 h (Agric. Handbook No. 379). The crude protein content of the residue will be determined with a Kjeldahl N assay on the total residue.

Calculations:

$$\text{Dry Matter Digestibility} = \frac{\text{Mass sample incubated - Mass residue}}{\text{Mass sample incubated}}$$

$$\text{Crude Protein Digestibility} = \frac{\text{Mass protein incubated - Mass protein residue}}{\text{Mass protein incubated}}$$

Ruminant dry matter and protein digestibility
Dried subsamples (0.5 g) will be incubated in two stages according to the Tilley and Terry method. The first represents rumen fermentation and the second, gastric digestion (Agric. Handbook No. 379).

Stage 1:
Sub-samples will be incubated in triplicate in a rumen liquor-buffer solution for 48h at 38 C. The tubes will then be centrifuged at 2000 x g for 20 min and the supernatant decanted.

Rumen liquor for stage 1 will be obtained from rumen fistulated reindeer fed a mixed vegetation diet, known to maintain a high diversity of microbes.

Stage 2:
The residue pellet from stage 1 will be resuspended in a pepsin-HCl solution and incubated for 48h at 38 C, filtered and the residue dried at 100 C for 12h.

References:

AOAC. 1980. **Official Methods of Analysis of the A.O.A.C.**, 13th ed. A.O.A.C., Washington.

Agric. Handbook No. 379. **Forage Fiber Analysis, Agriculture Handbook No. 379**, 1970. Agric. Res. Serv., USDA, Washington.

Bremner, J.M. and C.S. Mulvaney. 1982. Nitrogen-Total. In: Page, A.L., R.H. Miller, and D.R. Keeney (Eds.). 1982. **Methods of Soil Analysis**, Part 2. Chemical and Microbiological Properties. Second Edition. Am. Soc. Agron., Madison, pp. 595-624.

Olsen, S.R. and L.E. Sommers. 1982. Phosphorus. In: Page, A.L., R.H. Miller, and D.R. Keeney (Eds.). 1982. **Methods of Soil Analysis**, Part 2. Chemical and Microbiological Properties. Second Edition. Am. Soc. Agron., Madison, pp. 403-430.

Analysis QA & QC:
The autoanalyzer will be calibrated against fresh primary standards after every 50 samples to control for drift. Kjeldahl digestion and analysis efficiency will be monitored by periodically analyzing National Bureau of Standards plant material standards. If analysis of this material varies by 0.1 % from known N and P concentrations, no samples will be analyzed until the problem is resolved.

SUPRATIDAL STANDARD OPERATING PROCEDURE No. 4

Analysis of Soil/Sediment Microbial Activity

1. Take soil cores
Only take cores in areas where there is at least 5 cm of "soil" substrate (organic containing material). Using an aluminum core, take a core from a central position immediately adjacent (on the right looking up the transect) to each quadrat sampled for vegetation studies. Take the core to 10 cm depth. If there is between 5 and 10 cm depth of soil material, take a core as deep as possible and record the actual depth.

2. Return the samples to the lab for analysis of microbial activity. Refrigerate (do not freeze) until returned to the laboratory.

3. Break up each core and sieve the material to 4 mm. Take a subsample (25g) for determining gravimetric moisture content (drying at 105 C) and total organic matter content (loss on ignition after drying; Nelson and Sommers 1982). A subsample (25g) will be analyzed for water holding capacity (WHC; saturated water content). An additional subsample will be extracted with 2 M KCl (10:1 extractant:soil) and analyzed for NH_4^+ and NO_3^- by colorimetric analyses on an autoanalyzer system. Ammonium will be analyzed by the Indophenol method and NO_3^- by reduction to NO_2^- by cadmium followed by the Griess-Ilosvay method for NO_2^- (Keeney and Nelson 1982). These will be carried out on an autoanalyzer system (Lachat Quickchem methods #12-1-7-06-1-B and 12-107-04-1-B respectively; Lachat Instruments, Milwaukee, WI).

4. Take a subsample (25g) for analysis of microbial respiration rate. These samples will be moistened to 40% of WHC. Samples will be placed in a sealed vessel and incubated at 15 C. Respiration rate will be determined by the rate of increase in CO_2 concentration over 6 h, which will be analyzed by gas chromatography using a thermal conductivity detector. The incubation temperature has been chosen as 15 as this is close to soil temperatures that could be expected during the growing season.

5. Take a separate subsample (25g) for analysis of N-mineralization potential. These samples will be moistened to 40% of WHC and incubated for 30 d at 15 C in closed containers with a small hole in the lid to allow gas exchange. They will be weighed weekly to determine moisture loss, and this will be made up by adding distilled water. The soil samples will then be extracted for NH_4^+ and NO_3^- and analyzed as above. Mineralization is calculated as the increase in extractable mineral N over 1 month.

Analysis QA & QC:
The gas chromatograph will be calibrated regularly against premixed standards. The accuracy of the machine used primarily will be tested and ensured by running test samples on several machines.

All autoanalyzer analyses will be performed using standard assays. Standards will be run at least every 50 samples to control for drift.

References:

Keeney, D.R. and D.W. Nelson. 1982. Nitrogen-inorganic forms. In: Page, A.L., R.H. Miller, and D.R. Keeney (Eds.). 1982. **Methods of Soil Analysis**, Part 2. Chemical and Microbiological Properties. Second Edition. Am. Soc. Agron., Madison, pp. 643-698.

Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. In: Page, A.L., R.H. Miller, and D.R. Keeney (Eds.). 1982. **Methods of Soil Analysis**, Part 2. Chemical and Microbiological Properties. Second Edition. Am. Soc. Agron., Madison, pp. 539-579.

SUPRATIDAL STANDARD OPERATING PROCEDURE No. 5

Sampling of Soils And Sediments For Hydrocarbon Concentration.

1. All implements that come in contact with the sample will be either stainless steel, aluminum, Teflon, or glass and they will be prewashed with detergent and thoroughly rinsed with water, acetone, and hexane. Solvents will be reagent grade.

2. From each vegetation zone, one hydrocarbon sample will be taken. This will be taken from a central position adjacent to a randomly selected quadrat used for plant sampling. A core will be taken as for soil sampling, using a clean core (see 1.).

3. This soil core will be transferred to an I-CHEM series 200 bottle (precleaned by the manufacturer to EPA specifications).

4. At each beach a separate bottle will be used for a field blank. This bottle will be opened and handled as for the sample bottles, except that no sample will be put in it.

5. Samples will then be frozen until analysis for hydrocarbons. This analysis will be done by an outside contractor (Auke Bay Fisheries Laboratory).

Analysis QA & QC.
Potential contamination of the bottles will be determined by the use of field blanks. Actual quality of the analyses will be ensured by the external contractor.

INTERTIDAL STANDARD OPERATING PROCEDURE NO. 1

Locating Quadrats

A. Once the orientation of the transect line has been determined (see Coastal SOP 2-E), stretch a meter tape along the transect line beginning at the starting point of the transect. Do not pull the tape tight or attempt to fit every bump on the beach; rather, let the tape conform to the natural contour of the beach. Confine walking to the path (see F below).

B. Use a surveyor's line level and a meter stick to determine 1 m of vertical fall as follows: Place a visible object at the head of the transect. Move down the beach, along the path, and place the meter stick upright on the ground next to the tape. Rest the line level on the top of the meter stick and sight the object at the head of the transect. Move up or down the beach as necessary, along the path, finding the location along the tape where the line level is even with the marker. This is the first meter of vertical fall. The distance between the head of the transect and the location going 1 m of vertical fall is called distance B on the Log Sheet (Fig. 3) - write it down. Repeat this procedure 3 times for a total of 4 m of vertical fall.

Occasionally, sections of a transect line within any one 1 m of vertical fall will be disjoint (see Figure 5). If this occurs, it will usually be on a rocky or fine textured beach. In this case, all the disjoint sections must be identified and considered as belonging to the same meter of vertical fall. The objective is to create a one-dimensional topographical map of the beach intersected by the transect lines. Elevational bands, measured in 1-m increments, are to be identified and sampled.

C. Attempt to establish permanent removal and control quadrats in each of the first 4 m of vertical fall from the head of the transect (see Coastal SOP 2-D). Quadrats are 50 cm by 20 cm. For the first meter of vertical fall, subtract 0.5 m from distance B (Fig. 3) and multiply by a random number to get distance C (the pocket calculator provided has a random number function). (Also see G below) Record all of these numbers on the Log Sheet. Place the upper ends of the removal and control quadrats along the tape C meters from the head of the transect line. The removal quadrat should be placed on the left side of the tape and the control quadrat should be placed on the right side of the tape. The longer edge of the quadrats should be parallel to and touching the tape. If on a rock substratum, use the rotohammer to drill a hole in the upper and lower right-hand corners of the quadrat. Place a plastic anchor in the holes. Attach a numbered aluminum tag with a stainless steel screw in the upper hole. Just insert a screw in the lower hole. The screws will make the dividing line between the quadrants and serve as reference points in photographs. Repeat this procedure in each of the first 4 m of vertical fall from the head of the transect.

Once the edges of the quadrat frames are parallel to the tape, let the quadrats rest naturally on the substrate. Do not attempt to hold the frames horizontally! If the frames straddle a steep slope (such as the side of a rock) or a deep crack between rocks, attempt to fit the frame to the slope or into the crack. Once a frame is placed, treat it as a window frame. Look through the frame as if it is a picture, from a point above and perpendicular to the frame. The "3-dimensional" volume viewed in this manner is the volume sampled.

D. After the screws are in, and before doing any collecting, photograph the removal and control quadrats, using the cameras with strobes. Organisms will only be collected from the removal quadrat. Collect all drift algae in one bag and collect all resident algae in another bag. Then photograph the removal quadrat again. Collect all remaining organisms visible on the surface and place in a third bag. Attempt to dig down to 10-cm depth and place this material in a fourth container. Then photograph the removal quadrat a third time. Place one of the provided collection tags in each bag or container. Be sure to record frame numbers in a Rite-in-the-Rain notebook and on the Log Sheet. The proper distance to hold the camera above the substratum for maximum magnification and clarity is 70 cm - 80 cm. Do not use a roll of film on more than one

transect. Be sure to record site no., habitat type, transect no., quadrat no., and date on each roll of film. The ASA setting for the film is 25.

E. Occasionally, a transect may contain unworkable sections. Examples of unworkable sections of a transect would include those sections crossing freshwater streams or intertidal pools. When locating quadrats within elevational zones containing unworkable sections, subtract the unworkable length of the elevational zone from the total length of the elevational zone before subtracting 0.5 m and proceeding as in C above. This procedure eliminates any possibility of a quadrat falling in an area that cannot be sampled. Sketch a map of the transect and document, including measurements, the existence of any unworkable sections.

F. To avoid damaging the site, crews should not land skiffs on the site and should only walk across the site at the high tide line (see C). When establishing and working transects, define a "path" approximately 1 m to the right of the transect and immediately below the quadrat. Limit all movement to this path. Do not step in the control quadrat! Do not stand or work on the left-hand side of removal quadrats because future removal quadrats will be located in this area!.

G. When the portion of a transect lying within any given elevational zone is in disjoint sections (see 3-B), the procedure for locating quadrats outlined in 3-C can result in a quadrat falling across two elevational zones. If 50% or more of the quadrat falls within the selected elevational zone, the quadrat is moved completely within that section of the elevational zone. If less than 50% of the quadrat falls within the selected elevational zone, the quadrat is moved completely to the appropriate section of the correct elevational zone.

H. In cases where the substratum is loose and will be turned over or dug up, the adjacent area will undoubtedly be disturbed and cannot be used as a control. In this case, place the control quadrat up to 3 m to the right of the transect line. To do this, multiply 280 cm by a random decimal to determine how far the near side of the quadrat will be from the transect line. If this results in a control that is not similar to the removal quadrat, reject and use the next random number, etc.

I. For habitats in which there is a well-developed band of organisms, such as mussels, barnacles, or Fucus, and the regular quadrats do not fall in the band, it will be necessary to establish additional quadrats. If the band is poorly developed where the transect crosses it, do not collect additional quadrats. For sampling in the bands, measure the band width and subtract 0.5 m. Multiply this distance by a random decimal to determine where the place the top of the quadrat. The same information must be recorded on the Log Sheet as for the other quadrats. The establishment of control quadrats and collecting procedures are the same as for the regular quadrats.

INTERTIDAL STANDARD OPERATING PROCEDURE NO. 2

Swath Surveys

A. Some organisms are important members of the intertidal community but are sparsely distributed and are not likely to be adequately sampled in the quadrats. Therefore, look for such organisms, i.e., sea-stars or anemones, along a swath 1 m to either side of the transect. This swath survey should be conducted before any other work is done on the transect. If necessary, one person could follow the tide out while other crew members are working the upper end of the transect. Space has been provided on the Log Sheet to record the type of organism (be as specific as possible), location (distance from the start) along the transect, and the perpendicular distance from the transect to the organism. Do not collect any organisms sighted.

INTERTIDAL STANDARD OPERATING PROCEDURE NO. 3

Reproductive Condition

A. Mussels. Approximately 50 mussels of 2 cm or more in length should be sampled from each site. Collect the first 6 such individuals encountered below and to the left of the left-hand corner of each permanent removal quadrat. Attempt to search in "quarter circles" of increasing diameter between the transect line and a line at the bottom of the quadrats and perpendicular to the transect line. Do not extend this pattern below the next quadrat farther down the transect! If there are 9 removal quadrats in the major habitat type present, this procedure will yield approximately 54 mussels from the major habitat type.

If a certain number of mussels are needed for the study of reproductive condition, subsample this number from the 54 mussels collected. The remainder of the collected mussels can be preserved for the study of hydrocarbons. If mussels collected for the study of hydrocarbons must be handled using special techniques, collect these mussels first and then collect mussels needed for the study of reproductive condition. If more than 54 mussels are required to adequately study both reproductive condition and hydrocarbon content, increase the number of individuals collected associated with each quadrat.

B. Limpets. The limpet species of interest is only found in the upper intertidal zone. From the location of the head of the transect, search for limpets to the right of the transect. Search in "quarter circles" of increasing diameter between the high tide line and the lower edge of the zone in which the target species is found. Collect the first 10 individuals encountered which satisfy necessary size requirements. If the right edge of the interval of habitat in which the transect is located is reached before sufficient numbers of individuals are found, go to the left edge of the same interval of habitat and continue searching for individuals in the same manner. Stop searching when 10 individuals are found or when the transect is reached from the left. If the collection of 10 individuals from each transect line does not result in a sample of sufficient size, or results in too large a sample, adjust the number of individuals collected from each transect accordingly. Avoid walking on control or future removal quadrats!

C. Barnacles and Algae. Follow the same procedure for these organisms as is outlined for mussels in A above. Adjust the number of individuals collected off each quadrat as is necessary to meet collection needs.

D. If the above procedures (A-C) do not result in sufficient sample sizes, do not use any other procedures or increased sampling effort. If this is the case, the organisms are probably so rare or widely distributed that no random sampling procedure will produce sufficient numbers of individuals. Also, we do not want to put ourselves in the position of removing most or all members of a species from any given site.

INTERTIDAL STANDARD OPERATING PROCEDURE NO. 4

Growth and Survivorship

A. If well-defined beds of organisms (mussels, barnacles, Fucus) exist, then at least 200 individuals will be collected from a 3-cm strip across the bed. Locate these strips immediately to the left of the additional removal quadrats discussed in Intertidal SOP 1. However, extend the strip to cut across the complete width of the bed. Collect all individuals found within this strip. Divide the width of the bed (length of the strip) into thirds. Bag all individuals found within each of the thirds separately.

INTERTIDAL STANDARD OPERATING PROCEDURE NO. 5

HYDROCARBON SAMPLING PROCEDURES

Preparation of sampling equipment

In order to assure there is no contamination of any sediment or animal tissue samples collected for hydrocarbon assessment, it is essential to keep any petroleum products off of sampling equipment. Please use the following procedure for cleaning any implements used in the collection of sediment or animal tissue samples.

1. Wash spoons, spatulas, forceps, etc. with hot water and Joy detergent. Let them air dry.

2. Rinse each utensil twice with a hexane rinse. Make sure the hexane is kept in a glass or Teflon bottle. If a regular plastic bottle is used, the hexane may dissolve some of the plastic molecules and contaminate the equipment.

3. Place the hexane-rinsed utensil in a piece of aluminum foil that has also been rinsed with hexane. Make sure the dull side of the foil is the one rinsed and next to the utensil.

4. Use only jars that have been specially pre-cleaned to collect the samples. Make sure the jar lid was screwed on tightly before you use the jar. If the jar lid is loose or has fallen off, do not use that jar.

5. Make sure not to touch the sample with anything other than a cleaned utensil before it is placed in the sample jar. Do not use your fingers to collect or touch the specimen. When collecting oil or sediment samples, make sure there is no dead plant material in the sample (eg. no spruce needles or algae fragments).

Collection of samples

1. Sediment samples:

a. On a moderate to heavily oiled beach, collect three (3) replicates of gravel, sand, or small rock pieces from an area within the designates beach markers where there is evidence of oil. Samples should be taken from different areas of the beach. One blank jar should be collected from each beach also. To collect a blank, open the jar, close it, label it, and treat it just as the other sample jars are by freezing it and processing it. The blanks are done to make sure there has been no contamination of the jars. Small 6-8 oz. jars should be used for these sample collections.

b. On a lightly oiled beach or a control beach, collect two (2) replicates and one blank per beach.

c. Make sure that the jars are filled to the shoulder. If there is too much air space, some oxidation may occur and affect the reliability of the sample.

d. Label jars in ink with the labels in the pre-cleaned jar boxes. The labels do not stick well to wet jars. Make sure the beach number, location, collection date, kind of sample (eg. sediment, animal tissue), collector, and method of preservation are on each label.

e. Fill out the inventory form on the chain of custody sheets. Seal the top of each sample jar with evidence tape that has been signed and dated by the collector with a waterproof pen.

f. When a box of jars has been filled, write the beach numbers of the sites included on the outside of the box, seal the box with strapping tape, and place a piece of signed and dated evidence tape over the top of the strapping tape.

g. Freeze samples and keep them at -20 F if possible.

2. Animal Tissue samples

a. Currently, we are collecting only Mytilus edulis, the blue mussel for our animal studies. Other species may be collected in the future.

b. Collect two (2) 16 oz. jars of mussels per site using a pre-cleaned spoon or forceps. Collect them from an area adjacent to the samples that are collected for the survivorship studies. Fill each jar to the shoulder with mussels as a minimum of 10 grams of tissue is needed per sample. Also collect one blank jar per beach site, using the same technique as listed above for sediments.

c. Label each jar with the beach number, location, date collected, kind of sample, method of preservation and collector.

d. Fill out inventory sheet for chain of custody. Seal each jar with evidence tape that has been signed and dated. Seal and label each filled box as described above for the sediment samples.

e. Freeze and store the samples at -20 F.

INTERTIDAL SOP #6 INTERTIDAL FISH

Terms displayed in bold print at their first occurrence are defined in a glossary at the end of this document.

SOP 6a. Locating Transects

A. Three transects specifically for fish will be established in the main habitat of each site. The number of transects to be established in subhabitats will depend on their lengths. One transect will be placed in subhabitats 15 to 50 meters long, two transects in subhabitats 50 to 100 meters long, and three transects in subhabitats of over 100 meters (as in Coastal-SOP 2-A). If a subhabitat is less than 15 meters long, the area will be considered unworkable because of likely overlap with a main transect. These rules apply to **workable** areas. For any unworkable areas within a subhabitat, subtract the length of the unworkable area from the subhabitat length before applying these previous rules.

B. We will use the following procedure to locate transects within each habitat. From the workable length, subtract 10 meters for each main transect established in that habitat. For example, if the habitat contains three main transects, subtract 30 meters (3*10) from the workable length. We will call this the **net habitat length**.

C. Divide the net habitat length obtained above by the number of fish transects to be sampled (determined in paragraph A). This divides the habitat into **habitat sections** of equal length; one transect will be located in each section. Subtract 1 meter (the width of the **fish sampling quadrat**) from this number. This ensures that the sampling quadrat will not extend into another section. This number is the **habitat section length**.

D. The habitat section length will be multiplied by a random number (between 0 and 1) to give the location, measured from the left (facing inland) **site marker**, of the Transect F1 ("F" for "Fish"). For main habitats and subhabitats with more than one fish transect, add the habitat section length to the location of the first transect to get the location of Transect F2. Add the habitat section length to the location of Transect F2 to locate Transect F3. Note: The habitat sections will occur in disjoint pieces interrupted by main transects, other habitats, and unworkable areas. We will subtract these areas and make all length measurements within a habitat as if the pieces were contiguous. We will also subtract an area five meters either side of main transects (ten meters total per main transect). Repeat the above procedure for each habitat identified at a site.

E. Example 1

A beach 518.0 meters long is all one habitat type and contains no unworkable areas. Because there are no other habitat types present, we will put three fish transects on the site.

Subtract 30 meters (to exclude areas occupied by the main transects) from our main habitat length; 518.0 - 30 = 488.0. This is our net habitat length.

Divide the net habitat length by the number of fish transects; 488.0/3 = 162.0. Subtract 1 meter from this number (to allow for the width of the fish sampling quadrat); 162.0 - 1 = 161.0. This is the habitat section length.

We obtain a random number of 0.779 from our calculator. Multiply this random number by the habitat section length; 161.0 * 0.779 = 125.4. This, measured from the left site mark, is the location of fish Transect F1.

Add the habitat section length to the location of Transect F1; 125.4 + 161.0 = 286.4. This is the location of fish Transect F2.

Add the habitat section length to the location of Transect F2; 286.4 + 161.0 = 411.8. This is the location of fish Transect F3.

F. Example 2

A 445.0 meter site is composed of three habitat types; sheltered rocky (main habitat), coarse textured (subhabitat), and fine textured (subhabitat). A section of the sheltered rocky habitat is determined to be unworkable. The habitats are distributed as follows (from left to right); 50 meters of sheltered rocky, 30 meters of coarse textured, 40 meters of fine textured, 50 meters of coarse textured, 25 meters of unworkable sheltered rocky, and 250 meters of sheltered rocky.

Three transects are to be established in the sheltered rocky, since it is the main habitat. There are 325 meters of sheltered rocky, but only 300 meters are workable. Subtract 30 meters (to allow for skipping main transects) from the main habitat length; 300.0 - 30 = 270.0. This is the net habitat length. Divide the net habitat length by the number of transects; 270.0/3 = 90.0. Subtract one meter to allow for the quadrat width; 90.0 - 1.0 = 89.0. This is the habitat section length. We multiply 89.0 by our random number, say 0.618, to get the location of Transect F1; 89.0 * 0.618 = 55.0 meters. Adding the habitat section length gives us the location of Transect F2; 55.0 + 89.0 = 144.0 meters. Again adding the habitat section length gives us the location of Transect F3; 144.0 + 89.0 = 233.0 meters. So the main habitat transects are located at 55.0, 144.0, and 233.0 meters as measured within the sheltered rocky, or as 200.0, 289.0, and 378.0 as measured on the whole site.

Since there are 80 meters of coarse textured beach, two transects will be established in this subhabitat. Subtract 20 meters (to allow for two main transects) from the subhabitat length; 80.0 - 20.0 = 60.0 meters. Subtract one meter; 60.0 - 1.0 = 59.0 meters. Divide by two transects; 59.0/2 = 29.5 meters. Multiply by the random number, say 0.126, e.g 29.5 * 0.126 = 3.7 meters. Transect S1F1 ("S1" is for "Subhabitat 1") is located at 3.7 meters and S1F2 at 33.2 meters, as measured within the coarse textured subhabitat, or at 53.7 and 123.7 meters as measured on the whole site.

Since there are 40 meters of fine textured beach, only one transect will be located there. Subtract 10 meters (to allow for one main transect); 40.0 - 10.0 = 30.0 meters. Subtract

one meter: 30.0 - 1.0 = 29.0. Multiply by random number, say .468: 29.0 * .468 = 13.6 meters. The location of S2F1 is 13.6 meters, as measured within the fine textured subhabitat, or 93.6 meters as measured on the whole site.
Note: All left/right directives are made while facing inland and all measurements should be made from left to right.

G. The starting point of the transect should fall along the **tapeline** made when the sites were measured. This will be done as carefully and consistently as possible as it will directly effect the location of the study quadrats.

H. The main things to consider in the orientation of the **transect lines** are: 1) the transect lines should span the gradation of intertidal habitat exposed at low tide, and 2) all intertidal habitat exposed at low tide should have a chance of being sampled. When facing inland from the water's edge, if the beach is concave, orient the transects perpendicular to the tapeline. If the beach is convex, orient the transects toward the nearest water at low tide (See coastal SOP 2). Choose the orientation that best suits each transect.

I. Record all measurements and calculations on the log sheet for Intertidal Fish.

SOP 6b. Locating Quadrats

A. After establishing the transect, mark the **top of the transect** (at the tapeline) with flagging tape. Do not pull the tape tight or attempt to fit every bump; rather, let the tape conform to the beach's natural contour of the beach. To avoid damaging the site, crews should not land skiffs on the site and should only walk across the site at the high tide line. When establishing and working transects, define a path approximately two meters to the right of the transect and immediately below the quadrat. Limit all movement to this path.

B. Each transect will be divided into **elevational zones** defined by a drop of one meter in elevation along the transect from top to bottom. One quadrat will be established in each elevational zone.

C. The fish sampling quadrat will consist of a collapsible frame made of 1/2" wide aluminum strips bolted together to make a rectangle 2 meters long by 1 meter wide. It will have 30 centimeter telescoping legs. A 30 centimeter wide skirt (1/8" mesh netting with lead weights along the bottom) will hang from the quadrat. The skirt is to prevent fish from escaping the quadrat area once the quadrat is in place.

D. Use a surveyor's line level and a meter stick to determine one meter elevation drops as follows: Place a visible object on the substrate at the top of the transect. Move down the transect and place the meter stick upright on the ground next to the tape with the level on top. Sight the object at the top of the transect. Move up or down the transect as necessary to find the location where the line level is even with the top of the transect. This is the first elevational zone. Mark this spot with flagging tape tied to a stick or rock. Repeat this procedure three times (for a total of four elevational zones per transect), each time sighting the level on the marked bottom of the previous elevational zone. Measure and record the length of each elevational zone.

Occasionally, an elevational zone will be broken up into disjoint pieces by another elevational zone (See Intertidal SOP 1). In this case, all disjoint pieces must be identified and considered as part of the same elevational zone. A transect may contain unworkable areas. An example of an unworkable section would be an area with an slope of greater than 45^0. When locating quadrats in elevational zones with unworkable areas, subtract the unworkable length from the elevational zone length before proceeding. This will keep a quadrat from falling on an area that cannot be sampled.

E. The following procedure is to be followed for each elevational zone. Subtract 2 meters (the length of the fish sampling quadrat) from the length of the elevational zone . This is the **net elevational zone length**. Multiply the net elevational zone length by a random number. This is the location of the quadrat in that elevational zone, measuring from the inland end of the section. Each elevational zone gets its own random number.

SOP 6c. Sampling Quadrats

A. Place the quadrat on the substrate so that the top left corner is at the location as previously determined (see SOP 6b-D) and the sides of the quadrat are parallel to the tape. Extend the legs of the quadrat so that the **sampler** is as close to horizontal as possible. On a 3x5" card, write down the site number, transect number, quadrat number, and sampling date. Place the card at the edge of the quadrat and photograph twice, the area circumscribed by the quadrat. Note in the field notebook a description of any vegetation occurring in and around the quadrat.

B. When the portion of a transect lying within any given elevational zone is in disjoint sections, the procedure outlined in SOP 6b-C can result in a quadrat falling across two elevational zones. If 50% of more of the quadrat falls within the selected elevational zone, the quadrat is moved completely within that portion of the elevational zone. If less than 50% of the quadrat falls within the selected elevational zone, the quadrat is moved completely to the appropriate portion of the correct elevational zone.

If a quadrat, when placed on the substrate, overlaps the water's edge or lies entirely in the water, that quadrat is not sampled. The reason for not sampling the quadrat should be noted on the Intertidal Fishes Log Sheet.

C. Remove vegetation and rocks to a depth of 10 centimeters. Capture any fish you find using one or more 11x11 centimeter aquarium nets. Place fish in Whirl-pack bag. Pour enough 10% formaldehyde solution into bag to cover fish. Fill out a label and insert in bag. Seal bag. If any fish are seen within the quadrat but evade capture, the number and broad type (sculpin, snailfish, prickleback, etc.) of fish should be noted in the field notebook.

D. Measure the length of the transect from tapeline to water's edge. If a portion of an elevational zone lies underwater, the portion of the zone above water should be measured and noted. Record all measurements and calculations on Intertidal Fishes Log Sheet (see Intertidal Fishes-SOP 7).

E. If a tidal pool intersects a quadrat, measure the length and width of the portions of the pool, inside and outside the quadrat. Record measurements in field notebook. Capture all fish in the pool using one or more 11x11 centimeter aquarium nets. Treat pool with MS-222 by add 1 level teaspoon per estimated 20 liters of water in the pool. Wait 5 minutes and try again to capture fish. Preserve and label fish as described in C above.

SOP 6d. Minnow Trap Sampling

A. One standard size minnow trap (1 centimeter mesh) will be placed in the water at the base of each transect. Obtain two moderate size barnacles from the beach outside the study site. Crush and place in trap. Also place in each trap one ounce of salmon eggs (wrapped in cheese cloth and prepared in advance).

B. Each trap will have attached a two pound cement and a brightly colored float. The anchor will be attached to trap on a tether of 50 centimeter and the float a two meter tether. Each trap will be placed in 30 centimeters of water at low tide. After three hours the traps will be retrieved and fish bagged, preserved, and labelled as described in SOP 6b-C above. Record the time trap is set in the water and retrieved on Intertidal Fishes Log Sheet.

SOP 6e. Sample Storage and Identification

A. Twenty four hours after each sample is taken, discard the formaldehyde solution, rinse the fish with seawater, and add 70% ethanol to cover fish. This preservative exchange will be done by the **collector** of the sample.

B. All samples collected in the field will be tracked by a full chain of custody.

C. Before the start of the study special sample tags (See Coastal SOP 3) will be prepared with spaces for noting site, transect, quadrat, type of sample, date, and name of collector. These tags will have a unique sample number preprinted on them. There will be a data log sheet (Coastal SOP 3) prepared for each transect to record pertinent information for each transect (habitat, location, quadrat location, etc.). These tags will be taped on the outside of the bags. Information on the labels will be transferred to the transect log sheet, including sample number. Thus, each sample will be identified in two ways to avoid error: by quadrat and by unique sample number. After the formaldehyde has been exchanged with alcohol (see A) the collector will seal each sample container with custody tape, sign, and date the tape. The relevant information will be recorded on a chain of custody form (Coastal SOP 3). All writing in field notebooks, log sheets, and forms will be done in indelible ink, except as previously noted.

D. The collector is personally responsible for the care and custody of samples until they are transferred to another individual. The chain of custody forms will accompany the samples. When samples are transferred from one person to another, the person relinquishing and the person accepting the samples will sign, date, and note the location of the transfer on the chain of custody form. Shipping containers will be custody sealed, and the seal signed and dated. If samples are sent by common carrier, copies of all bills of lading or air bill will be retained with the custody forms as part of the permanent documentation.

SOP 6f. Fish for Hydrocarbon Analysis

A. Fish hydrocarbon sampling will be done only after quadrat sampling is completed.

B. Before obtaining each sample, scrub a metal kitchen strainer bent in the shape of a D with soap and steel wool and rinse with hexane. The sample containers will be Ichem 250 milliliter glass jars.

C. Fish will be captured within one meter of the transect line using the metal strainer as if it was an aquarium net. Beginning at the edge of the water, turn over vegetation and rocks. Take care not to touch fish with hands or clothing. Rinse fish in freshwater. Place fish of different taxonomic groups (for instance, sculpins, snailfish, pricklebacks, etc.) in separate chemically treated 250 milliliter glass sample jars. Continue moving up the transect and capturing fish until each sample jar is one half filled (by volume) with fish. Close the jar and place with a appropriate label in Whirl-pack bag. Custody seal, sign, and date each sample bag. Sample information will be recorded on a chain of custody form.

D. At each site an additional sample jar will be used as a field blank. This jar will be opened and handled as for samples, except no fish will be added. For each box of sample jars, reserve one jar unopened. Otherwise handle this jar like the other samples and submit for analysis. All hydrocarbon samples will be frozen pending analysis.

GLOSSARY

Collector: The person obtaining the sample in the field.

Elevational zones: The length of a transect defined by a drop of elevation of one meter.

Fish sampling quadrat: An aluminum frame circumscribing an area of substrate to be sampled.

Habitat section: The habitat subdivision that will contain one transect.

Main habitat: The habitat type that constitutes the largest portion of the site.

Net elevational zone length:The length of a transect section minus the quadrat length quadrat (2 meters).

Net habitat length: The habitat length minus ten meters for each main transect located in the habitat and minus the width of the quadrat (one meter).

Site marker: The marker on the beach designating the left or right limit of the site.

Subhabitat: A habitat type that makes up less than one half the total site.

Tapeline: The line along which a measuring tape is extended to measure the length of the site. Also the field definition of the high tide line.

Top of the transect: The point of the transect intersecting the tapeline.

Transect: A line stretching from a random point on the tapeline to the water's edge.

Unworkable: An area of a site that does not allow sampling; areas with a slope of over 35^{O} and areas dangerous to sample.

Verrucaria: A black lichen. When present, the bottom of the Verrucaria zone defines the high tide line.

SUBTIDAL STANDARD OPERATING PROCEDURE NO. 1

Subtidal Sampling

A. Definitions

Habitat type - One of the five habitat types defined by the study plan team: rocky sheltered, rocky exposed, estuary, fine sediment beaches, cobble beaches.

Study site - A randomly selected area of coastline to be sampled; within each habitat type study sites may be defined as heavily oiled, lightly oiled, or unoiled (control).

Station transect - A line perpendicular to the shoreline extending from the 0 tide depth out to a depth of 20 m, at locations selected randomly within a study site. Normally, station transects are seaward extensions of intertidal transects.

Depth stratum - One of three depth ranges located along a station transect.

Sampling transect - A line perpendicular to a station transect along which subtidal sampling is conducted.

Quadrat - A randomly selected sampling location along a sampling transect.

B. Study Site Selection

In Prince William Sound six subtidal study sites will be selected within each habitat type as a subset of intertidal study sites. The selected sites will be comprised of equal numbers of heavily oiled and unoiled (control) sites in each habitat type. The order of priority of habitat types is: (1) sheltered rocky, (2) estuary, (3) exposed rocky, (4) cobble beaches, and (5) fine sediment beaches.

C. Study Site Confirmation

Prior to beginning sampling in a region, the research team will visit all of the preselected study sites to determine if they can be located based on site markers placed by the intertidal study group and to validate habitat classifications. At each study site divers will swim a transect from the 0 tide depth out to a depth of 20 m, unless the distance precludes a single survey swim. Divers will video-record the substrate and the water column immediately above the bottom to characterize the subtidal zone and to ensure that the subtidal study site is of the appropriate habitat type.

D. Station Transect and Sample Transect Selection

At a study site, at least three intertidal transect locations will be located. At least three subtidal station transects will be selected, if appropriate, as seaward extensions of the intertidal transects. A small boat will be driven seaward from nearshore along a course perpendicular to the shoreline, dropping marker buoys at randomly preselected depths in each of three depth strata: 0-2 m, 3-8 m, and 9-20 m. The protocol for random selection or positions for the buoys is: (1) For each station transect select a random proportion (using a calculator or random number table). (2) Multiply the range of depth in each strata by the proportion. For example, if the random proportion is 0.35, the depth (D) in the three depth strata would be:

0-2 m	D = 0.35 x 2	=	0.7 m
3-8 m	D = (0.35 x 6) + 2	=	4.1 m
9-20 m	D = (0.35 x 12) + 8	=	12.2 m

E. Censusing Fish Populations

1. If a kelp canopy is present in the area, two divers will randomly select a starting point within the canopy and will swim a 30-m transect through the canopy, one diver will record fish present within a 2-m band with a video camera, the other will visually count fish within the 2-m band, recording numbers by species on a slate. If no kelp canopy is present two divers will randomly select an open-water starting site for a transect and swim a 30-m transect near the surface, video-recording and visually counting and recording all fish within 2 m of the transect path.

2. Two divers swim to the bottom at the deepest of the three marker buoys. Then then attach a 30-m fiberglass transect tape to the anchor and swim a 30-m isobathyal sampling transect to the left or right (preselected randomly with a coin toss). One diver records fish in a 2-m wide band with a video camera, the other plays out the tape and visually counts fish, by species, within 2 m of the transect path. Visual counts are recorded on a slate as the diver swims.

3. After completing the initial swim of the sample transect the two divers swim about 3 m off the end of the 30-m transect band and wait two minutes. After the two-minute wait the two divers swim back along the transect tape, each recording benthic fishes within a 1-m band on either side of the transect tape.

4. Following completion of the deepest sample transect the two divers will move up to the next shallowest marker buoy and repeat the procedure. Identical procedures as described above for the deepest sample transect will be followed at the sample transects in the two shallower depth strata, with the shallowest strata sampled last.

F. Sampling Algae and Photograph Records of Quadrats

1. Following the fish census at a sampling transect two divers swim down to the marker buoy anchor. At randomly preselected locations in the sampling transect, diver #1 places four large (0.25 m) and four small (0.1 m) quadrat frames, the latter adjacent to and shoreward of each of the former. The random positions of the quadrats are determined as follows: (1) The 30-m sample transect is divided into four 7.5-m sections. (2) A random proportion is identified and multiplied by 7.5. (3) The quadrat position is the resultant position in each of the 7.5-m sections, with the starting (zero) end of each section being closest to the marker buoy. For example, if the random proportion is 0.26, the four quadrat locations on the 30-m sample transect would be 1.95 m, 9.45 m, 16.95 m and 24.45 m.

2. Diver #1 estimates the amount of algal cover in each of the large (0.25 m) quadrats. Both divers then clear all macroalgae from each large quadrat, placing the cut pieces in labeled plastic bags. Diver #1 photographs each large quadrat with a grid of six close-up photographs that cover all of the cleared area. Diver #2 collects all smaller algae from quadrat #1 (closest to the buoy anchor) by scraping the substrate clean of all plants and invertebrates. The divers pick up the large quadrats. The sampling procedures are repeated at each sample transect.

3. Aboard ship, algal samples are patted dry and weighed. Samples of representatives of each canopy species are preserved. Notes are made as to reproductive status of each canopy species. A subsample of plants is photographed to estimate fouling cover. All large brown algae are measured. All small plants from large quadrat #1 are preserved.

4. In soft-bottom habitats (e.g., estuaries), the above procedures are repeated except that eelgrass (if present) is clipped just above the bottom and bagged. The scraping is omitted.

G. Sampling Invertebrates

1. Following completion of the photographic quadrats and algal sampling, two divers will go to the sample transect, which still has the 30-m tape and the four quadrats in place. Using an airlift sampler, the divers vacuum all loose material within each quadrat and bag all loose racks with attached epifauna into a mesh bag that is attached to the quadrat frame. If organisms are attached to rocks too large to remove, all organisms will be scraped off and vacuumed into the airlift.

2. On board ship all samples will be preserved in 10% buffered (sea water) formalin.

H. Sample Collections

1. Collecting fishes for food habits, condition factor and hydrocarbon concentration studies

Following completion of the transect-sampling at a study site, a collection of fishes will be made to assess food resource utilization, condition factor, and tissue hydrocarbon levels. Species to be collected will be determined based on rough abundance estimates obtained from the initial survey of the study sites. Species will be selected based on their abundance and an a priori estimate of their trophic position. Two species will be selected: (1) a commonly occurring benthic feeding species and (2) a commonly occurring pelagic feeding species. At each site 20-25 individuals of each selected species will be collected.

Collecting techniques will depend to a considerable extent on the behavioral characteristics of the species selected for these studies and their size. Techniques may include diver spearing, hook and line fishing, gill nets, or diver-operated hand nets. Fishes collected will be measured (fork length) and weighed. Their stomachs will be excised and fixed in 10% formalin. Selected tissues and/or organs will be removed and treated as specified in the documents detailing collection and handling of samples for hydrocarbon analyses.

2. Collecting invertebrates
Selected taxa of larger macrofauna (e.g., crabs, shrimp, seastars) will be collected at each study site for trophic and hydrocarbon analyses.
3. Sample accountability

All samples collected in the procedures described above will be handled and documented as specified in the protocols for sample accountability and chain of custody described in Coastal SOP No. 3.

Pre-spill and post-spill concentrations of hydrocarbons in sediments and mussels at intertidal sites within Prince William Sound and the Gulf of Alaska.

Coastal Habitat Study Number 1

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Lead Agency - U.S. Forest Service
(Contract to National Marine Fisheries Service)

Cost - $218.0K (Only for NOAA/NMFS/Auke Bay Laboratory)

Dates of Study Plan - 26 March 89 to December 91

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Note: The material contained herein addresses the commitment, activities and responsibilities of only the Auke Bay Laboratory.

INTRODUCTION

Damage assessment of the oil spill in Prince William Sound and the Gulf of Alaska requires information on hydrocarbon contamination levels in water, sediment and biota prior to the spill (Baseline) and at various times after the spill occurred to determine the potential impact and duration of impact. Hydrocarbon baseline information is available for several sites in PWS prior to oil transport and for the first 4 years of oil shipment. Our intertidal baseline for hydrocarbon levels in mussels, sediment, water and fish had been established at 10 sites from 1977 to 1981.

For this study, we re-established these baseline sites prior to impact from the spill, established several additional sites along the spill trajectory, and took samples to measure the increase of hydrocarbon levels in sediments and mussels resulting from the spill. This occurred within 2 - 10 days following the spill and prior to any obvious oil contamination of established and selected sites. We re-sampled these sites several times this summer to document oil contamination or lack thereof. We intend to follow the persistence of hydrocarbons in the environment for several years, if necessary, to estimate the long term potential for damage to biota. See Table 1.

PRODUCTS: Concentrations of the full range of individual aliphatic and aromatic hydrocarbons in sediments and mussels from intertidal sites will be reported. Abundance of mussels and other epifauna along sediment and mussel transects will be photographically recorded during each sampling period. These data will provide a basis for estimating temporal and spatial impact to other biota of the nearshore environment.

OBJECTIVES

1. To estimate the hydrocarbon concentrations in mussels and other species such that the estimate is within 10% of the actual concentration 95% of the time when total aromatic concentrations are greater than 200 ng/g dry wt..

2. To estimate the hydrocarbon concentrations and their persistence in sediments such that the estimate is within 10% of the actual concentration 95% of the time when total aromatic concentrations are greater than 200 ng/g dry wt..

3. To test the hypothesis that hydrocarbon contamination of sediments and mussels is the same for the pre-spill and post-spill period such to detect at least a difference of 0.10 between concentrations with a= 0.05 and B=0.10.

4. To document changes in abundance and distribution of intertidal epifauna.

METHODS

Ten intertidal sites in PWS were sampled for sediments, mussels, water, and fish annually from 1977 to 1981 to establish a baseline against which future changes in hydrocarbon concentrations could be measured. Sites were initially sampled in spring, summer and fall to determine if short term changes occurred during the warm season. Photos of sediment and mussel transects were taken to document epifauna and flora. These sites were resampled in March 1989 immediately before several of them were impacted by the EXXON VALDEZ oil spill, and a few additional sites were established to cover areas of special concern. Only sediment and mussel samples were taken. Photo documentation was expanded on mussel and sediment transects and along selected transects at each site. Sites were resampled post spill in April, May, June and August in 1989 and will be sampled three times in 1990. Because of documented persistence of hydrocarbons in sediments in temperate and subarctic intertidal and subtidal environments, sampling should continue several years to follow depuration and recovery.

Sediments. Triplicate sediment samples were collected at each site by compositing 10 cores (dia 5 cm x depth 1.25 cm) taken at random along a 30 meter transect for each sample. Sediments in 16 oz. jars were transported in an ice chest and frozen within 2-3 hours of collection (Brown et.al. 1976).

Mussels. Triplicate mussel samples were collected by compositing a minimum of 30 mussels taken at random along a 30 meter transect in the mussel zone above the sediment transect. Samples were cooled and frozen as above (Brown et.al. 1976).

Photo Documentation. Overall views of the sediment and mussel transects were taken in color to document exact location, beach type and topography. Close up views of the substrata along each transect were taken at 2 meter intervals to document epifauna and flora type, abundance and distribution.

Analyses. Duplicate samples of sediments and mussels were analyzed for aromatic hydrocarbons (naphthalene to perylene) by GC- MS by the National Analytical Facility, NWAFC (Warner 1976, Macleod et.al. 1976, Karinen et.al. in prep). The third sample was archived for later use. Duplicate water and fish samples were analyzed similarly during the early baseline work. We propose to limit the present analyses to sediments and mussels unless high HC concentrations are found. The high cost of analyses allowed only duplicate analyses to be performed.

Equipment Protocol. All equipment and sample containers will be constructed of stainless steel, glass or teflon. No plastics will be allowed to contact samples. Sample containers will be solvent rinsed and/or baked at 600 degrees F. and protected from ambient air prior to sample collection, to assure that they are hydrocarbon free. Sample containers will be prepared as above and sealed in boxes. The seal will not be broken until the containers are used in the field. Sampling equipment will be rinsed in solvent and sealed in HC free foil between sample sites.

Quality Assurance. Sample blanks to check for HC-free integrity of sample containers and ambient air contamination at sample sites will be obtained by opening a sample container at each sample site over the duration of one sample collection, and then sealing it and carrying it through the sample processing and analysis procedure. Sample collection procedures will be ensured by requiring that one person on each team be experienced in the sampling procedure. Sample labelling will be done immediately upon collection of samples according to an established procedure. Chain-of-custody and protection of samples from tampering will be assured by maintaining the samples in control of the party chief at all times. Sample labels will be checked at the end of each daily sample period, the containers sealed and signed with custody tape, the containers boxed and each box sealed and signed with custody tape. Samples will be maintained in locked freezers or in freezers within locked rooms under the control of the party chief. Control will be maintained until analysis of samples.

DATA ANALYSIS

Random sample and subsample collection up to the analysis procedure should assure that hydrocarbons present in the sample represent the average concentration at the site. "Hot spots" of hydrocarbon concentration over the 30 meter transects should be cancelled out by this procedure. Duplicate samples will be analyzed, the mean concentrations and deviations from these means determined, and appropriate statistical tests applied. Digital tables of individual hydrocarbons will be reported.

SCHEDULES AND PLANNING

All schedules and report deadline as set by the Trustee Management Team and the Hydrocarbon Technical Committee will be met.

Intertidal baseline sites were sampled in March-April, May, June and August of 1989. We plan on resampling these sites in April, June and August of 1990.

BUDGET

Period 26 March 1989 to 30 September 1989

LABOR	TRAVEL	CONTRACTS	SUPPLIES	TOTAL
72000	20000	45000[1]	8000	128000

Period 1 October 1989 to 30 September 1990 (estimated)

LABOR	TRAVEL	CONTRACTS	SUPPLIES	TOTAL
32000	15000	38000	5000	90000

GRAND TOTAL				218000
				======

Labor includes, for the first phase:

John F. Karinen	.5 FTE
Malin Babcock	.4 FTE
Assistants	.5 FTE

and includes Payroll taxes, surcharges, overtime and Hazardous Duty Pay (all sampling is done by heliocopter charter and Hazardous duty pay is required).

[1] This figure is significantly reduced from what might have been actual costs. Much of the transportation for the first and second field trip was provided by the U.S. Coast Guard, NOAA, DEC and ADF&G.

CITATIONS

Brown, D. W., A. J. Friedman, D. G. Burrows, F. R. Snyder, B. G. Patten, W. E. Ames, L. S. Ramos, P. G. Prohaska, D. D. Gennero, D. D. Dungan, M. Y. Uyeda, W. D. MacLeod, Jr. 1976. Investigation of Petroleum in the Marine Environs of the Strait of Juan de Fuca an Northern Puget Sound. NOAA Tech. Memo., National Oceanic and Atmospheric Administration. Seattle, Wash. 107 pp.

Karinen, John F., L. Scott Ramos, Patty G. Prohaska, William D. MacLeod, Jr. In Preparation. Hydrocarbon Distribution in the marine environment of Port Valdez and Prince William Sound, Alaska.

MacLeod, W. D., D. W. Brown, R. G. Jenkins, L. S. Ramos, V. C. Henry. 1976. A Pilot Study on the Design of a Petroleum Hydrocarbon Baseline Investigation for Northern Puget Sound and Strait of Juan de Fuca. NOAA Technical Memorandum ERL-MESA 8, National Oceanic and Atmospheric Administration. Boulder, Colorado. 53 pp.

Warner, J. S. 1976. Anal. Chem 48:578-583.

TABLE 1. Site locations for intertidal baseline sampling.

PRINCE WILLIAM SOUND

Port Valdez
1. Dayville Flats
2. Mineral Creek
3. Gold Creek
4. Sawmill Creek

Unakwik Inlet
5. Siwash Bay

Bligh Island
6. West Bay

Naked Island
7. Outside Bay

Perry Island
8. South Bay

Knight Island
9. Bay of Isles, South Arm
10. Drier Bay, Barnes Cove

Evans Island
11. Crab Bay

Montague Island
12. Rocky Bay

Hinchinbrook Island
13. Constantine Harbor

Port Gravina
14. Olsen Bay

Latouche Island
15. Sleepy Bay

Elrington Island
16. Elrington Passage

GULF OF ALASKA Kenai Peninsula

17. Quicksand Cove, Aialik Bay
18. Verdant Cove (oiled), Aialik Bay
19. Harris Bay
20. Petrof Point, Nuka Passage

LIST OF STUDY PLANS BY VOLUME

Volume 1

Coastal Habitat	CH1	Comprehensive Assessment
Air/Water	AW1	Geographical Extent in Water
	AW2	Injury to Subtidal
	AW3	Hydrocarbons in Water
	AW5	Injury to Air

Volume 2

Fisheries	F1	Salmon Spawning Area Injury
	F2	Egg and Preemergent Fry Sampling
	F3	Coded-Wire Tagging
	F4	Early Marine Salmon Injury
	F5	Dolly Varden Injury
	F6	Sport Fishery Harvest and Effort
	F7	Salmon Spawning Area Injury, Outside PWS
	F8	Egg & Preemergent Fry Sampling, Outside PWS
	F9	Early Marine Salmon Injury, Outside PWS
	F10	Dolly Varden & Sockeye Injury, Lower Cook Inlet
	F11	Herring Injury
	F12	Herring Injury, Outside PWS
	F13	Clam Injury
	F14	Crab Injury
	F15	Spot Shrimp Injury
	F16	Injury to Oysters
	F17	Rockfish Injury

Volume 3

Fisheries	F18	Trawl Assessment
	F19	Larvae Fish Injury
	F20	Underwater Observations
	F21	Clam Injury, Outside PWS
	F22	Crab Injury, Outside PWS
	F23	Rockfish Injury, Outside PWS
	F24	Trawl Assessment, Outside PWS
	F25	Scallop Mariculture Injury
	F26	Sea Urchin Injury

Volume 4

Marine Mammals	MM1	Humpback Whale
	MM2	Killer Whale
	MM3	Cetacean Necropsy
	MM4	Sea Lion
	MM5	Harbor Seal
	MM6	Sea Otter Injury
	MM7	Sea Otter
Terrestrial Mammals	TM1	Injury to Sitka Blacktail Deer
	TM2	Injury to Black Bear
	TM3	Injury to River Otter and Mink
	TM4	Injury to Black Bear
	TM5	Injury to Small Mammals
	TM6	Reproduction of Mink

Volume 5

Birds	B1	Beached Bird Survey
	B2	Censuses & Seasonal Distribution
	B3	Seabird Colony Surveys
	B4	Bald Eagles
	B5	Peal's Peregrine Falcon
	B6	Marbled Murrelets
	B7	Storm Petrels
	B8	Black-legged Kittiwakes
	B9	Pigeon Guillemots
	B10	Glaucous-winged Gulls
	B11	Sea Ducks
	B12	Shorebirds
Technical Services	TS1	Chemistry
	TS2	Histopathology
	TS3	Mapping

Missing Coastal Habitat No 1

to arrive 11-6

& Cover letter

CONFIDENTIAL

STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT
DETAILED STUDY PLAN

Project Title:	Geographic Extent, Temporal Persistence and Mapping of Floating Oil from the T/V EXXON VALDEZ Oil Spill
Study ID Number:	Air/Water Number 1
Lead Agency:	State of Alaska, Department of Environmental Conservation, Administrative Services-Data Processing
Cooperating Agencies:	State:University of Alaska Fairbanks, Geophysical Institute Federal:NOAA
Principle Investigator:	Marshal Kendziorek, Analyst Programmer
Date Submitted:	October 6, 1989

	Signature	Date
Principle Investigator:	Marshal Kendziorek	10/6/89
Supervisor:	MT by Judy Bender	10/6/89
OSIAR Senior Biometrician:		
OSIAR Program Manager:		
OSIAR Director:		

Study Title:
Geographic Extent, Temporal Persistence and Mapping of Floating and Beached Oil from the T/V EXXON VALDEZ Oil Spill

Introduction:

The general mission of this Natural Resource Damage Assessment floating oil mapping effort will be to document the extent, amount and persistence of oil resulting from the T/V EXXON VALDEZ oil spill. Maps have been produced on a regular basis showing the location of oil from aerial surveys from the first day of the spill on March 24, 1989. While the aerial overflight mapping effort has been reduced since mid May, to one flight a day from two or three, there are still regular aerial overflights being performed to monitor the location and extent of oil in the water. Another source of information that will yield answers on the extent of floating oil is satellite imagery. The data source used here consists of imagery obtained from a variety of polar-orbiting satellites. The function of the satellite imagery portion of this study is to devise digital filtering techniques to remove noise and to perform digital enhancements to improve the identification of oil. In addition, the satellite imagery will be enhanced to provide oceanographic data useful in determining the oil's trajectory as well as its weathering, mixing with suspended sediments and related evolution. Finally, there is a possibility that some of the satellite imagery will yield information that will document the extent of oiled beaches.

The aerial overflights produce three basic data types. The first type is a hard copy of a nautical chart with observers notes and markings indicating the location and extent of the oil as well as the flight track taken by this crew. The second data type is video tape showing the oil on the water. The third data type is a written report from the observers with any other observations they may have as well as weather information indicating the observing conditions. In many instances still photographs also exist from the flight. All of this information is combined to ensure the accuracy and reliability of the information.

The satellites produce image format data of the earth's surface in a variety of wavelength bands ranging from blue visible light to the thermal infrared. Some of these bands are useful for the identification of oil while others are useful for identification of suspended sediment, the thermal regime, and possibly large concentrations of plankton. The oil signature in most cases is only slightly different from that of the ocean, requiring sophisticated digital image enhancement techniques to separate the two. It is possible that the oil signature will be found to change over time as a result of its weathering. Other techniques are used to display the identified oil relative to regions of suspended sediment where the oil may have become sufficiently heavy to have become submerged.

In the event that any samples of oil will need fingerprinting to confirm the connection to the T/V Exxon Valdez oil spill, NOAA has agreed to perform the chemical analysis.

Objectives:

A. Produce standard formatted maps of the location of floating oil for each day that information is available.

Relationship with Other Studies:

This study is coordinated between ADEC for the aerial overflight data and the University of Alaska, Fairbanks for the satellite imagery data. Please refer to the attached State of Alaska Winter Operations Plan for details of the aerial overflight data gathering. The electronic versions of these maps can be made available after the completion of this project for transfer to other graphic and GIS systems. The information on distribution of oil will be available to support any of the other studies in the damage assessment process that require such information.

Methodology and Data Analysis:

Aerial overflights:

Through the use of existing computer mapping techniques, composites of the distribution of the oil can be produced and have been from the beginning of the spill. A book of maps for each day and composites for each month showing the location, type and extent of oil will be produced. This book will also include documentation on the techniques and software used to produce these maps. All maps of the entire area effected by the spill will be produced in black and white 8x10 format for easy copying. Separate 8x10 blowups of Prince William Sound, the Kenai Peninsula, and Kodiak/Alaska Peninsula will be produced to give greater detail. Each map will also include a wind vector showing the direction and speed of the wind at the meteorological stations available. All maps will be produced to scale. Calculations of the area (in square kilometers) of each type of oil (i.e. rainbow sheen, mousse, black oil, etc) will be shown with each map. The monthly composite maps will also be produced in full color on 30 inch by 30 inch paper. The large format color maps, while not appropriate for copying, will be produced in numbers sufficient for distribution to parties requiring them. The volume of maps required may be produced with the cooperation of the Alaska Dept. of Natural Resources and use of an electrostatic plotter. All maps will be available on diskette in both autocad DWG format as well as DXF format for use by other groups with computer based system.

In addition, a spatial database with attributes will be created that will allow one to perform a database search of a geographical area for presence of oil in the water. This database capability will allow damage assessment workers the ability to request a map of a specific site at any needed scale and time with oiling information present. This should greatly enhance the damage assessment workers ability to "see" what was going on in an area where they are doing research into the damage caused by the spill. By looking at the change over time of the amount and type of oil at any given area, damage assessment staff will better understand what happened during the critical days when the oil was impacting their study sites.

A computer based animation of the oil spill will be produced electronically from the maps and

transferred to video to show graphically a time series of the movement of oil from the beginning of the spill. This animation will be made directly from the maps produced and will thus maintain the first generation accuracy of the maps. The animation will also include the wind vectors to show the relation between wind conditions and the direction of the flow of oil.

Satellite Imagery:
This is not a statistical study utilizing a priori designed discrete samples but rather one involving mensuration using data sets which are randomly available. Thus, in many respects the methods described here will appear to be considerably different from the methods employed for most of the programs in the CERCLA damage assessment studies.

1. AVAILABLE DATA. At the time of the oil spill there were four satellite observational systems in operation which have subsequently been found to provide data which will help meet the objectives listed above. These are:

A. The Advanced Very High Resolution Radiometer (AVHRR). This system is carried aboard the NOAA series satellites. At the time of the spill, two of these systems were in orbit. These systems provide wide area coverage in five wavelengths with rather coarse resolution (1km). Counting nighttime passes, up to six useful data-acquisitions are theoretically available daily. To date, the most useful data set to this study from this instrument has been the thermal infrared channel which provides useful images of sea surface temperature both day and night. The next most useful data set is the broad-band visible light channel which provides suspended sediment information. The utility of the near infrared and mid infrared channels is still under investigation. These channels have been found to be useful for the identification of oil in the data from higher resolution systems. However, it is possible that their utility is diminished here because of the coarse resolution of this system. These data are cloud-limited but because of the high frequency of coverage, this system offers the greatest quantity of imagery. The Geophysical Institute acquires these images daily in 8-bit format. However the greatest radiometric resolution is obtained from the 10-bit data which must be ordered retrospectively based on examination of the 8-bit imagery. (Discrimination must be employed because the 10-bit tapes cost nearly $100 each.)

B. The Landsat Thematic Mapper (Landsat TM). This system is carried on-board the (now) commercial Landsat Satellite. This system has a relatively high spatial resolution (20-30m), but scans a swath about one tenth the useful portion of the AVHRR swath (approximately 180km). As a result, a given location in the oil spill study area can be imaged about three times every two weeks. Because of the size of the oil spill study area, on any given day there is about a 25% chance that some part of the study area will be in the area of coverage. These data are also cloud-limited. The Landsat TM images the earth in 7 wavelengths ranging from blue to the thermal infrared. As a result every aspect of the study can be

addressed by these data.

C. The SPOT HRV camera in multispectral mode (SPOT MS). Two High Resolution, Visible (HRV) sensor systems ride aboard the commercial French satellite, SPOT. In the MS mode they obtain data in three cloud-limited wavelength bands: blue-green to green, yellow to red and the near infrared. These data are obtained in 20m pixels which results in pixel areas less than half the area of Landsat TM pixels. However the signal-to-noise ratio at low light levels encountered in this work is poorer than the Landsat TM. As a result the utility gained by the higher spatial resolution is considerably diminished. These sensors can be "pointed" to some extent, with the result that the ability to image a specific point on the earth's surface has a greater frequency than Landsat TM. However the rectification of off-nadir images to map projections is more difficult than for nadir-pointed sensors. As a result of this pointing capability, although the orbital characteristics of SPOT are similar to Landsat, the frequency of coverage is potentially about three times as great.

D. The SPOT HRV camera in panchromatic mode (SPOT PAN). When the HRV cameras (see description in C above) are in panchromatic mode, spectral resolution is traded for spatial resolution resulting in a single black and white image per camera with 10m resolution.

2. DATA SELECTION. Because of the costs involved some care must be exercised when selecting the AVHRR imagery and considerable care must be taken selecting the Landsat and SPOT imagery. For this reason two distinct techniques are employed:

A. AVHRR selection. These data are received at Fairbanks and are available in hard copy format at the Federal Building for data selection purposes. 8-bit tapes of selected images may be borrowed from the Gilmore Creek receiving station for copying. Copying of these tapes costs the project approximately $20. Upon digital image display, selection of high quality images for analysis at high radiometric resolution is made and 10-bit tapes are ordered from the national archive at a cost of $75 each. Selection criteria for images include, absence of clouds, a useful solar elevation angle (good illumination but absence of sunglint) and absence of extreme distortion.

B. Landsat TM and SPOT selection. In order for the respective satellites to be activated, these two data sets must be ordered in advance and an acceptable degree of cloudiness must be specified. This gives the purchaser some cost protection Successful data takes cost approximately $3500. It is possible however that data will be acquired and archived which failed this selection criterion. These images may be re-examined retrospectively for useful data after the budgetary impact of images acquired under the original criterion is known. For this project a cloudiness criterion of a maximum of 20% was chosen. Sun angle is not a problem with these data but the specific area of coverage must be determined because it is necessary to specify the image acquisition location rather generally if all possible data takes are to be considered.

3. DATA AVAILABILITY. As explained above each satellite imaging system used in this study has different operating characteristics and different managing entities. As a result data availability varies considerably from one system to the next. As of September 15, 1989 data availability appears to be as follows.

A. AVHRR. These images have been acquired up to several times daily. Of these approximately 20 have been analyzed in terms of one or more of the stated objectives. Others await analysis. These images contain a considerable range of cloudiness which can only be accurately assessed when the tapes are displayed digitally. Based on our selection of scenes for which we have acquired digital tapes, we estimate that some data related to the oil spill study objectives described above is to be found on AVHRR scenes for at least one third of the days between March 27 and the present, or about 50 scenes.

B. Landsat. Throughout the study period four scenes were acquired which met the selection criterion. Two scenes were acquired on both April 7 and September 3. We have the digital tapes for all four of these scenes. In addition we have acquired the tapes for a scene one year previous to the spill for calibration purposes.

C. Spot. Spot management has decided to acquire imagery regardless of cloud cover. As a result there have been approximately 160 scenes acquired. We plan to select scenes for analysis on the basis of both cloud cover and date of acquisition. We estimate that we may eventually acquire between 20 and 30 of these images. To date we have acquired two.

DATA ANALYSIS

The imagery utilized in this study is in digital image format and is analyzed using digital image analysis hardware and software. The University of Alaska Fairbanks has two digital image analysis systems co-located at the Geophysical Institute. These systems allow for operator-interactive image enhancement as well as the application of standard computer-driven digital image analysis routines (digital filtering, clustering, principal component analysis, fourier analysis, etc.) In addition, the systems have the capability of image-to-image and image-to-map registration and geometric image rectification. Finally there is a capability to scan a hard copy product such as the Coast Guard's Side-Looking Airborne Radar data and convert it to digital image format. Output products are displayed on full color screens and recorded on 35mm or larger film format in 1024 by 1024 pixel arrays. In the paragraphs below the techniques and data sources to be used for addressing each objective are outlined.

Method 1. All three satellite systems have been found useful for delineation of the oil extent at specific times. The oil is not readily identified in any spectral band so that contrast enhancement routines must be applied. Principal component techniques have been used to compress oil data from several wavelengths into one variate. It has also been found useful to create a digital mask for land surface areas so that the oil-water enhancement is not applied to those areas as well. To meet this objective all available satellite imagery should be examined for useful data and the oil extent extracted from each.

Method 2. As the morphological state of the oil changes its spectral signature will change correspondingly. This should allow us to identify the oil on the products generated for objective 1 in terms of morphological state using on-site observations from field observers for training sets.

Method 3. The paths taken by the spilled oil can be determined from the sequence of products generated for objective 1 and from detailed analysis of water mass movement as shown on AVHRR thermal IR images

Method 4. Suspended sediment is generally observed on spectral bands other than those particularly useful for detecting oil. It has therefore been found possible to display oil and suspended sediment as separate signatures on the same image. This allows the exposure of oil to suspended sediment to be documented and analyzed in terms of both duration and concentration.

Method 5. The thermal bands on both the Landsat TM and AVHRR systems are useful for mapping ocean surface temperatures and identifying the locations of upwellings. We have been supplying the ADEC Kodiak office ocean with relative ocean temperature data by facsimile for this purpose. Retrospective preparation of calibrated ocean surface temperature maps combined with reported on-site observations of the sudden appearance of oil in various forms will help validate the occasions when weathered oil was advected to the surface by upwellings.

Method 6. It appears possible that plankton blooms can be identified on Landsat TM and SPOT MS imagery that have been properly enhanced. Research is currently underway to determine the correlation between spectral response on the April 7 1989 TM image and simultaneous plankton density measurements made during the Alpha Helix cruise. If this proves possible we may be able to document the interaction between the spilled oil and plankton.

Schedule and Reports:

Date	Overflight data entry	Composite map production	Wind vector calculation	Spill area calculation	8x10 final printing	Large format color	Animation of spill map	Documentation of system	Spatial database
March 24									
April 1									
15									
29									
May 6									
20									
June 3									
17									
July 1									
15									
29									
August 5									
19									
Sept. 2									
16									
30									
Oct. 7									
21									
Nov. 4									
18									
Dec. 2									
16									
30									
Jan. 6, 1990									
20									
Feb. 3									
17									

Aerial overflight and beach survey work will continue throughout the winter. This study will produce a final report on February 15 but it will continue to be added to as long as information continues to be gathered.

Lead Agency: Alaska Department of Environmental Conservation

Cooperating Agencies: State: University of Alaska Fairbanks, Geophysical Institute
Federal: NOAA

Project Budget:[1]

Budget:Alaska Department of Environmental Conservation

Contact: Marshal Kendziorek
ADEC
P.O. Box O
Juneau, Ak. 99811-1800
(907) 465-2621

Salaries	regular and overtime for AP IV on spill duty		10.0
subtotal		$10.0	
Travel	Juneau-Valdez		4.5
	Juneau-Seattle (meet with NOAA)		.8
	Valdez-Rhode Island (coordination with ETech)		3.0
subtotal		$ 9.3	
Contracts	GIS customization and programming		19.7
	ETech services		20.0
	Printing		10.0
subtotal		$49.7	
Supplies	Plotter pens, paper and supplies		5.1
	Printer cartridges, paper and supplies		1.1
	Backup tapes, diskettes, cable		2.5
	Film and processing		.5
	Video tape		.2
	Plotter maintenance		2.1
	Equipment shipping		2.0
subtotal		$13.5	
Equip.	Graphics workstation		38.0
	Computer/Video subsystem		5.0
	Plotter		2.0
subtotal		$45.0	
TOTAL		$127.5	

[1]This budget will require an amendment to the existing RSA to ADEC to adjust line items within the total awarded amount of $127.5

Budget:University of Alaska Fairbanks, Geophysical Institute

Contact: W.J. Stringer
Geophysical Institute
U.A.F.
Fairbanks, Ak. 99775-0800
(907) 474-7455

Personal Services		
Associate Professor of Geophysics		$14.5
Remote Sensing Geologist		$15.0
Technician III		$8.0
Remote Sensing Analyst		$12.0
subtotal	$49.5	
Travel		
Fairbanks to Valdez and Kodiak		$2.5
Fairbanks to Juneau		$1.0
Fairbanks to Seattle		$1.0
subtotal	$4.5	
Contractual		
Photographic Services		$10.0
Computer Service Center charges		$17.0
subtotal	$27.0	
Supplies Satellite Imagery		$22.5
subtotal	$22.5	
Administrative overhead to U.A.F.	$20.7	
TOTAL	$124.2	

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Petroleum Hydrocarbon-Induced Injury to Subtidal Marine Sediment Resources

Air/Water Study Number 2

Stanley D. Rice[1], Charles E. O'Clair[1], Jon Lindstrom[2], Art Weiner[2] and David G. Shaw[3]

1. National Marine Fisheries Service, Auke Bay Laboratory, Auke Bay, Alaska.

2. Alaska Department of Environmental Conservation, Valdez, Alaska.

3. School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Lead Agency - National Marine Fisheries Service

Cooperating agencies - Alaska Department of Environmental Conservation

Institute of Marine Science, UAF

Cost of Proposal - $883K

Dates of Study Plan - April 20, 1989 to February 28, 1990

	Signature	Date
Principal Investigators:	Stanley D. Rice	6 oct 89
	C. E. O'Clair	10/6/89
	D. Rothman for John L. Lindstrom	10/6/89
Organization Leaders:	[illegible]	10/6/89
Financial Officers:	Deb Rathbone	6 Oct 89

Petroleum Hydrocarbon-Induced Injury to Subtidal Marine Sediment Resources

INTRODUCTION

Approximately 10 million gallons of crude oil were released into the marine environment when the Exxon Valdez ran aground on Bligh Reef on 24 March 1989. Abelson (1989) quotes an Exxon estimate that the amount of oil in Prince William Sound dropped about 70% during the first 4 weeks after the spill. Ten percent of the original spill remained on Prince William Sound as oil slicks; 18% had grounded on the shoreline (Abelson 1989). The short-term effects of the spill particularly in the form of massive mortality among marine mammals, seabirds and some fish is being closely monitored. However, the duration of the effects will depend to a great extent on the proportion of the oil that accumulates in fine sediments and on the geographical distribution of those sediments (Roberts 1989). Because the specific gravity of oil initially ranges from 0.8 to 1.0 g/ml (that of Prudhoe Bay crude oil is 0.89 g/ml) and floats on seawater (Juszko and Green 1983) a large percentage of the oil that contacts sediments is stranded in the intertidal region. However, a proportion of the constituents of oil can make its way to the subtidal region by erosion of oiled sediments and at high latitudes by ice scour (Boehm et al. 1987). Oil may accumulate in subtidal sediments relatively slowly, but once incorporated persists (Boehm et al. 1987).

Determining the geographical and bathymetric extent of subtidal hydrocarbon contamination is key to evaluating to what extent the marine environment will serve as a long-term repository for petroleum hydrocarbons causing chronic toxicity to benthic organisms directly and to demersal species through remobilization of oil into the water column and through food webs. Benthic infauna and epifauna are important constituents of the diet of many species of fish, marine mammals, and birds. Documenting hydrocarbon contamination of subtidal sediments is a fundamental step toward providing modelers with the requisite information on the fate of the oil spilled by the Exxon Valdez allowing a realistic basis for quantifying damages to biological resources. By visiting beaches with different levels of oiling and different types of treatment we will be able to test for differences in occurrence and persistence of petroleum hydrocarbons in benthic sediments as a function of the degree of oiling and treatment. Providing information on the distribution of hydrocarbon contamination with sediment type will be helpful for identifying possible contamination pathways from benthic to demersal or pelagic food webs.

This study will extend beyond the arbitrary boundaries of several study-committee groups. It will determine the extent of subtidal oiling from the intertidal region to 300 m at selected sites within Prince William Sound and on the coast of south central Alaska from Prince William Sound to Kodiak. The different responsibilities of the agencies cooperating in this study will be specifically identified in subsequent sections of this plan.

OBJECTIVES

A. Determine occurrence, persistence, and chemical composition of petroleum hydrocarbons in subtidal marine sediments.

B. Provide marine sediment data to assist agencies in mass balance calculations on the fate of oil in the marine environment.

C. Relate subtidal oil concentrations to adjacent intertidal concentrations and other studies.

D. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

METHODS

The methods employed by the three agencies cooperating in this study are described separately below beginning with those of the Auke Bay Laboratory (ABL). Because the methods of the Alaska Department of Environmental Conservation (ADEC) will be largely identical to those of the Auke Bay Laboratory we describe those aspects of the methods of ADEC only when they differ from those of ABL.

Auke Bay Laboratory

The part of the study completed by the Auke Bay Laboratory included 29 sites in Prince William Sound (four reference sites and 25 contaminated sites; Table 1). Eigthteen sites were studied intensively using transects (at least one per site) that extended from the intertidal region to 100 m. Three additional sites were sampled at three depths, (intertidal, 3 m and 6 m). A manned submersible sampled sediments in the range 100 - 300 m at six of the above sites as well as seven additional sites in Prince William Sound.

Outside Prince William Sound 25 sites were sampled intensively. These sites are distributed such that 11 sites are on the Kenai Peninsula, 4 sites are in Lower Cook Inlet and 10 sites are in the area of Kodiak and Afognak Islands (Table 2). The submersible sampled two sites on the Kenai Peninsula and eight sites in the area of Kodiak and Afognak Islands. All sites were arbitrarily selected to encompass at least three levels of impact as well as reference sites.

Three samples each a composite of 8 subsamples collected randomly along a 30 m transect laid parallel to the shoreline were taken at each intertidal site. These samples were collected at low tide or by divers. Intertidal collections were made at a single tidal height in the range of +0.5 to -1 m depending on the distribution of fine sediments.

Subtidal sediment collections were made at depths of 3, 6, 20, 40, 100, 200 and 300 m below mean lower low water (MLLW). Collections at 3 and 6 m were made by divers on transects laid along the appropriate depth contour and sampled in the same way as described above for the intertidal transects. Collections below 100 m were made with a manned submersible. Samples collected at depths between 6 and 100 m were collected with a van Veen grab.

Sediment sampling from the submersible involved a stainless steel electrical pump (attached to the submersible) that suctioned sediments through a 2 inch diameter tube and deposited the sediments into 100 micron mesh bags. The suction tube was clamped into a metal arm that was contolled mechanically from inside the submersible. At each dive site, duplicate sediment samples were usually collected at depths near 100, 200, and 300m. Samples were sealed in 4 oz sterile jars and placed in a freezer within 1 hour of the return of the submersible to the support vessel. Small samples were frozen in their 100 micron sampling bags, whereas larger samples were removed from the 100 micron sample bags and sediments frozen from the middle of the samples. Two samples were frozen from each dive site; both samples were frozen when duplicate samples were collected and two subsamples from the same sediment sample were frozen when only one sediment sample was collected (see standard operating procedures in Appendix A).

Remote sampling with the van Veen grab included three grabs taken at each depth. Four cores were removed from randomly selected points within each grab. The subsamples were combined to form one sample per grab. Where remote sampling could not be effectively conducted at 20 m such as in boulder fields or dense algal beds divers collected the sediment samples along a transect as described for the intertidal region above.

All samples collected by hand (including those removed by hand from the van Veen grab) were taken from the surface (top 0-2 cm) of the sediment column. Samples taken by hand in the intertidal region or by divers were collected using a stainless steel core tube or spoon. Each subsample was transferred to a sample jar using a spatula. The core tube and the spatula were washed, dried and rinsed with methylene chloride between sampling periods. Sample jars had been baked at 440°C or rinsed with methylene chloride prior to use. The jars were fitted with teflon lined caps that were also rinsed with methylene chloride prior to use. Samples were placed in coolers with ice immediately after collection and frozen within a few hours. Appropriate blanks were collected at each site. Chain of custody procedures were followed after collection of all samples.

Alaska Department of Environmental Conservation

The Alaska Department of Environmental Conservation (ADEC) will sample 22 sites in Prince William Sound through the winter of 1989/90 (Figure 1). Five of these sites will be the same as those sampled by the Auke Bay Laboratory. Where this overlap occurs ADEC will extend in time the data set on occurrance and persistence of petroleum hydrocarbons in subtidal sediments into the winter months thereby providing a more complete record of the changes in distribution and concentration of petroleum hydrocarbons in these sediments over time. Using methods identical to those of the Auke Bay Laboratory ADEC will sample sediments at 3, 6, 10 and 20 meters below mean lower low water. Water depths on the transect will be determined with a diver's depth gauge which will be field calibrated to determine instrument error at each target depth.

University of Alaska

The sampling plan of the University of Alaska has several goals; 1) to provide geographic coverage of Prince William Sound including areas impacted and unimpacted by the spill, 2) to include sediments from a range of water depths and sedimentation regimes, 3) to provide information about particularly sensitive areas such as salmon hatcheries, 4) to support other damage assessment studies in the sound, and 5) to coordinate with available pre-spill data. The station coordinates are listed in Table 3. All stations except OB 1, OB 5, CB, EI, and MB were sampled during a cruise of the R/V Alpha Helix, 1-6 June, 1989. We will attempt to resample all stations during another cruise in October 1989.

The sample collection protocol for the University of Alaska is described in detail in Appendix B. Briefly, samples are collected using a HAPS corer (a stainless steel mini-box corer) from a research vessel equipped with radar, satellite, and Loran C navigation systems. At each sampling station three replicate

lowerings of the corer are made. Sediment from 0-2 cm is transferred to a pre-cleaned glass jar and frozen for later analysis. Samples are obtained and stored under chain-of-custody procedures which are described in detail in Appendix C.

Definitive analysis of the chemical composition of petroleum hydrocarbons in the sediments will be accomplished in the laboratory with gas chromatography/mass spectrometry as directed by the Analytical Chemistry Quality Assurance/Quality Control Group. The types of analyses to be performed will, in part, be controlled by the Analytical Chemistry Group and will include 1) TPH/GC and PNA/SIM characterization of oil in marine sediments, 2) total organic carbon on selected samples, and 3) size fraction analysis on representative samples. Prescreening analyses of collected samples will occur prior to full GC/MS analysis in areas of low liklihood of oiling. Details of the methods used in the chemical analyses are recorded under the Quality Assurance Program.

Recognizing that the Analytical Chemistry Group will determine the types of hydrocarbon analyses to be performed on sediments the University of Alaska suggests the following protocol to meet their analytical data requirements. Because analysis of environment samples for hydrocarbons is expensive and time consuming work, a phased sequence of analyses is suggested. Only samples which show evidence of contamination with EXXON VALDEZ oil in the earlier phases will be subjected to later phases.

Phase 1 Concentrations of petroleum hydrocarbons will be determined in one replicate sample from each of the stations listed in Table 3, using material collected in June 1989 whenever available. The analytical protocol will be compatible with the NOAA Status and Trends Program (Krahn et al., 1988); quantification will use flame ionization detection gas chromatography. For stations judged particularly sensitive (Esther Island, Main Bay, Sawmill Bay), three replicates will be analyzed. The limit of detection will be 10 ng/g (dry sediment weight basis). Stations which show qualitative evidence of contamination based on pristane/phytane ratio, heptane/hexane ratio and the abundance of polycyclic aromatic hydrocarbons, will be advanced to Phase 2.

Phase 2 The remaining two replicates will be analyzed as in Phase 1. The data quality will meet Objective I. That is, the estimate of the concentration will be within 50% of the actual value 95% of the time. Stations which show quantitative evidence of contamination based on the criteria listed in Phase 1 will be advanced to Phase 3.

Phase 3 Alkylated polycyclic aromatic hydrocarbons will be determined by gas chromatography-mass spectrometry. Total organic carbon (by combustion analysis) and sediment grain size distribution will be determined for all replicates. For stations where a second time period collection is available (June and October), the three October replicates will also be fully analyzed. Additional analyses to meet Objective A will be performed. The content of this additional work will be based on detailed studies of weathering of spilled oil from the EXXON VALDEZ being conducted by the National Marine Fisheries Service.

DATA ANALYSIS

The critical aspect of this study is whether concentrations of petroleum contaminants from the EXXON VALDEZ are present at concentrations which cause deleterious effects to aquatic life, since such concentrations constitute a violation of state and federal water quality criteria. Because the "deleterious effects" criterion is complex and subject to subjective interpretation, a detailed comparison is required of the measured concentrations and information from the scientific literature about concentrations at which various behavioral, biochemical, physiological, organismal, population, and ecological effects occur. This analysis of the data will take the form of a narrative discussion. Statistically valid comparisons of results will be made where possible. However, the available background information suggests that at least for the environments at greater depth where the University of Alaska will be sampling such comparisons may be relatively few.

Data collected in the shallow subtidal region show more promise for the application of statistical analysis. Where statistics can be successfully employed the null hypotheses to be tested will depend on which of the objectives listed above is under consideration. In general, the null hypothesis will state that the concentrations of petroleum hydrocarbons at particular depths or the distribution of petroleum hydrocarbons with depth at oiled sites does not differ from those at reference sites. All data will be tested for heteroscedasticity with Bartlett's test or equivalent. Data will be reported as means and 95% confidence intervals calculated according to a standard formula (Sokal and Rohlf 1981). Parametric statistics (analysis of variance and Scheffe's a posteriori test) will be used to test for differences in hydrocarbon concentrations between sites and depths if underlying assumptions of the parametric procedures are met, otherwise nonparametric tests (eg. the Kruskal-Wallis test) will be employed. Key petroleum weathering and source ratios will be calculated (Boehm et al. 1987).

SCHEDULES & PLANNING

Sediment sampling by the Auke Bay Laboratory (ABL) within Prince William Sound began on 5 May 1989. Sites were sampled in June/July and September 1989 (Table 1). Sediment sampling by ABL outside Prince William Sound began on the Kenai Peninsula in late July and continued through early August in Lower Cook Inlet (Table 2). Sites in the Kodiak/Afognak region were sampled in August (Table 2). The timetables for data compilation, analysis and report writing depend on the date of completion of the chemical analyses which are funded under Technical Services Study Number 1. The Technical Services Committee controls the reporting schedule for chemical analyses. Dates of completion of data compilation, analysis and report writing for the 1989 sediment sampling will be 4, 8, and 12 months respectively after the date of completion of the chemical analyses.

The Alaska Department of Environmental Conservation will begin sampling in October 1989; sampling will continue through April 1990 (Table 4). The schedule for laboratory and data analysis and report writing is shown in Table 4.

The schedule for sampling, analysis and report preparation of the University of Alaska follows:

Sampling: June 1989; October 1989

Phase 1 Analysis: October-November 1989

Phase 2 Analysis (if necessary): December 1989-February 1990

Phase 3 Analysis (if necessary): March-April 1990

Data Analysis: This activity will begin as soon as Phase 1 analytical results are available and continue until one month after the completion of the final implemented phase. Depending on the number of phases which are implemented, data analysis will be complete by January, April, or June 1989.

Report Preparation: The final report will be submitted one month after the completion of the data analysis.

BUDGET

	Salaries	Travel	Contracts	Supplies	Equipment	Total
Auke Bay Laboratory	125K	10K	160K	25K	10K	$330K
Alaska Department of Environmental Conservation	75.0K	6.0K	7.5K	7.5K	5.0K	$553K*

* Includes an RSA of $452K to UAF, including 42 days of the R/V Alpha Helix for support of various Air/Water and Fish/Shellfish projects.

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Table 1

Location of sites in Prince William Sound where intertidal and subtidal sediment samples were collected in 1989. Letters in body of table represent depths sampled: A = intertidal (I), 3 and 6 m; C = I, 3, 6, 20, 40 and 100 m; S = 100, 200 and 300 m sampled with a manned submersible.

Location	North Latitude o ' "	West Longitude o ' "	May	Jun/Jul	Sep
Bay of Isles	60 23 00	147 44 54	-	C	A
Cabin Bay	60 39 21	147 26 18	-	C	A
Culross Island	60 38 10	148 04 26	-	S	-
Disk Island	60 29 55	147 39 40	-	C	A
Elrington Passage	59 59 20	148 12 21	-	S	-
Eshamy Bay	60 26 54	147 58 30	A	C	A
Ewan Bay	60 22 00	148 08 00	A	-	A
Fox Farm	59 58 26	148 10 30	A	C	A
Green Island	60 16 18	147 26 18	-	C,S	A
Heather Bay	60 58 49	147 02 00	-	C	-
Herring Bay	60 25 51	147 47 06	A	C,S	A
Iktua Bay	60 06 00	147 59 42	A	C	A
Latouche Passage	60 00 10	147 58 54	-	C	A
Mc Pherson Passage	60 39 10	147 22 18	-	-	A
Montague Strait	60 08 23	147 40 52	-	S	-
Mummy Bay	60 12 32	147 53 19	-	S	-
Mummy Island	60 17 16	147 54 23	-	C	-
Northwest Bay	60 33 07	147 34 36	-	C,S	A
Olsen Bay	60 45 05	146 11 13	-	C	A
Outside Bay	60 39 05	147 26 17	-	A,S	A
Paddy Bay	60 25 00	148 06 00	A	-	A
Pleiades Islands	60 30 29	148 01 40	-	S	-
Rocky Bay	60 20 19	147 07 59	-	C	A
Shelter Bay	60 06 31	147 57 42	-	C	A
Sleepy Bay	60 4 01	147 50 11	A	C,S	A
Smith Island	60 31 47	147 20 45	-	C	A
Snug Harbor	60 15 46	147 45 55	-	C,S	A
Storey Island	60 44 13	147 21 20	-	S	-
Windy Bay	60 34 08	145 56 22	-	S	-

Table 2

Location of sites outside Prince William Sound where intertidal and subtidal sediment samples were collected in 1989. Letters in body of table represent depths sampled: C = Intertidal, 3, 6,9 20, 40 and 100 m; S = 100, 200 and 300 m sampled with a manned submersible.

Location	North Latitude o ' "	West Longitude o ' "	Date	Depth Code
Agnes Cove	59 46 00	149 34 24	26 Jul	C
Amakdedori Beach	59 16 30	154 07 48	6 Aug	C
Andreon Bay	58 30 12	152 25 06	9 Aug	C
Black Bay	59 32 07	150 12 17	28 Jul	C
Cape Douglas	58 50 36	153 21 00	15 Aug	C
Cape Kekurnoi	57 43 35	155 13 49	13 Jul	S
Chignik Bay	56 19 36	158 25 06	20 Aug	C
Chiniak Bay	56 19 36	158 25 06	16 Jul	S
Chugach Bay	59 11 12	151 37 48	3 Aug	C
Douglas Beach	59 00 00	153 29 30	7 Aug	C
Fox Island, NE	59 56 12	149 19 00	25 Jul	C
Gore Point	59 14 14	150 58 47	31 Jul	C,S
Halibut Bay	57 21 28	154 45 00	18 Aug	C
Hallo Bay	58 27 29	154 00 14	16 Aug	C
Harbor Island, NE	59 41 31	149 36 24	10 Jul	S
Ivanof Bay	55 50 16	159 23 17	21 Aug	C
Katmai Bay	57 55 00	155 05 00	17 Aug	C
King Cove	58 11 00	152 03 18	14 Aug	C
Kukak Bay	58 18 52	154 04 07	14 Jul	S
Kupreanof Strait	57 52 29	152 20 25	16 Jul	S
Malina Bay	58 13 28	153 04 14	12 Jul	S
McArthur Cove	59 26 36	150 20 30	29 Jul	C
Port Dick	59 17 15	151 08 45	1 Aug	C
Seldovia Bay	59 25 51	151 44 18	4 Aug	C
Shuyak Island	58 38 56	152 17 35	12 Jul	S
Taroka Arm	59 37 32	150 08 18	27 Jul	C
Tonsina Bay	59 18 42	150 55 00	30 Jul	C
Uganik Bay	57 49 57	153 30 33	15 Jul	S
Ursus Cove	59 30 48	153 45 24	5 Aug	C
Ushagat Island	58 56 58	152 17 37	8 Aug	C
Viekoda Bay	57 57 57	153 20 31	15 Jul	S
Wide Bay	57 26 22	156 13 49	19 Aug	C
Windy Bay	59 13 50	151 31 00	2 Aug	C
Zachary Bay	55 19 33	160 36 30	22 Aug	C

TABLE 3. Station names, locations and depths for collection of benthic sediments for hydrocarbon analysis in Prince William Sound.

Name	Latitude	Longitude	Depth
Montague Buoy			
MSX	59.975	147.812	234
Green Island Transect			
GI 1	60.250	147.667	92
GI 2	60.242	147.617	258
GI 3	60.233	147.567	80
GI 4	60.225	147.520	62
GI 6	60.208	147.410	77
GI 7	60.201	147.364	33
Rocky Bay			
RB 2	60.363	147.029	76
ORCA BAY			
OB 1	60.583	146.032	178
OB 6	60.580	146.901	432
CENTRAL BASIN			
CB	60.720	147.045	446
BLIGH ISLAND			
BI	60.836	146.916	103
PORT VALDEZ			
PV 40	61.103	146.476	226
PV 50	61.106	146.596	240
NAKED ISLAND			
NI 4	60.748	147.435	108
ESTHER ISLAND			
EI	60.771	148.056	380
MAIN BAY			
MB	60.567	147.950	586
HERRING BAY			
HB	60.470	147.739	140
KNIGHT ISLAND PASSAGE			
KI 2	60.180	147.890	392
SAWMILL BAY			
SB	60.058	147.966	176

Table 4

Timetable of field sampling, laboratory and data analysis and report writing for the Alaska Department of Environmental Conservation.

ACTIVITY:	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
SUMMER CRUISE DATA REVIEW	/---------/								
SUBTIDAL SED. SAMPLING	/---------/	/---------/	/---------/	/---------/	/---------/				
GRANULOMETRY	/---------/	/---------/	/---------/	/---------/	/---------/				
PHC & PNA ANALYSES	/---------/	/---------/	/---------/	/---------/	/---------/				
TOC ANALYSES	/---------/	/---------/	/---------/	/---------/	/---------/				
REVIEW RESULTS & WRITE REPORTS							/---------/		

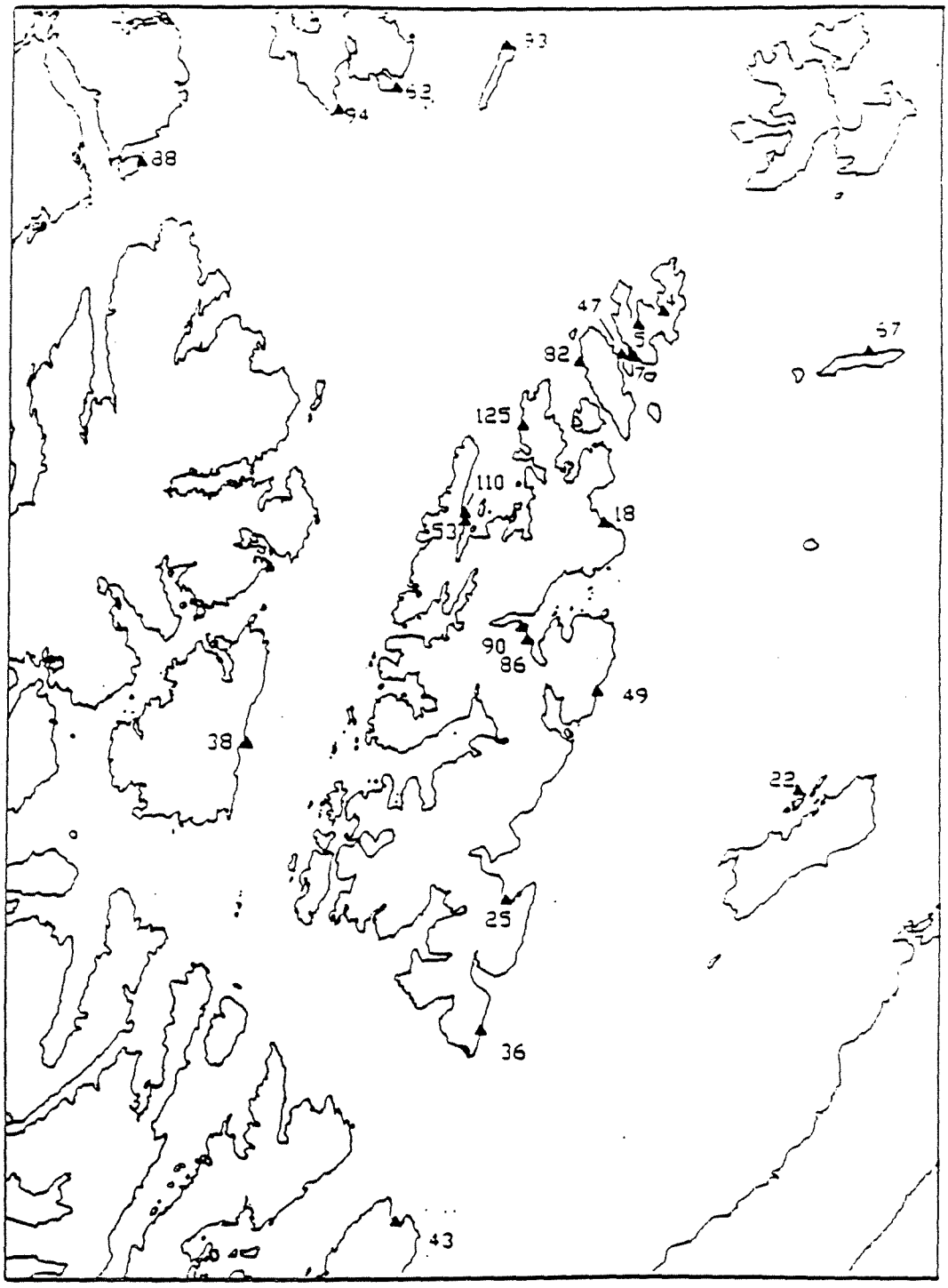

Figure 1. Locations of field stations to be monitored through the winter.

Appendix A.

STANDARD OPERATING PROCEDURES
FOR SAMPLING BENTHIC SEDIMENTS

INTERTIDAL SEDIMENTS

1. Choose an area of intertidal beach having a substrate as homogeneous as possible with particle sizes of 2 mm or less. The area must be large enough to accomodate a 30 m transect. Lay the transect parallel to the water's edge within the designated area.

2. Choose 8 random distances along the transect from a random number table or pocket calculator.

3. Three samples of substrate will be collected at each station (= transect). Each sample will represent a composite of 8 subsamples, each subsample having been taken at one of the 8 randomly selected points. Using a metal core tube and spatula or metal scoop remove approximately 10 g of sediment from the upper 2 cm of substrate at one of the 8 randomly selected points on the transect and place in a properly cleaned 4 oz jar. Repeat the procedure for two more jars collecting 10 g of sediment from adjacent patches of substrate and placing it in each of the two additional jars.

4. Repeat the procedure described in 3 for the 7 remaining points on the transect.

5. At one station per site a sample blank (handled in the same way as the sediment samples except without receiving any sediment) will be taken.

6. Label, seal (with custody control seal) and freeze sediment samples and blank as soon as possible after collection.

7. Proper cleaning procedure for sampling implements and jars.

Sampling implements - All sampling implements will be washed with soap and water, rinsed, dried, rinsed with methylene chloride and if not used immediately wrapped in clean aluminum foil that has been rinsed with methylene chloride. The cleaning procedure will be performed before each transect is sampled.

Jars - If sample jars have not come from the supplier cleaned to EPA specifications they will be baked for four hours at 440°C or rinsed with methylene chloride. Sample jars will have teflon-lined lids rinsed with methylene chloride or will be capped with aluminum foil rinsed with methylene chloride before the lid is replaced after sample collection.

SUBTIDAL SEDIMENTS

Diver collected

Sampling will be conducted as described above for intertidal sediments with the following modifications.

1. Lids will be closed on sample jars on the surface before divers descend to the bottom to prevent contamination by petroleum hydrocarbons floating on the surface of the water.

2. Care must be taken to avoid contamination of dive mitts/gloves with petroleum hydrocarbons.

Remote sampling by van Veen grab.

1. The grab or corer the interior surfaces of which have been cleaned and rinsed with methylene chloride will be lowered to the bottom and activated to enclose a sample of substrate and then retrieved. The surface of the water will be checked visually for sign of contamination by petroleum hydrocarbons (such as an oil sheen) before the grab is lowered or retrieved through it. If any indication of oil is observed the vessel will be moved to a visually clean area.

2. When the grab is brought to the surface and placed on deck after having taken a sample the sample will be subsampled using a stainless steel core tube and spatula. The location of the subsamples will be determined randomly. Four subsamples will be taken from each sample and placed in a 4 oz cleaned jar. Three samples will be taken at each station. Subsamples of different grabs will be placed in separate jars. Samples will be labeled, sealed and frozen as soon as possible after being collected.

3. Sampling implements and jars will be cleaned as described in the section on intertidal sediments above.

SUBMERSIBLE SEDIMENTS

1. Wash 100 micron mesh bags in Alconox detergent and rinse thoroughly in hot water daily.

2. Wash sampling hose with Alconox detergent and rinse thoroughly with hot water daily. (A plastic suction hose was used June 27-July 5, and a teflon suction hose used July 5-July 15.)

3. Wash the stainless steel suction pump daily with methylene chloride.

4. Use sterile gloves to attach and detach sample bags from submersible, and process sediment samples for freezing.

5. Label samples with date, area, method of sampling, name of sampler, depth of sample, and sample number.

APPENDIX B.

SAMPLE COLLECTION PROTOCOL

SUBTIDAL SEDIMENTS TO BE ANALYZED FOR HYDROCARBONS

Prepared by D. G. Shaw
September 11, 1989

Questions about these procedures should be directed to David G. Shaw.

I. COLLECTION APPARATUS

Collection Device Sediment is collected with a HAPS corer (Kanneworff & Nicolaisen, *Ophelia*, 10:119 (1973)) available from the Seward Marine Center, University of Alaska Fairbanks. Before use the corer is inspected to be sure that it is free of oil, grease or other contamination. If contamination is found or suspected, the affected areas are washed with hot water and detergent and rinsed copiously with seawater.

Sample Jars Sediment is typically stored in wide-mouth 8 oz glass bottles (VWR catalog # 16195-088). Bottles are pre-cleaned by ordinary washing (if previously used) and baking at 450° C for at least four hours in air. Lids are lined with either aluminum foil (baked as above) or teflon (soaked in boiling aqua regia) circles cut to fit snugly into the lid. Lids with liners are placed on jars as soon they are cool enough to handle after baking. Adhesive labels are placed on jar lids before going into the field.

Other Materials Large spoon, propane torch, clear tubing (1/4 inch diameter by 24 inches long), Waterproof markers ("Sharpie" or equivalent), field notebook.

II. SAMPLING HANDLING

Sampling Procedure The station name and position are given to the deck officer of the ship. The spoon is pre-cleaned by heating to redness with the torch. Contact of any potentially contaminating object (skin, plastic, ship exhaust, etc.) with the interior of the corer, the inside of the sample jar, or the cleaned spoon must be avoided. On station the HAPS corer is cocked and deployed. Each time the corer enters the water, the water depth is recorded

useable sample is recorded. A useable core is one in which there is more than 10 cm of sediment in the core, the core is not overfilled and there is no indication of washout. For useable samples, overlying water is siphoned out with the plastic tubing. Sediment from the 0 - 2 cm depth interval is transferred from the corer to the jar taking care to avoid any remaining overlying water and to avoid getting sediment on the lip of the jar. The jar is filled with sediment to just below the shoulder (greater filling increases the risk of glass breakage on freezing). On the jar label the following information is recorded: station name, replicate number, date, depth, collector's initials. This information is also recorded in the field notebook. The jar is placed in a freezer at -20° C. At the end of the cruise a copy of the bridge log is obtained to provide a record of the actual position occupied for each named station.

APPENDIX C.

CHAIN OF CUSTODY PROCEDURES

Prepared by D. G. Shaw
September 11, 1989

Chain of Custudy Procedures developed by Alaska Department of Environmental Conservation (attached) are to be read and followed. Any questions should be directed to David G. Shaw. If a question arises at a time when you can't seek advice (probably in the field) use your best judgement and carefully document in writing the procedure followed.

Immediately upon collection, sample containers are sealed with evidence tape in a way that prevents opening without damage to the tape. Next, the sample is recorded in the chain of custody log book and stored is as secure a fashion as field conditions permit. Upon return to the laboratory, the evidence tape is inspected and any defects noted in the log book. Then samples are placed in the locked freezer in Room 133, Irving II Building, UAF. All of these steps must be done by one individual - the person who has custody. If a sample is transfered to another individual (at the same or another location) a Chain of Custody form (also called Request for Laboratory Services, attached) is filled out and signed by both the person relinquishing custody and the person accepting custody. The original form is filed and a copy is given to the person accepting custody.

DRAFT CONFIDENTIAL Enforcement Sensitive

Geographic and Temporal Distribution of Dissolved and Particulate Petroleum Hydrocarbons in the Water Column

Air/Water Study Number 3

Jeffrey W. Short[1] and Jon Lindstrom[2]

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Department of Environmental Conservation
Oil Spill Response Center
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Lead Agencies - National Marine Fisheries Service
Alaska Department of Environmental Conservation

Cost of Proposal - $552.5K

Dates of Study Plan - 31 March, 1989 to February, 1990

	Signature	Date
Principal Investigators:	Jeffrey W. Short	10/10/89
	D. Kilburn for Jon Lindstrom	10/10/89
Organization Leaders:		10/11/89
	Don Easton	10-10-89
Financial Officers:	Carol A. Taylor	10/10/89
	Debi Rawlinson	10/10/89

II. INTRODUCTION

This study will assess the geographic and temporal distribution of dissolved and particulate hydrocarbons in the water column resulting from the Exxon Valdez oil spill. Knowledge of these concentrations will determine whether violations of State of Alaska Water Quality Criteria have occurred, and in addition will allow estimation of the exposure risk of subsurface marine biota to petroleum hydrocarbons.

This study includes and combines programs conducted by ADEC, UAF, NOAA/NMFS, and NPS. Agencies implementation of this study began within one week of the beginning of the Exxon Valdez oil spill, and due to the crisis nature of this event these agencies initially acted independently. This Detailed Study Plan describes efforts of these agencies to make the best use of all relevant samples collected under these circumstances to meet the objectives of this Study, and to minimize duplication of effort. Accordingly, the contribution and budget requirement of each lead agency (ADEC & NOAA/NMFS) and cooperating agency (UAF & NPS) is separately identified within.

The products of this study will consist of estimates of aliphatic and aromatic hydrocarbons in the matrices examined, and of estimates of hydrocarbonoclastic bacterial densities in selected water samples. These data may be used by economists or modelers to determine violations of Water Quality Criteria, to determine biological resource exposure to petroleum hydrocarbons, and to estimate the recovery potential of affected areas through microbial activity.

Restoration of the near surface habitat will occur as dissolved and particulate hydrocarbons are removed from the water column by natural chemical, mechanical and biological processes. Restorative plans suggested by other studies, Air/Water 2 and Coastal Habitat in particular, will have a bearing on the rate of restoration of near surface waters if they reintroduce sediment hydrocarbons into the water column.

III. OBJECTIVES

1. Document water column hydrocarbon concentrations at a range of depths, locations, and times.

Dissolved and particulate hydrocarbon concentrations would be determined in the nearshore and shoreline interstitial water such that the estimate is within 25% of the actual concentrations 95% of the time (ADEC).

Concentrations of petroleum derived hydrocarbons at 1 m and at 5 m depths along the oil spill trajectory within Prince William Sound

will be estimated such that the estimate is within 25% of the actual concentrations 95% of the time during the first six weeks of the oil spill (NOAA/NMFS).

Verify origin of surface crude oil collected outside Prince William Sound along the trajectory of the Exxon Valdez oil spill (NPS).

2. Quantify injury to water resources.

Water quality analyses and particulate hydrocarbon measurements will be used to quantify injury to water resources. The Alaska Administrative Code's Water Quality criteria (18 AAC 70.020, section 2(c)) establish the allowable threshold hydrocarbon concentration in marine waters which determines injury to the water resource, whether nearshore or within the shoreline matrix. Any concentration which is above this threshold value constitutes de facto evidence that water uses protected under regulation have been jeopardized (ADEC).

3. Relate water injury to biological injury.

Water injury will be assessed through comparison of values derived under Objective 1 to the threshold concentrations established for growth and propagation of fish, shellfish and aquatic life according to the Alaska Administrative Code (18 AAC 70.020, section 2(c)).

4. Evaluate trends in ambient water quality using biological indicators (Mytilus and hydrocarbonoclastic bacteria) as surrogates for chemical measurements.

Estimate concentrations of petroleum derived hydrocarbons accumulated by initially hydrocarbon-free bay mussels transplanted for about 1 month to water depths of 1 m, 5 m, and 25 m, along the whole oil spill trajectory such that the estimate is within 25% of the actual concentrations 95% of the time during the first 6 months of the oil spill. Similar estimates will be made for selected intertidal native mussels at shore sites adjacent to transplanted mussel sites (NOAA/NMFS).

5. Identify potential alternative methods and strategies for restoration of injured water resources through assessment of natural microbiological capacity to mineralize petroleum.

RELATIONSHIPS WITH OTHER STUDIES: This study is coordinated with the other Air/Water studies and with the Coastal Habitat study to provide information on petroleum hydrocarbon distribution and movement in the intertidal and nearshore water column.

IV. METHODS

A. ADEC

Preliminary review of petroleum hydrocarbon analyses from water quality samples obtained during summer cruises, in conjunction with the literature (e.g., Berne et al., 1980; Bishop, 1983), suggest that petroleum hydrocarbons which persist in the water column after marine crude oil spills are associated primarily with sediment particles and with runoff from heavily oiled shorelines and intertidal zones. Therefore, this study will focus on areas adjacent to shorelines identified as having been heavily impacted by spilled Exxon Valdez crude and also having the potential for reintroducing oil into the water column. Twenty two sites were selected that represent a spectrum of oiling, treatment and shoreline types found within Prince William Sound (Fig.1)

1. Sample Collection, Labelling and Chain of Custody:

a. For water and particulate hydrocarbon analysis-

Samples collected for hydrocarbon analysis fall into three categories: water collected from the surface adjacent to the target shoreline, water collected from within the shoreline beach matrix, and particulates collected in subtidal sediment traps offshore of the target shorelines. Samples from the water column adjacent to the target shorelines will be collected in triplicate according to established procedures. A field blank will accompany the sampling team at each sampling station to serve as an analysis control.

Water samples from within the shoreline beach matrix will be collected in the following manner. A 30m transect will be established parallel to the tide line in the intertidal zone at low tide. At eight randomly chosen points along this transect, holes in the beach sediment will be dug with a precleaned (dichloromethane) shovel or trowel. The holes will be allowed to fill with interstitial water which will be collected in containers according to established procedures for water sample acquisition for hydrocarbon analysis. Two field blanks will accompany the sampling team to each site.

Subtidal particulate samples for hydrocarbon analysis will be collected in a manner to provide both time-integrated total input, and rate of hydrocarbon input. Sampling platforms containing two sediment traps each will be placed in triplicate in the subtidal zone adjacent to target shorelines at no more than twenty meters depth (below mean lower low water). These platforms will each contain one long-term sediment trap to sample sediments over the course of the study, and one short-term trap to be sampled periodically throughout the study. This will generate information on sedimentation rates and associated hydrocarbon inputs from adjacent beaches, as well as total input to subtidal sediments. Sediment traps will be constructed of polycarbonate and will be precleaned with methylene chloride prior to placement in the subtidal zone. The short-term trap

will be sampled periodically (weather permitting) during the winter and spring. The long-term trap will be sampled at the end of the study. The traps are designed to be removable from the platforms and will serve as sample containers.

Sample labels or Request for Laboratory Services (RLS) forms accompanying the samples will include sample identification number, time and date of sampling, and identify the sampler. Chain of custody procedures are as described later in this study plan (see NOAA Part 1).

b. For microbiological analysis--

Samples for analysis of hydrocarbon degradation activity will be collected from nearshore and shoreline interstitial water at the same sites and time as those for hydrocarbon analysis. Nearshore water column samples will be collected in triplicate in sterile (autoclaved) 125-ml wide-mouth poly bottles. Interstitial water samples will be collected in similar bottles from each of the holes along the shoreline transect. Sediment from the subtidal traps will be removed for microbiological analysis at the end of the study. For analysis of macronutrients essential to microbial growth (i.e., P and N), water samples from these sites will also be taken in clean, phosphate-free glass containers. These samples will be taken in triplicate for nearshore samples and one from each of the shoreline transect sample sites.

2. Analyses:

a. For water and particulate hydrocarbon analysis--

Water and particulate samples obtained in the sampling program will be screened for hydrocarbon content by ultraviolet fluorescence spectrophotometry (ASTM, 1982) after methylene chloride extraction of the samples in the field. UVF is a semiquantitative method of analysis for hydrocarbons. Samples showing significant quantities of petroleum hydrocarbons will be further analyzed for polynuclear aromatic hydrocarbons (PAH) and total petroleum hydrocarbons (PHC) according to procedures established by the analytical chemistry group.

b. For microbiological analysis--

Hydrocarbon-degrading bacteria will be enumerated, and their ability to oxidize selected biologically recalcitrant and environmentally persistent petroleum components (e.g., naphthalene, phenanthrene) at ambient temperatures will be assessed. Additionally, total nitrogen and dissolved inorganic phosphate concentrations in the samples will also be measured by established procedures.

Hydrocarbon degradation potential associated with sediment microbes will be assayed by adding 14C-radiolabelled aliphatic (e.g., hexadecane) and polycyclic aromatic (e.g., naphthalene or phenanthrene) substrates to sediment (and water) samples. Each substrate will be monitored for biological oxidation at 5 degrees C by the evolution of radio-CO2 from the samples after three, seven, 14 and 28 days.

For sediment samples, a total of 50 grams of sediment from each sample will be needed. Each sediment sample assayed for degradation will first be mixed 1:10 (w/w) with sterile marine Bushnell-Haas medium (Difco) in a clean, sterile wide-mouth poly bottle. Water samples will not be diluted.

Ten ml aliquots of water or sediment slurry will then be placed in sterile 40-ml incubation vials (I-Chem Research) fitted with silicone septa. For each substrate, 15 replicate vials will be prepared by adding 10 ppm (ug/ml slurry or water) of the radiolabelled hydrocarbon to be tested. The hydrocarbons will be added in an acetone carrier (Bauer and Capone, 1988). Three vials of each kind of substrate will be used as abiotic controls for each of the degradation incubation periods (i.e., three-, seven-, 14- and 28-day). Biooxidation in the control vials will be stopped by addition of 1 ml 10N NaOH to the samples through the septa. All vials will be placed on a rotatory shaker for 48 hours and then incubated at five degrees C for the rest of the incubation period.

Following incubation of the samples for the desired period, biological activity in the vials will be stopped by addition of one ml 10N NaOH. The extent of hydrocarbon biodegradation will be monitored by measuring the radio-CO2 evolved from the sample in each vial (Foght et al., 1988). After acidification of the vial contents by addition of 1.5 ml concentrated HCl by syringe through the septum, the sample will be purged of radio-CO2 for 15 minutes. The effluent gas will be passed through a toluene reservoir to trap any non-metabolized organics purged from the sample and then through KOH scintillation cocktail to trap the evolved CO2. The mean of the replicate biodegradation samples will be compared to the abiotic controls for that sample to assess for losses due to inefficient trapping of CO2. The extent of biodegradation will be expressed as a percentage of the total radiocarbon added to the sample after correction for abiotic losses.

Samples will be analyzed for the presence of hydrocarbon degrading microorganisms using the Most Probable Number (MPN) technique. While it is generally recognized that no technique to enumerate specific metabolic types of microorganisms in aquatic sediments is perfect, a properly designed MPN will give consistent results that are adequate for comparative purposes to within an order of magnitude of hydrocarbon degraders. Even the more recent metabolic tests such as

assays for mixed function oxygenases must be standardized to some biomass parameter to make the results useful.

We will use the standard "5-tube" MPN (APHA, 1985) as modified for hydrocarbon degrading microorganisms and field laboratory space considerations. Hydrocarbon degrading microorganisms are, for the purposes of this study, defined as those microorganisms capable of growing in a marine minimal salts medium amended with Prudhoe Bay crude oil as a carbon source. Samples will be collected as described above. The general procedure will entail inoculation of five 100 ul aliquots of 1:10, 1:100, 1:1000 and 1:10,000 dilutions (sample w/w into marine minimal salts with vigorous mixing) of each sample into sterile 24-well microtiter plates. Following sample addition, 1.5 ml of sterilized M9 (Miller, 1972) or Bushnell-Haas (Difco Laboratories, Detroit, Michigan); marine mineral salts and one "drop" of sterile Prudhoe Bay crude oil will be added to each well. Each microtiter plate will be covered and incubated at ambient laboratory temperatures for up to six weeks following inoculation. Wells will be scored as positive for growth (turbidity) and oil emulsification.

B. NOAA/NMFS

The NOAA/NMFS portion of this study comprises three parts, identified as parts 1, 2, and 3 below. Part 1 involves direct determination of petroleum hydrocarbons in the water column by chemical analysis, and Part 2 involves indirect determination by measuring the petroleum hydrocarbons accumulated by clean sentinel organisms transplanted to the areas affected by the oil spill. Part 2 gives an indication of biologically available petroleum hydrocarbons. Part 3 describes the collection and storage of surface crude oil samples by the National Park Service (NPS).

The number of sample sites, depths at each site, and replicates at each depth for Parts 1 and 2 are based on the project leaders informed professional opinion. In particular, a replication level of three was chosen as the minimum necessary to determine analyte observation variance.

Part 1.

Sites

Twenty seven sites within the oil spill trajectory and three sites outside the trajectory, as indicated by early maps produced by Air Water Study 1, were selected with emphasis on areas where high hydrocarbon levels might be most damaging, ie. juvenile salmon rearing areas and migration routes. In addition some sites were sampled where oil slicks or mousse were apparent. See figure 1 for site locations and table 1 for details of sampling schedule.

Physical data required at each site were location (geographic

coordinates), site depth, sampling time, tidal stage, and temperature and salinity at sampling depths. Coordinates were determined from the sampling vessel's Loran system and by taking bearings from radar images. Site depth was indicated by the vessel's depth sounder. Tidal stage was estimated from NOAA tide tables (1989). Temperature of seawater sample was measured by a digital thermometer; salinity estimated by using a refractometer, and comparing the sample to a known standard.

Sampling Procedures

Analytes of interest are near surface petroleum derived hydrocarbons, present as oil-water dispersions (OWD), and water soluble fractions (WSF) in the water column. Near-surface seawater samples were collected by pumping seawater through a stainless steel tube into a 2 liter vacuum flask with a peristaltic suction pump. Separate stainless steel tubes were cut to length for 1m and for 5m sampling depths. These tubes were arched at one end so that they could be passed through a rubber stopper fitted to the vacuum flask. The side arm of the flask was connected to the peristaltic pump with silicone pump tubing. The seawater sample contacted only stainless steel or glass during collection, and was not exposed to hydrocarbon vapors.

The end of the stainless steel tube that penetrated the sea surface was protected from surface oil contamination by a 10cm length of tygon tubing, which had been heat sealed on one end to form a cover for the end of the steel tube entering the water. The tube cover had an internal diameter such that the tubing had to be soaked in fresh hot water to allow it to be fitted over the steel tube end. The tube cover was blown off the end of the steel tube with compressed air from a self-contained underwater breathing apparatus (SCUBA) tank after the covered end was lowered to the sampling depth. The SCUBA tank was connected to the above surface end of the steel tube with laboratory vacuum line tubing. Twine was tied to the tygon tube cover prior to submersion to allow recovery of the cover after it was blown off. Tube covers were used only once and were discarded after their recovery.

After a steel tube was in place at sampling depth, the steel tube, the vacuum flask, and the peristaltic pump were connected and about 1.5 l seawater was collected. This seawater was used to rinse a 1 l glass graduated cylinder and three 1 l teflon separatory funnels three times each. The rinses and excess seawater were discarded, and another 1.5 l of seawater was pumped from the sampling depth. Nine hundred ml of this seawater were measured with the graduated cylinder and transferred to a teflon separatory funnel. The 900 ml seawater aliquot was extracted with 50ml dichloromethane for 1 minute and allowed to separate for 1 minute. The dichloromethane was drained into either 25ml liquid scintillation vials with teflon lined lids or 120ml glass jars with teflon lined lids. Both types of containers had been rinsed previously with dichloromethane. The 900ml seawater aliquot was extracted again with 25 ml dichloromethane for 1 minute and allowed

to separate for 1 minute. This extract was then combined with the previous extract. Excess seawater in the flask was discarded. Two additional 1.5 l seawater aliquots were similarly pumped and extracted at the sampling depth.

After the extractions were completed, the separatory funnels, graduated cylinder, and filter flask were each rinsed 3 times with dichloromethane and the sampling steel tube was quickly pulled vertically out of the water so that seawater inside drained as the end of the tube left the sea surface. The steel tube was cleaned with dichloromethane prior to use at another sampling site. Glassware preparation, sample collection and extraction were similar at the second sampling depth at each site. At each site, therefore, triplicate samples were collected at both 1m and 5m depths; in total, approximately 540 dichoromethane extracts were collected on the three sampling cruises. Sample extracts from sites outside the spill trajectory will be used to identify analyte artifacts resulting from the sampling environment.

Sample Labeling

Each sample extract label contains the sampling site latitude and longitude, sampling depth, sampling repetition number, and date. This information was also recorded in a numbered field notebook along with physical site data. Sampling field notes were signed daily, but samples were not because samples were collected before this requirement was stipulated.

Sample Storage in the Field

Immediately after they were collected and labelled, sample extracts were locked in a storage chest and stowed in a section of the vessel hold reserved for that purpose. Access to that area was restricted until the sample extracts were removed from the vessel on return to port.

Chain of Custody

The record of each person who had custody of the sample extracts, together with a list of the particular extracts, and the date, time, location of custodial transfer, and signatures of transferring parties is on file with Mr. Sid Korn at the Auke Bay Laboratory. All sample extract shipping containers were cross-wrapped with tape prior to shipment, and the tape was signed and dated at each of two tape intersections by the person shipping the containers. Samples were shipped to Auke Bay Laboratory where they have been stored in a restricted access freezer at -18 degrees centigrade awaiting analysis.

Field QC

Field QC consisted of collection and storage of the dichloromethane used for extractions, and collection and storage of water samples from sites unaffected by the oil spill during the sampling cruises.

Quality assurance will consist of the demonstration that these samples contain no detectable analytes.

Part 2.

Sites

Twelve sites sampled in Part A were chosen as bay mussel deployment sites. One site, Olsen Bay, was chosen as a control site as it appeared not to have been oiled, based on early Air/Water Study 1 maps. The remainder were chosen for their importance to juvenile salmon. The 16 sites outside of Prince William Sound were selected from sites suggested by US Fish and Wildlife and the National Park Service for high "natural resource value", generally to wildlife. Of the total 28 sites, 6 were unoiled, 8 were oiled, and 14 may have been oiled (oiled beaches were reported in the site area but not directly inshore of the site) as indicated on the most recently available maps produced by Air/Water 1. Local siting ensured a site depth of 34 m to accommodate the deepest mussel cage and the best available protection from weather and currents that could damage the mooring. Sites are listed in table 2 and mapped in figures 1 and 2.

Site geographical location and depth and tidal stage were determined as in Part 1. Salinity and temperature at cage depths were measured using a CTD.

Mussel Collection and Deployment

Bay mussels, Mytilus edulis, were collected from Admiralty Island (58 $^{\circ}$ 18.2'N 134 $^{\circ}$ 48.3'W) in southeast Alaska, a hydrocarbon free site. Successive collections were made a few days before each new deployment cruise. Animals were transported to Auke Bay Lab and held in living stream tanks, that had been rinsed with dichloromethane and flushed with ambient unfiltered seawater at the rate of 2 l/minute at least overnight. Mussels with shell length greater than 45mm were selected for deployment. A sample from each collection of at least 30 individuals was measured for shell length, width, and height and whole wet versus dry weight. A reference sample of another 40-50 animals was taken immediately prior to shipment of mussels to a deployment vessel.

For shipment to the field, mussels were layered with healthy Fucus in insulated coolers whose lids had been drilled with air holes. "Blue ice", double-wrapped to contain possible leaks, kept mussels cool despite air holes in cooler lids. Mussels were kept aboard the deployment/collection vessel in coolers and the blue ice

changed daily for up to 9 days. After 9 days, mortality increased greatly. On longer cruises that could not be resupplied with mussels by air, mussels were irrigated with the vessel's seawater. Samples of irrigation water were taken daily, following water sampling described above, and a mussel baseline sample was taken before deployment of irrigated mussels at each new site.

Deployment "cages" were nylon mesh diver collecting bags held open by a perforated polypropylene sheet that had been rinsed with dichloromethane and fitted into the bag bottom. Twenty mussels were placed in each bag. Assuming some mortality during exposure, this number was chosen to provide at least triplicate samples of 3 +or- .5g of tissue for hydrocarbon analysis (Krahn et al 1988). In the last round of deployment, 40 mussels were placed in the 1 m bag at half of the sites, to provide a field replicate. Filled bags were closed and attached to the mooring line with a stainless steel or galvanized standard halibut snap. At each site, bags were attached at the 1 m, 5 m, and 25 m depths. High mortality among mussels held aboard ship made it necessary to deploy only the 2 shallower bags with 15 mussels per bag at some Alaska Peninsula sites. Moorings are detailed in figure 3.

Exposed Mussel Collection

Exposure times, determined largely by the availability of a vessel to collect exposed mussels and deploy new animals, ranged from 2 to 8 weeks (see table 2).

When exposed mussels were retrieved the number of clumps of mussels, the number of individuals per clump, comments re the strength and elasticity of byssal threads, the and the number of alive, dead, or gaping animals were recorded to provide some indication of stress produced by the exposure environment and pre-exposure handling. Dead or gaping animals were discarded. At least 1 16oz jar (2 if sample was to be replicated in the field) was filled with live animals from each bag, kept in a cooler, and frozen at -18 $^{\circ}$C as soon as possible. A field air blank was taken at the site and on the vessel, if sample jars were filled aboard the vessel. Jar specifications were similar to those for water samples. Bags were refilled and redeployed. Reference samples of mussels were taken just after the final deployment on a cruise to determine any hydrocarbon uptake or deterioration of general condition during holding of mussels on the vessel.

Native Mussel Collection

Native mussels were collected at 12 sites in intertidal areas adjacent to deployment sites, packed in clean 16oz jars and handled similarly to caged mussel samples.

Sample Inventory

In total, approximately 320 caged exposed mussel samples, 27 native

mussel samples, 70 reference samples, and 37 air blanks were collected.

Sample Labeling

Sample Labels included site name, type of sample, Julian date of sampling, sample depth (if applicable), and replicate number. Samples collected on the last 2 cruises were signed and dated by the collector.

Chain of Custody

Chain of custody procedures followed were those described in Part 1.

Field QC

Field QC consists of the collection and storage of mussels just prior to deployment, of mussels remaining after cruise deployments are completed, and of mussels deployed at sites unaffected by the oil spill. Quality assurance will consist of the demonstration that these mussels contain no detectable analytes.

Part 3. (NPS)

Sample Sites:	Kenai Fjord National Park	=	45 samples
	Katmai National Park	=	55
	Aniakchak National Monument	=	6
	Total Surface Oil Samples	=	106

Sample Collection: U. S. Coast Guard (USCG) issued glass jars with teflon-lined lids; collection according to USCG instructions provided with sample bottles, including collection with wooden tongue-depressors provided with sample jars.

Replicates: In field - 1 to 2 samples per site
In lab - standard USCG procedure

Sample Labeling: Chain of custody number, date, location, collector's name; all samples entered on chain of custody form; photographs taken of sample collection.

Chain of Custody Procedure: Standard NPS chain of custody procedure for law enforcement cases.

Chain of Custody Officer: Chief McKitrick, USCG, Groton, Conn. has custody of 96 oil samples. Scott Taylor, NPS Tort Investigation Coordinator, has custody of 10 oiled beach rock samples.

Present location of samples: 96 oil samples at USCG Oil

Identification Laboratory, Groton, Conn.

10 oiled beach rock samples: NPS Oil Spill Incident warehouse, Anchorage, Alaska.

V. DATA ANALYSIS

A. ADEC

Hydrocarbon concentration data will be tested for heteroscedasticity (Bartlett's test) and reported as means and 95% confidence intervals calculated according to a standard formula (Sokal and Rohlf, 1981). Parametric statistics will be used to test for differences between hydrocarbon concentrations between sites, if the assumptions of parametric procedures are met. Otherwise, nonparametric tests (e.g., the Kruskal-Wallis test) will be employed.

Microbiological enumeration data will be reported as means and 95% confidence intervals (Sokal and Rohlf, 1981).

B. NOAA/NMFS

Analysis of variance will be used to determine the significance of differences of any hydrocarbons found in the collected samples.

Products of this study will consist of tables containing lists of hydrocarbons found in the samples collected.

Standard USCG oil identification methods will be used to verify the origin of crude oil collected by NPS.

VI. SCHEDULES & PLANNING

A. ADEC

AIR/WATER STUDY #3 TIME SCHEDULE

ACTIVITY:	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
SUMMER CRUISE DATA REVIEW	/---------/								
SAMPLE COLLECT. Surface & Interst. water	/---------/	/---------/	/---------/	/---------/	/---------/	/---------/			
Subtidal part.	/---------/	/---------/	/---------/	/---------/	/---------/	/---------/			
ANALYSES Subtidal Part.		/---------/	/---------/	/---------/	/---------/	/---------/	/---------/		
Bacterial Cnts.		/---------/	/---------/	/---------/	/---------/	/---------/	/---------/		
Total N & DIP		/---------/	/---------/	/---------/	/---------/	/---------/	/---------/		
REVIEW RESULTS & WRITE REPORTS							/---------/	/---------/	/---------/

B. NOAA/NMFS

Parts 1 and 2

Sample collection for this study is complete. Collection of water samples began March 31, 1989; subsequent cruises began April 4 and May 1 ,1989. Mussels were deployed on the May trip and again in late May, June, July, and August. Final collections of mussels were completed by September 10, 1989. A final report will be submitted within three months of receipt of final results from chemical analysis. No quarterly reports will be submitted, however a special report containing the results of preliminary chemical analyses of the water samples that have already been performed at ABL will be submitted at the request of the management team.

All samples are retained at Auke Bay Laboratory in a restricted access freezer by Mr. Sid Korn until instructed otherwise by the Trustees. All field data sheets, notebooks, quality assurance plans, computer files, photographs, and project related reports are retained by the project leader at Auke Bay Laboratory.

This project will be managed by Jeffrey Short, Research Chemist, (907) 789-6065, who is authorized to conduct negotiations. Other participants include Patricia Rounds, Julie Sharp-Dahl, Terry Stinnett, and Tony Chan, who are staff at ABL, and who participated in sample collection. Patricia Rounds will also participate in report preparation.

Logistics requirements included vessel charters, air charters, and base operations in Cordova.

Part 3.

All sample collection is complete. Present location of samples is given above. A final report for this portion of the study will be prepared by NPS on receipt of oil ID results.

VII. BUDGET

A. ADEC

Salaries	$ 50.0
Travel	10.0
Contracts	130.0
Supplies	10.0
Equipment	10.0
TOTAL	$210.0

B. NOAA/NMFS

Salaries	$ 65.0
Travel	11.5
Contracts	231.0
Supplies	20.0
Equipment	15.0
TOTAL	342.5*

* Includes $62.5 contract to NPS

Project Leader Qualifications

Jeffrey Short has conducted research on the effects of Alaskan crude oil on aquatic fauna at ABL for over 10 years, and has authored several peer-reviewed publications on this subject. In particular, he had

primary responsibility for the chemical analysis of petroleum hydrocarbons in seawater and accumulated by exposed animals during his tenure at ABL.

Jon Lindstrom has conducted research on microbial degradation of toxic petroleum hydrocarbons. In addition, he has performed analyses on petroleum by capillary gas chromatography and had extensive experience in hydrocarbon-degrading microbial enumeration while a research associate at the University of Alaska.

VIII. CITATIONS

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Table 1. Air/ Water 3 near surface water chemistry sampling sites and schedule. Coordinates are expressed as degrees.minutes.seconds

SITE	LAT	LONG	SAMPLE DATES 1989		
Olsen B.	60.43.13	146.13.45	4/1	4/12	5/5
Gravina P.	60.63.31	146.18.11	3/31	4/12	
Snug Gorner C.	60.44.42	146.41.41	4/1	4/12	5/2
Rocky B.	60.20.19	147.06.05	4/3		5/3
P. Chalmers	60.15.24	147.13.30	4/3	4/15	5/8
E.Naked I.	60.39.22	147.13.34	4/1	4/12	5/3
S.Smith I.	60.31.07	147.21.20	4/4	4/15	5/5
McPherson Psg.	60.39.43	147.22.53	4/1	4/12	5/3
S.Green I.	60.14.59	147.23.24	4/3	4/15	5/8
N.Smith I.	60.31.09	147.24.06	4/4	4/15	5/5
N.Green I.	60.16.25	147.25.00	4/3	4/15	5/8
SW. Montague I.	60.06.07	147.26.13	4/3	4/15	
Cabin B.	60.39.52	147.26.50	4/1	4/12	5/3
Montague Str.B.ofIsles	60.23.52	147.30.08	4/4	4/15	5/8
M.Montague Str.	60.10.22	147.33.09	4/3	4/15	5/8
SE.Eleanor I.	60.32.07	147.34.03	4/4	4/15	5/5
Outside B.	60.40.22	147.34.52		4/12	5/3
Northwest B.	60.33.06	147.37.06	4/1	4/13	5/6
B. of Isles	60.23.14	147.37.44	4/4		5/8
S.Montague Str.	60.04.35	147.40.48	4/3	4/15	5/7
Snug H.	60.14.27	147.42.58	4/3	4/15	5/7
Herring B.	60.29.07	147.43.30	4/2	4/13	5/6
Sleepy B.	60.05.00	147.50.38	4/3	4/14	
Shelter B.	60.07.38	147.55.01	4/2	4/14	5/6
Squire I.	60.13.56	147.57.10	4/2	4/13	5/6
Granite B.	60.24.53	147.57.23	4/2	4/13	5/6
Eshamay B.	60.27.54	147.57.59	4/2	4/13	5/6
Johnson C.	60.03.72	147.58.66			5/7
Sawmill B.	60.03.33	148.00.09	4/2	4/14	

Table 2. Air/Water 3 Mussel Deployment Site and Schedules

Coordinates: degrees, minutes, decimal minutes

* Indicates a new deployment, original mooring lost
-- indicates mooring lost or pulled intentionally and not replaced

PRINCE WILLIAM SOUND

Site	Coordinates				Deploy Date	Service Dates '89			
Olsen B.	60 43.8	N	146 13.2	W	5/8	5/30	7/8	8/5	9/5
Snug H.	60 15.32	N	147 44.05	W	5/7	5/30	7/10	8/4	--
N. Smith I.	60 31.94	N	147 21.4	W	5/5	6/1	7/8	8/5	--
Outside B.	60 38.49	N	147 28.70	W	5/8	6/1	7/8	8/3	--
Herring B.	60 29.39	N	147 43.55	W	5/6	6/1	7/8*	8/3	9/6
Main B.	60 32.62	N	148 04.08	W	5/6	6/1	7/9	8/3	9/10
Elrington Psg.	59 58.3	N	148 07.0	W	5/7	6/2	7/10	8/4	9/8
Squire I.	60 14.33	N	147 56.65	W	5/6	6/1	7/9	8/3	9/8
Needle	60 07.05	N	147 34.35	W	5/7	6/1	7/11*	8/4	9/9
Johnson C.	60 03.72	N	147 58.66	W	5/7	6/3	7/10	8/4	9/9
P. Wales Psg.	60 04.86	N	148 04.40	W	5/7	6/3	7/10	8/4	9/8
Bainbridge Psg.	60 08.67	N	148 05.57	W	5/6	6/3	7/9	8/3	9/8

KENAI, AFOGNAK, KODIAK, ALASKA PENNINSULA

Sunny C.,Fox I.	59 54.85	N	149 20.5	W	6/6	7/24	9/8		
Black B.	59 32.38	N	150 12.9	W	6/6	7/28	9/7		
Tonsina B.	59 18.71	N	150 54.6	W	6/8	8/1	9/7		
W. Port Dick	59 17.1	N	151 08.29	W	6/8	7/30	9/4		
P. Chatham	59 12.89	N	151 45.65	W	6/8	8/3	9/1		
P. Graham	59 21.7	N	151 51.7	W	6/8	8/4*	9/1		
Kamishak B.	59 00.6	N	153 24.6	W	6/13	--	--		
Discoverer B.	58 20.9	N	152 23.0	W	6/15	8/9	8/31		
Blue Fox B.	58 27.2	N	152 40.5	W	6/16	8/9	8/31		
Raspberry Str.	58 02.7	N	153 02.5	W	6/16	--	8/29		
Devil's C.,Kukak	58 21.09	N	154 11.20	W	6/17	8/16	8/30		
Hallo B.	58 28.4	N	154 01.9	W	6/18	8/16	8/30		
Puale B.	57 42.5	N	155 25.7	W	6/18	--	--		
Chignik	56 18.33	N	158 24.28	W	6/20	8/20	--		
Balboa B.	55 33.6	N	160 35.4	W	6/21	8/22	--		
Kodiak	57 45.81	N	152 22.12	W	6/23	--	--		

Figure 1.
Water sampling and bay mussel deployment sites Prince William Soun

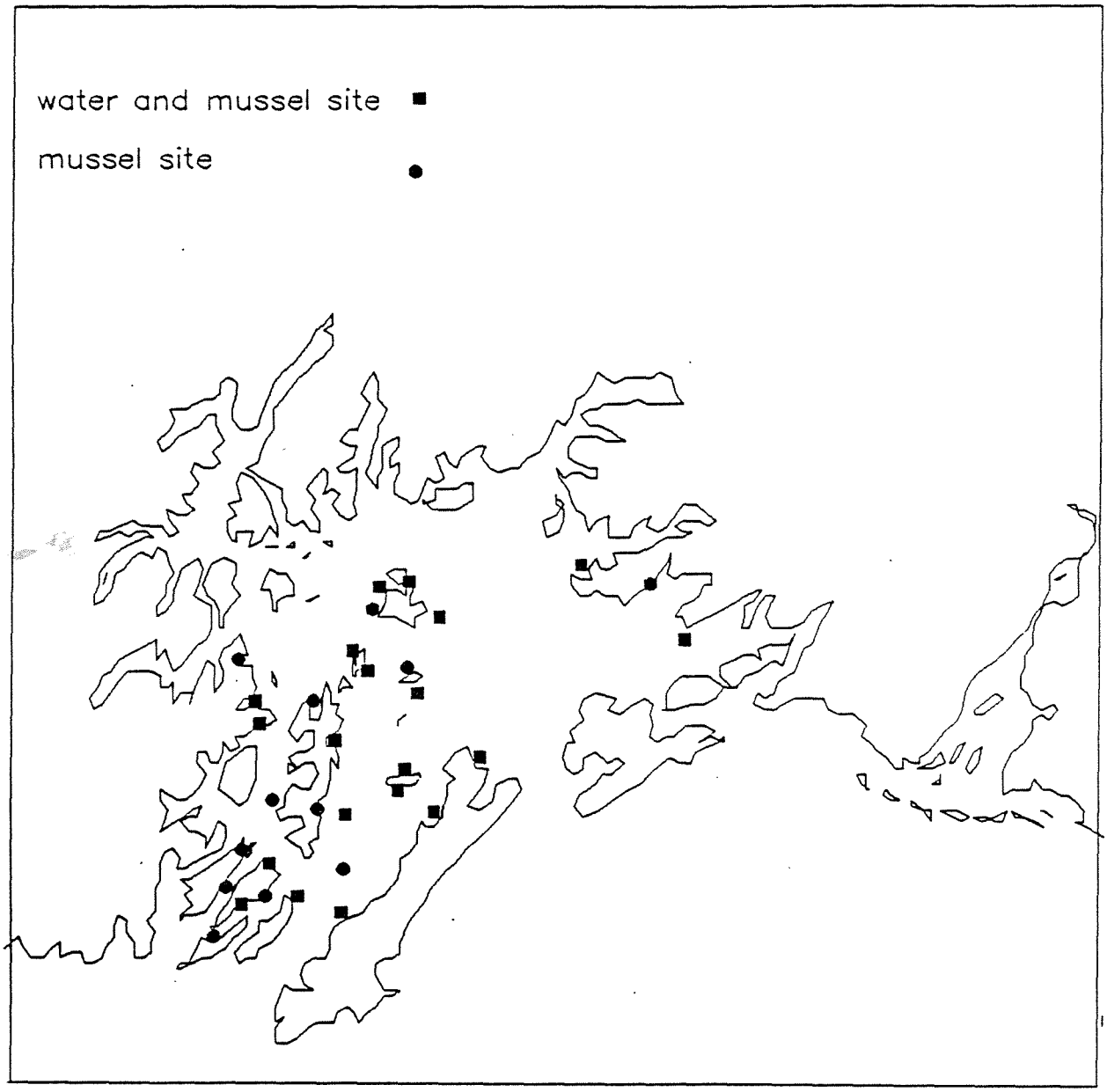
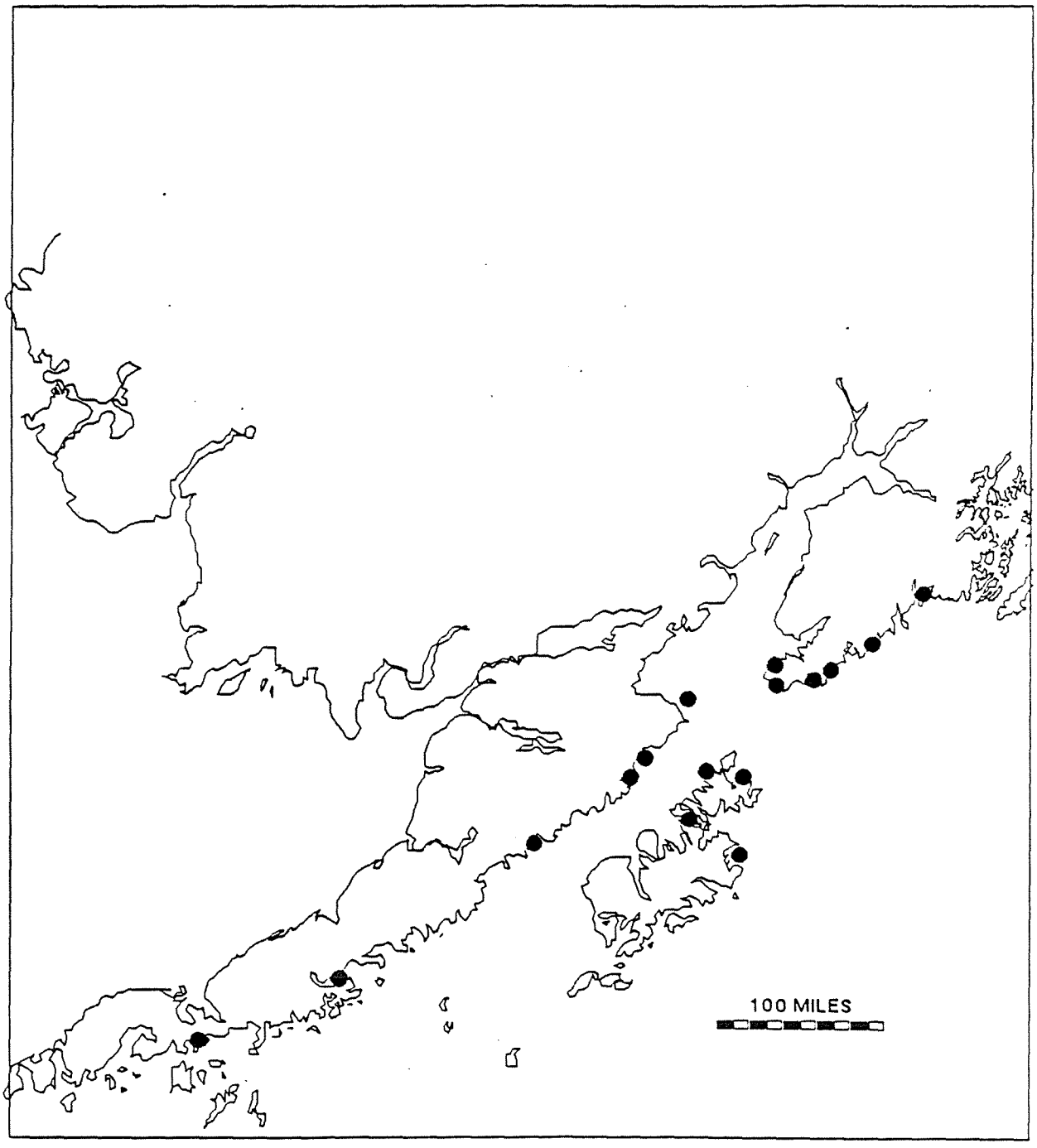


Figure 2. Bay mussel deployment sites Kenai Penninsula Alaska Penninsula, Afognak Island, Kodiak Island



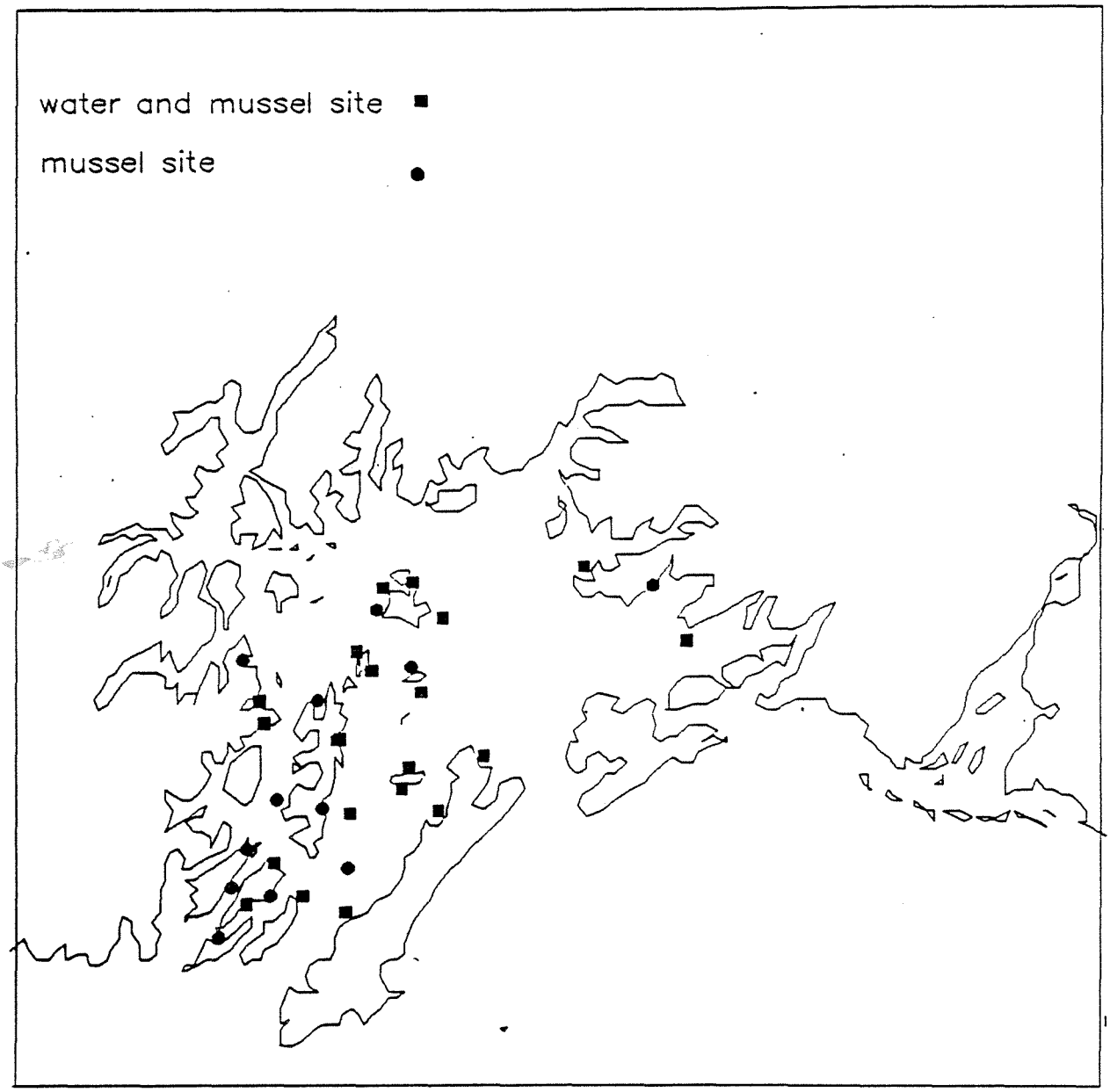


Figure 1.
Water sampling and bay mussel deployment sites Prince William Sound

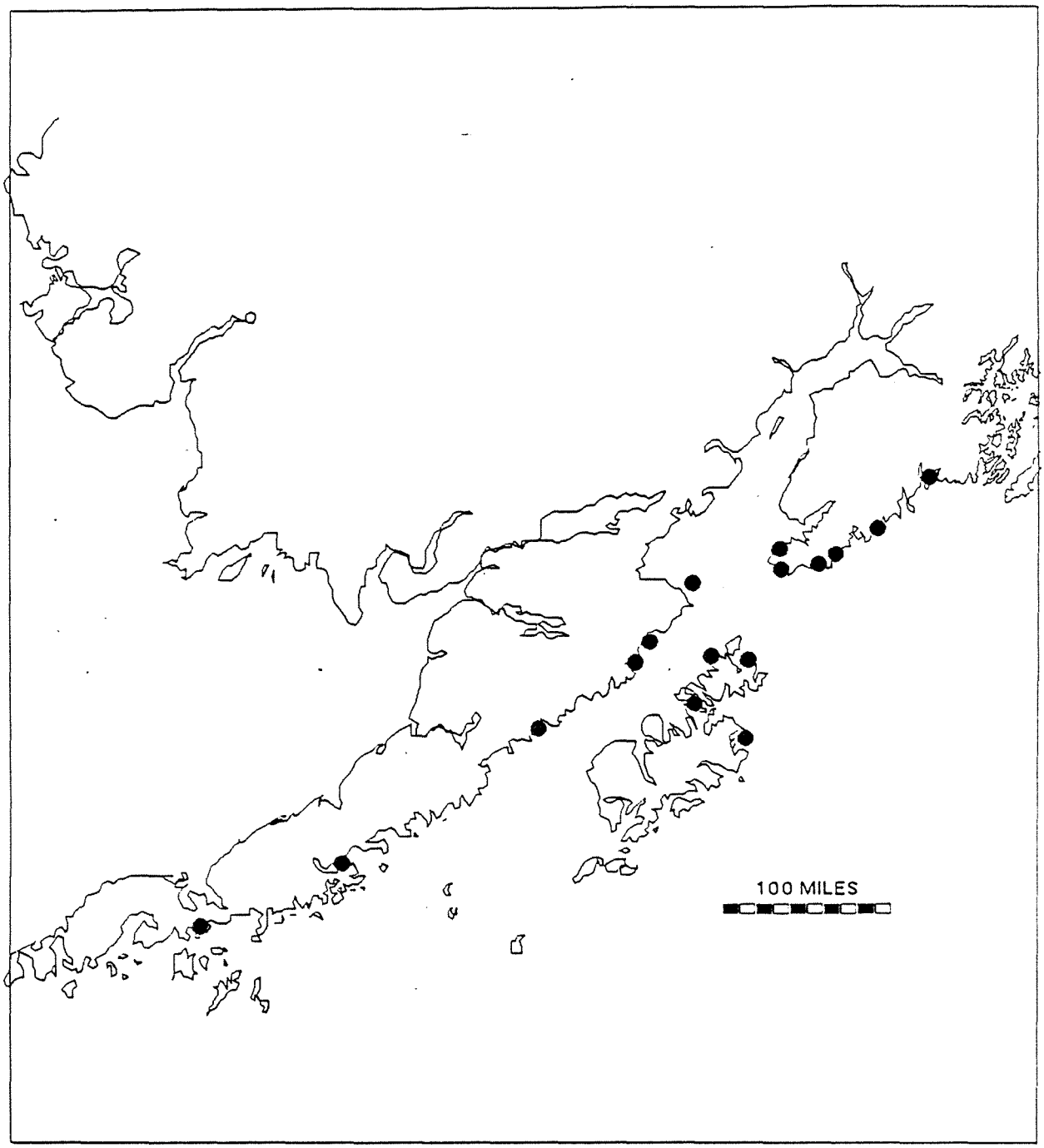


Figure 2. Bay mussel deployment sites Kenai Penninsula Alaska Penninsula, Afognak Island, Kodiak Island

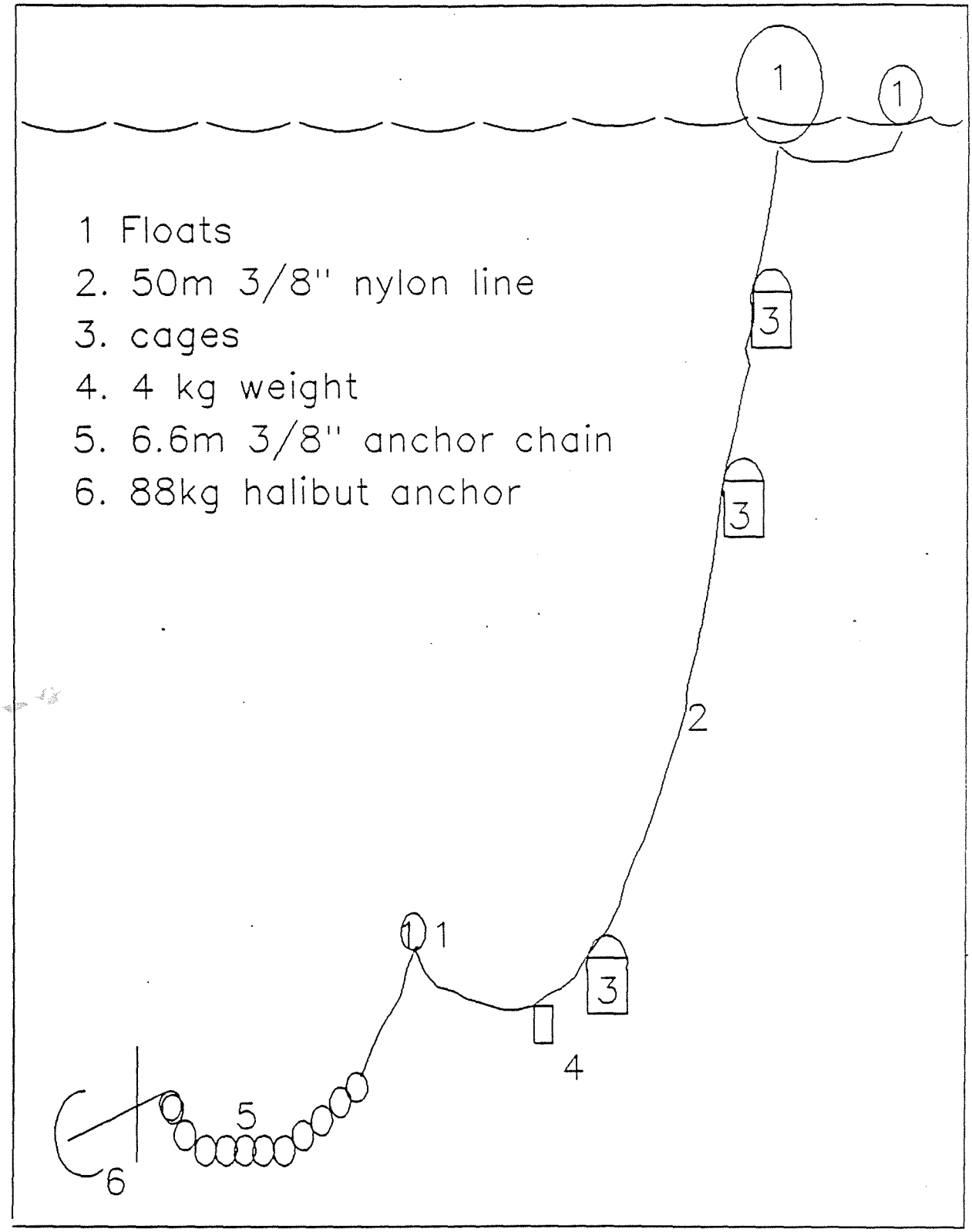


Figure 3. Typical mussel mooring

Air / Water No. 4 not available for printing.

To be published later.

CONFIDENTIAL

STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT
DETAILED STUDY PLAN

Project Title:	Injury to the Air Resource from the Release of Oil - Generated Volatile Organic Compounds
Study ID Number:	Air/Water Study Number 5
Lead Agency:	State of Alaska, Department of Environmental Conservation, Air Quality
Cooperating Agencies:	Federal: USFS, USF&WS, NOAA State: ADF&G, DNR
Principle Investigator:	Gerald A. Guay, Environmental Engineer
Date Submitted:	October 5, 1989

	Signature	Date
Principle Investigator:	Gerald a Guay	5 Oct 89
Supervisor:	Jon Chapple	10/6/89
OSIAR Senior Biometrician:		
OSIAR Program Manager:		
OSIAR Director:		

Study Title:

Injury to the Air Resource from the Release of Oil - Generated Volatile Organic Compounds.

Introduction:

During the early stages of the T/V Exxon Valdez oil spill, large quantities of volatile organic hydrocarbon (VOCs) were released into the atmosphere over Prince William Sound, Alaska. Because of the magnitude of these emissions, thousands of marine and land mammals, birds and plants may have suffered irreversible lung and vascular damage or death. The intent of this study is to reconstruct VOC emissions (primarily benzene, toluene, ethylbenzene, and xylene) during the actual spill period and then describe, through dispersion modeling, the VOC concentration gradients which resulted. Environmental impact will be evaluated through comparison with literature results from toxic risk assessment research on plants and animals.

Objectives:

A. Model loss rate of VOCs from crude oil.

B. Model the ambient VOC concentration as a function of time and distance from Bligh Reef.

C. Establish "zones of concentration" from predicted VOC concentration isopleths for levels of health-related injury

D. Evaluate "zone of concentration" for risk assessment impacts on the environment.

Note: Objective A has been modified to reflect that the loss rate of VOCs determined by this study will not be instrumental in the calculation of the spill hydrocarbon mass balance. Data from any official mass balance accounting process will be used as the basis for our modeling emissions. In addition, the only viable method for verifying the ambient air quality model results would have been through the use of actual monitoring data which was not collected during the spill.

Objective B has been changed to de-emphasize the impact on humans.

Methodology/Data Analysis:

The focus of this study is to conduct air quality dispersion modeling to identify pollutant concentrations at specific points and times in Prince William Sound. The actual scope of work will be accomplished by a consultant under contract to the Department of Environmental Conservation. Because this study is based on a modeling exercise, no field data collection will be accomplished. Data required for the dispersion modeling already exists and will be compiled by the Department's contractor. The following types of data (as a minimum) will be reviewed for input into the modeling database:

a. Amount of oil released into the environment from the T/V Exxon Valdez oil spill to include rate of release on a daily or hourly basis, if available.

b. Meteorological data for the North Gulf Coast and Prince William Sound during the period March 22, 1989, through April 15, 1989. Database should include all National Weather Service observations and forecasts, ship observations, any spill response specialty forecasts, and any unofficial/AMOS observations.

c. Oceanographic data for the period listed in "b" above.

d. The results of Air/Water Study #1 identifying location of the oil on any given day.

e. Any Situation Report data which identifies oil location, condition, and depth.

The contractor will compile and evaluate all of this data as part of the process for developing a modeling database. One potential source of delay may be the Weather Service data which is archived at the National Climatic Data Center in Ashville, North Carolina. The process of archival conversion to a modeling format takes time and may not have been completed yet.

Once the database has been assimilated, the contractor will run the appropriate dispersion model(s) to develop a VOC emission factor (on a surface area and/or volume basis as available). This emission factor will require time integration to best approximate the concentration and rate of change of concentration over the period of interest. The "emission factor" function will be used to produce daily VOC concentration isopleths. These exposures will be compared with toxicological research literature results to evaluate the impact on the plant and animal life. Risk Assessment evaluations will be conducted for impacted mammal and bird species for which dose response data is available.

Schedules and Reports:

The Department desires to contract out the work on this project. First priority will be given to hiring a temporary Intergovernmental Personnel Assignment (IPA) position from EPA to assist in the contract management. Two schedules have been established to reflect the different management schemes:

1) **IPA Management:**

Hire an IPA position	01 November
RFP development	15 November
RFP to Dept of Admin. for advertising	20 November
Initial study report	21 December
Select contractor	08 January
Preliminary Status Report	21 March
Final Report	21 May

2) **DEC Management:**

RFP development	17 November
RFP to Dept of Admin. for advertising	22 November
Initial study report	21 December
Select contractor	15 January
Preliminary status report	30 March
Final Report	01 June

Because this contract will be for more than $25,000, it will be issued bt the Division of General Services and Supply, Department of Administration. This normally adds two to four weeks to the contractor selection process. I have built in two weeks, hoping for a quick turnaround.

Project Budget:

Alaska Department of Environmental Conservation

Salaries	$22.15
Travel	7.5
Contracts	75.0
Supplies	1.5
Equipment	0.0
TOTAL	**$ 106.5**