19.11.02 (6 of 12)

Book on EVOS science for general readers

Project Number:	02570
Restoration Category:	Public Information
Proposer:	Shana Loshbaugh
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	no
Duration:	1st year, 1-year project
Cost FY02:	$43,900
Cost FY03:	none
Geographic Area:	Prince William Sound, Kenai Peninsula, Anchorage and Fairbanks
Injured Resource/Service:	Lost and reduced human services (indirectly)

ABSTRACT

The project will produce a publication-ready, book-length manuscript about the scientific and restoration projects following the EVOS. Written for the intelligent lay reader, it will emphasize the cutting-edge quality, adventurous experiences, ethical issues and lucid, non-technical explanations of findings. Based on interviews, symposium presentations and review of the technical literature, it will include discussions of scientists' personal motivations, partnerships between Western and indigenous knowledge systems, legal entanglements, technical advances, the interdisciplinary ecosystem approach and the implications both process and findings hold for future research design, science in the public arena, and the environment.

INTRODUCTION

The project being proposed is the research and writing of a manuscript to bring the scientific results and restoration efforts of EVOS Trustee Council to a broader audience beyond the circle of scientists and resource managers.

The proposal is new.

It is linked to all the projects that have gone before, in that it synthesizes their results and presents them to the public in a new -- hopefully appealing and enduring -- form. Its source materials will be reports on other projects, publications in the peer-reviewed scientific literature, interviews with investigators and regional stakeholders, and the presentations at the 1993 and 1999 symposia.

NEED FOR THE PROJECT

A. Statement of Problem

Professionals involved in the restoration process have expressed concern that the significance of their findings has only reached a small audience.

At the end of *Legacy of an Oil Spill,* the 1999 symposium commemorating the 10th anniversary of the *Exxon Valdez* oil spill, EVOS Trustee Council Director Molly McCammon addressed a conference room filled with scientists.

"There is still a disconnect between the scientists and the public," she said.

Scientist Charles "Pete" Peterson urged those present to bring the cutting-edge research and its findings' implications to a broader audience.

"We know about it," he said. "We've seen it here. Now we need to make sure it leaves this room."

The majority of findings from restoration projects have been published in technical periodicals or reports that are not readily accessible to the general reader. Popular publications (such as newspapers and magazines), with the notable exceptions of the "Restoration Notebook" and "Alaska Coastal Currents" series, have provided limited coverage on the major findings, technical advances and implications from EVOS-related science.

B. Rationale/Link to Restoration

This book would enhance the value of all the other restoration and research that preceded it. Disseminating results of the entire decade's work to a wider audience would have advantages including (but not limited to):

- Helping people in the spill area and other concerned citizens understand and feel connected to what happened in 1989 and is happening now;

- Dispelling myths that science is a dull and detached pursuit;
- Moving the general public toward a more sophisticated understanding of environmental problems;
- Inspiring educators and students, especially in Alaska, to examine vital, contemporary science; and
- Building a constituency that appreciates the relevance, stature and attraction of this type of scientific endeavor.

A book for general readers would find a place in public library shelves, offices, homes and classrooms. Motivated students, concerned residents, elected officials and researchers from other disciplines easily could pick it up and come away with insight into why the EVOS Trustee Council's projects have been significant.

By including the human drama and wilderness adventure involved with the efforts, the book will remain relevant and interesting long after more technical publications become dated.

C. Location

Most of the project's work would consist of reading and writing -- portable pursuits that can be done nearly anywhere. I intend to do most of this book project out of my home office in Kasilof.

To enhance accuracy and impact, some excursions to field and research sites in the spill area are necessary. These will be arranged with scientists being interviewed.

Library research and interviews also will necessitate infrequent trips to Anchorage and Fairbanks.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

People from affected communities will be included in the interview process.

The partnership developed between scientists and Native villagers to assist each other in understanding spill effects is one major topic to be included in the book.

Communicating findings and other project information to local communities in non-technical language is the main point of this entire project.

PROJECT DESIGN

A. Objectives

1. Produce a manuscript of 200 to 400 pages by the report deadline ready for publication.

2. Arrange for a publisher to print and distribute the work.

B. Methods

The project would consist of three major phases: research, writing and marketing.

The research phase would begin with a thorough reading of final project reports, symposium proceedings and review publications from EVOS Trustee Council and Exxon science projects. It would continue with interviews of people affected by the spill or involved in damage assessment or restoration research. The interviews would include discussions about attitudes toward the spill and the scientific work it generated; evaluation of findings investigators consider most significant; their impressions of the overall course of the restoration project; memorable experiences they encountered in the course of their work and their concerns about the future of Alaska's coastal areas, ecological research, and the environment. The research phase also would include reading of selected articles from the EVOS technical literature and study of how other popular books on science present their subject matter.

The writing phase would overlap the research. It begins with a general outline (see preliminary outline appended to this proposal) and detailed field and interview notes. Sections would be roughed out, then combined into a whole. Along the way, arrangements would be made for photographic and graphic illustrations. The draft text would be subjected to several revisions, including review by interview subjects, people knowledgeable about the history of the EVOS Trustee Council restoration efforts and professional editors.

The third phase would involve locating a publisher to print and distribute the completed book. (See below.)

C. Cooperating Agencies, Contracts and Other Agency Assistance

This project is, by its nature, inclusive and independent. No agency involvement -- in the conventional sense -- is needed.

However, publication requires assistance. To that end, I already contacted the University of Alaska Press, which expressed tentative interest.

SCHEDULE

A. Measurable Project Tasks for FY02 (October 1, 2001 - September 30, 2002)

October 1 - December 31:	Complete identification of source literature; complete review of half of basic review literature; identify preliminary interview list and complete intermediate outline.
January 14-23 (2 days):	Attend Annual Restoration Workshop
January 1 - March 31:	Complete basic literature review; complete first round of interviews; complete chapter outlines; identify potential illustrations

	and begin drafting text based on literature review and preliminary interviews.
March 10 - 31:	Complete and submit book proposal.
April 1 - June 30:	Conduct secondary interviews and secondary literature search; arrange summer field visits; complete detailed outline; complete bulk of rough draft and revise early sections.
July 1 - August 30:	Conduct summer field visits and final interviews; complete rough draft and preliminary revisions.
September 1-30:	Undergo peer review of text sections and professional editorial review of draft; complete revisions of manuscript

B. Project Milestones and Endpoints

March 31:	Submit book proposal to potential publisher
September 30:	Submit manuscript to potential publisher

C. Completion Date

The manuscript will be completed at the end of FY01. Actual publication date will be determined by the publisher. Some revision will be undertaken in FY02 in collaboration with the publisher.

PUBLICATIONS AND REPORTS

Submit a book, tentatively titled ***E.V.O.S.: the Alaska Oil Spill and the Frontiers of Environmental Science***, to the University of Alaska Press by September 30, 2001.

Other publications, based on excerpts of the book, may be submitted to mass market Alaska newspapers or magazines during the year of the project. Brief excerpts from the book will be available for posting on Internet sites describing EVOS Trustee Council restoration projects.

The annual report, to be completed by April 15, 2002, will include information about the completed manuscript and its status on the road to publication.

PROFESSIONAL CONFERENCES

Presenting this type of project at professional conferences is not appropriate. However, I may attend conferences on an *ad hoc* basis as an observer and distribute fliers describing the forthcoming book to conference participants.

NORMAL AGENCY MANAGEMENT

Not applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will integrate with nearly all other restoration efforts from an observer's point of view. The starting point will be meeting with Trustee Council staff and the Chief Scientist for recommendations and an overview of the entire research effort.

The interview phase and secondary literature search will require cooperation with individual investigators, including visits to laboratories and field sites for first-hand information about the day-to-day realities of their work. Interview subjects and leaders of major restoration projects will have opportunities to review sections of the draft manuscript referring to their own work.

The publication of the completed manuscript requires involvement of a publisher. The University of Alaska Press seems most appropriate for this task. They cannot commit to the publication until they see a detailed proposal; I cannot give them a detailed proposal until I have secured funding for the research and writing phase.

Following is the text of an e-mail from the press dated March 20, 2000:

> *Dear Ms. Loshbaugh:*
>
> *A book on the results of scientific research on the effects of the Exxon Valdez oil spill sounds like a worthy project, and one we would be pleased to consider. With more information at this development stage, the Press could lend its support in the form of a letter expressing interest; we could not enter into an agreement to publish a work without more about the book, a prospectus that includes an overview of the book's subject, contents, length, photographs, other illustrations, chapter by chapter narrative outline, potential audience and market for the book, and author's CV. A final decision by our editorial board is based on peer review of a complete*
> *manuscript.*
>
> *I shared your letter with our managing editor Carla Helfferich. She will contact you directly.*
>
> *Thank you for thinking of the UA Press.*
>
> *Sincerely,*
>
> *Pam Odom*

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Not applicable.

PROPOSED PRINCIPAL INVESTIGATOR, IF KNOWN

Shana Loshbaugh
Doug and Shana Loshbaugh, Freelance Writing
P.O. Box 1165
Soldotna AK 99669
(907) 262-3126 or 398-8956
fax (907) 262-6176
mutski@alaska.net

PRINCIPAL INVESTIGATOR

Shana Loshbaugh is a professional journalist with a background in science.

She holds a B.A. degree in biology from Carleton College and an M.S. degree in Animal Science from the University of Minnesota. She has lived in Alaska since 1981 and has worked in Homer, Kenai, Soldotna, Valdez, Seward, Cordova, Anchorage and Dillingham.

During the 1989 oil spill, she worked for the sea otter rehabilitation project, becoming the documentation supervisor and serving the second longest of any employee on the project. She subsequently worked for the U.S. Fish and Wildlife Service on the 1990 Sea Otter Symposium, serving as a presenter, section editor and technical editor of the published proceedings. She remains involved with organizations that grew out of that experience, serving as a member of International Wildlife Research, Inc. and the Marine Wildlife Rescue Team.

She has worked as a journalist since 1991, for the Homer News, freelancing, and, most recently, for the Peninsula Clarion. Her work has appeared in the *Peninsula Clarion*, the *Homer News*, the *Anchorage Daily News*, the Associated Press wire service; *Alaska* magazine, *National Fisherman, Outdoor America, Senior Voice, Business News Alaska* and others. In 1998 and 1999 she single-handedly researched, wrote and published *The Cook Inlet and Kenai Peninsula Science Newsletter*. Among other subjects, she has reported on science, the environment and the 1993 and 1999 EVOS symposia.

Her first book, a 300-page novel for young people, is undergoing final revisions.

Her writing awards include first place in the open nonfiction category of the Anchorage Daily News/University of Alaska Creative Writing Contest in 1992 for a natural history essay and five journalism awards from the Alaska Press Club including the 1999 award for best reporting on the environment in a daily newspaper.

OTHER KEY PERSONNEL

Not applicable.

LITERATURE CITED

Appended are copies of samples from my writing portfolio. Also contributed to:

Bayha, K. and J. Kormendy, editors. *Sea Otter Symposium: Proceedings of a Symposium to Evaluate the Response Effort on Behalf of Sea Otters After the T/V Exxon Valdez Oil Spill Into Prince William Sound, Anchorage, Alaska, 1990.* U.S. Fish and Wildlife Service Biological Report 90 (12).

Williams, T. M. and R.W. Davis, editors. *Emergency Care and Rehabilitation of Oiled Sea Otters: A Guide for Oil Spills Involving Fur-bearing Marine Mammals*, University of Alaska Press, Fairbanks, AK. 1995.

FY 02 *EXXON VALDEZ* TRI E COUNCIL PROJECT BUDGET
October 1, 200[illegible] - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS
Personnel		$38.0	
Travel		$4.1	
Contractual		$0.8	
Commodities		$1.0	
Equipment		$0.0	
Subtotal	$0.0	$43.9	Estimated FY 2003
Indirect			
Project Total	$0.0	$43.9	
Full-time Equivalents (FTE)		1.0	
	Dollar amounts are shown in thousands of dollars.		
Other Resources			

Comments:
New, one-year project.
Modified from last year's proposal to include more information.

FY02

Pre[illegible] 11-Apr-01

Project Number: 02570
Project Title: Book on EVOS science for general readers
Name: Shana Loshbaugh

FORM 4A
Non-Trustee
SUMMARY

FY 02 *EXXON VALDEZ* TR E COUNCIL PROJECT BUDGET
October 1, 20 eptember 30, 2002

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2002
Loshbaugh, Shana	Author		12.0	3162.5		37,950.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		12.0	3162.5	0.0	
					Personnel Total	$37,950.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2002
Anchorage, via auto		90.0	3	10	60.0	870.0
Fairbanks, via airplane and rental car		132.0	2	5	150.0	1,014.0
Juneau, via airplane and rental car		300.0	1	4	150.0	900.0
Cordova and Tatitlek via ferry out of Seward		96.0	1	4	100.0	496.0
Port Graham and Nanwalek via airplane or boat out of Homer		100.0	2	4	50.0	400.0
Field sites in Prince William Sound via boat out of Seward or Whittier		120.0	1	10	30.0	420.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$4,100.0

FY02

Prej 11-Apr-01

Project Number:
Project Title: Book on EVOS science for general readers
Name: Shana Loshbaugh

FORM 4B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRU E COUNCIL PROJECT BUDGET
October 1, 200[illegible] - September 30, 2002

Contractual Costs:	Proposed
Description	FY 2002
Independent manuscript review	800.0
Contractual Total	$800.0

Commodities Costs:	Proposed
Description	FY 2002
Office supplies (mainly printer ink, paper and postage)	350.0
Phone bills	500.0
Camping provisions (for field camps)	200.0
Commodities Total	$1,050.0

FY02

Prep 11-Apr-01

Project Number:
Project Title: Book on EVOS science for general readers
Name: Shana Loshbaugh

FORM 4B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRI E COUNCIL PROJECT BUDGET
October 1, 20(eptember 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
None -- existing equipment should be adequate			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units
Computer	2
Printer	2
22-foot skiff	1
25-foot sailboat	1

FY02

Prej 11-Apr-01

Project Number:
Project Title: Book on EVOS science for general readers
Name: Shana Loshbaugh

FORM 4B
Equipment
DETAIL

E.V.O.S.:
the Alaska Oil Spill
and
the Frontiers of Environmental Science

DRAFT OUTLINE

I. The catastrophe
- A. Wreck of the T/V Exxon Valdez
- B. Early response
- C. Cleanup
- D. Plans for litigation

II. Damage assessment
- A. Early plans for assessing damage
- B. The people vs. Exxon
  - 1. the gist of the lawsuits
  - 2. the lawyers supervise the scientists
- C. Role of the agencies
  - 1. state and federal partnerships
  - 2. individual agencies
- D. Seeking information in the chaos of response
  - 1. collecting dead animals
  - 2. walking shorelines
  - 3. starting databases
  - 4. 1990 Sea Otter Symposium
- E. Early areas of concern:
  - 1. where did the oil go?
  - 2. seabirds
  - 3. sea mammals
  - 4. fish and fisheries
  - 5. effects of cleanup

III. Shifting gears
- A. Effects of the 1991 court settlement on:
  - 1. funding
  - 2. direction of research
  - 3. openess
- B. The EVOS Trustees Council
  - 1. its establishment
  - 2. its functions
  - 3. its initial impacts on research
- C. Establishment of related institutions
  - 1. OSPIC
  - 2. PWS Science Center
  - 3. OSRI

IV.The Exxon Valdez Oil Spill Symposium
- A. Rationale and plans for the symposium

B. Major findings
    1. damage to subsistence resources & rural economies
    2. toxicity of hydrocarbons
    3. damaging effects of beach cleanup
    4. lingering damage to herring, salmon & other fish
    5. lingering damage to murres
    6. species not recovering
C. Public reaction
D. Exxon's reaction
    1. boycott of the Anchorage meeting
    2. Georgia symposium

V. Exploring the ecosystem
A. Choosing the ecosystem approach
B. Making it work
    1. setting up teams
    2. convincing scientists to collaborate
    3. using new approaches
C. Sound Ecosystem Assessment
D. Nearshore Vertebrate Predator project
E. Alaska Predator Ecosystem Experiment
F. Restoration at Port Dick

VI: People, the other victims
A. Damage to people's lives
    1. anecdotes of dislocation
    2. financial losses
    3. stresses
B. Role of the villages
    1. subsistence damages
    2. involving Natives in the research & restoration projects
    3. hunters' sampling project
        a. interview Monica Riedel on origins & significance
        b. interview participating hunter (Nick Tanape Sr. ?)
        c. scientific results
    4. Youth Area Watch
        a. origins
        b. participating schools
        c. favorite projects
        d. student comments
    5. Native leadership
C. Studies of Cordova's stresses
D. Archeological sites
    1. damage
    2. restoration
    3. plans for repositories

4. Kodiak's Alutiiq Museum and Archeological Repository
E. Public reaction
1. to research
2. to habitat purposes
3. to Exxon's legal maneuvers

VII. Science ascending
A. What funding surge means for area science
B. New technologies
1. computer power & modeling
2. remote sensing
3. telemetry
4. genetics
5. isotope analysis
C. The Alaska SeaLife Center
1. brief history
2. research facilities
3. EVOS projects
4. the critters in Seward

VII. Legacy of an Oil Spill
A. Planning for the 10th anniversary symposium
B. Exxon at the International Oil Spill Conference in Seattle
C. Public observances
1. the national press
2. Alaska observances
3. people's recollections
D. The anniversary symposium
1. species of concern: seals, orcas, clams, seaducks
2. lingering oil toxicity
3. oil signal receding into other cycles
4. ecosystem studies yield information bonuses
5. participants concerns
E. Lessons of the EVOS

VIII. Into a new century
A. Status of the Exxon settlement
B. The end of the EVOS Trustee mandate
C. The restoration reserve
D. GEM
E. Challenges for the Gulf of Alaska and its people in the 21st century

Samples of the sorts of things that will be included:

In a 1991 interview, Terrie Williams, marine mammal physiologist and assistant director of the sea otter rehabilitation project, talked about the stresses during the spill.

After one of the visiting veterinarians left Valdez, he sent her a packet of material. A little note with it said, "Beware of Post Traumatic Stress Syndrome". She wondered at the time what he meant. But in hindsight, she realized the risk was very real.

"It was a major, life changing experience. Sometimes now, I get really furious -- and I don't have a temper. I was never like that before. But ever since, sometimes I get really mad -- especially if it has something to do with the sea otters. ... I mean, I lost my job, lost friends. It changed everything," she said.

"As a PhD, biologist, all that rot, I was never allowed to burst into tears."

Charlie Cole, Alaska's attorney general and a member of the Trustee Council, questioned the role of scientific research in his introductory remarks at the 1993 Exxon Valdez Oil Spill Symposium in Anchorage.

He asked how much science is necessary to accomplish restoration, and urged participants to pursue studies for results, not for the sake of knowledge.

During litigation, the agencies sought rigorous studies to document damage for the courts. Should the same standards apply after the settlement, when restoration is the priority, he asked.

"The more we spend on studies the less there is for the restoration effort effort," he warned.

Ray Hilborn, from the University of Washington, at the 1993 EVOS symposium:

The oil spill created real problems for experimental design. The oil spill just "happened," and scientists scrambled to observe. No oiled beaches were even left alone to serve as controls to evaluate the effectiveness of cleaning methods.

"The way things are going, we're not going to know the effects of the spill," Hilborn said.

"It is going to be a greater tragedy if we never know what happened."

Craig Matkin began observing orcas in PWS in 1983, identifying and tracking individual animals. The summer "whale camp" in the sound became a family institution for him, his wife Olga, a

fellow biologist specializing in humpback whales, and their young children. Over the years, he made "friends" with certain animals accustomed to the observers. After the spill, he documented the disappearance of many orcas and the disintegration of their family units. As a scientist, he called the mortality "unprecedented and extreme," and it was a painful personal experience as well for Matkin and his colleagues.

Geophysicist Geoff Coble took part in the restoration of a salmon stream near Port Dick which had gone dry after the 1964 earthquake. The project, led by the Alaska Department of Fish and Game and funded by the EVOS Trustee Council, involved barging heavy equipment to the remote site and moving large amounts of gravel in the former streambed.

Coble describes various adventures trying to conduct water flow measurements at the primative site, including standing in the stream during a storm and flood to document the water surge and its scouring effects, trying not to drown in the process.

Are trace background levels of hydrocarbons in Prince William Sound from natural oil seeps or coal native to the area? The question becomes more than academic because wildlife in the sound continues to show signs of hydrocarbon exposure. If the hydrocarbons are from coal, they are biologically inert and the effects in animals are likely due to lingering effects of the oil spill. If petroleum was always present, Exxon has a biochemical alibi excusing it from causing long-term harm.

Jeff Short, a petroleum geochemist with the National Marine Fisheries Service,and chemist David Page of Bowdoin College and petrochemical fingerprinting specialist Paul Boahm of Arthur D. Little, Inc., locked horns over the matter.

Short accused the Exxon contractors of publishing misleading information and overlooking massive coal formations. Boehm and Page said the mistakes made did not change the conclusions, and Page said, "I hope the lab at Auke Bay can redirect their energies toward more important taxpayer-supported issues."

Sample:

Draft of Chapter One, part one

THE WRECK OF THE EXXON VALDEZ

The Alyeska Oil Terminal near Valdez looks as incongruous as a factory on the moon. By day, it sits against the dramatic backdrop of the wild Chugach Mountains. By night, its lights shine across the waters of Valdez Arm or glow in the fog. The thousand-acre tank farm and industrial complex marks the end of the Alaska oil pipeline and the beginning of this story.

Crude oil comes to the terminal from Prudhoe Bay, 800 miles to the north, through the famous Trans Alaska Pipeline -- one of the engineering marvels of the world. In 1977, the terminal opened as hub of a vast, state-of-the-art system to transport oil.

From then until March 23, 1989, Alyeska successfully shipped more than 8,000 oil tanker loads -- an average of several per day. The tankers carry North Slope crude oil from Alaska to California, where it is refined for the United States domestic market.

But time corroded the safety of the operation. The oil men turned the state legislature into a staunch industry ally. Budget cuts, complacency, and pro-industry political appointees of the Reagan 1980s enfeebled the U.S. Coast Guard, Environmental Protection Agency, and other federal oversight agencies. When

radar installations near Valdez failed, the Coast Guard didn't replace them, opting instead to reduce its tracking of tankers.

Even for the oil companies, the black gold was loosing luster. Profits were down. Managers laid off people and lengthened shifts. The tanker fleet was aging but, with coastal petroleum reserves dwindling, shipping companies painted over the rust and welded the cracks rather than invest in new vessels.

Ironically, on the night of March 23, 1989, the weakest link in the deteriorating chain of safeguards turned out to be the newest ship in the fleet. She'd first set sail in 1986, christened the tanker vessel (T/V) Exxon Valdez. A high-technology vessel 987 feet long, she graced Exxon Shipping Company's March 1989 calendar, captioned with the motto, "safety first".

At 8:30 that evening, Captain Joe Hazelwood returned to his ship. He'd been to town that day, ordered Easter flowers for his wife and daughter, picked up a pizza, and spent some time in the dingy Pipeline Club bar. He'd been drinking there, either beer or vodka -- depending on whom you believe.

Joe Hazelwood had his problems. An experienced seaman with a good record, he considered quitting the tanker business because staffing cuts had frozen his pay, increased his workload, and diminished his authority. Back in his home town of Huntington, New York, he'd lost his driver's license for the third time after a series of arrests for driving while intoxicated. But Exxon hadn't asked many questions since he'd completed their alcohol rehabilitation program in 1985.

Once aboard the Valdez, Hazelwood relieved his chief mate, James Kunkel. Kunkel had worked for 24 hours straight, supervising the loading of all 1,263,000 barrels of oil. Such long hours were commonplace since the crew sizes were cut. The bleary-eyed mate went to his cabin and put himself to bed.

The ship prepared to leave port an hour ahead of schedule. At 9:15 p.m., it cast off, bound for Long Beach, California. Captain Hazelwood entrusted the ship to the terminal's harbor pilot, a local navigator who would thread the giant ship through the rocky shallows.

In the darkening night, the pilot slowly accelerated the bulky tanker southward, past the white mountains and through the half-mile slot of the Valdez Narrows. As they rounded Rocky Point, 17 miles from port, a small speed boat pulled alongside and picked up the harbor pilot. Hazelwood resumed command of the bridge, a control room perched five stories above the vast deck.

It was a dismal night. The wind was calm and visibility good, but there was incessant drizzle and the temperature hung at a clammy 33 degrees. Ahead, dark islands receded into the distance.

The shipping reports warned of icebergs, nicknamed "growlers," floating out to sea from the Columbia Glacier after the first spring thaws. Radar showed faint shadows of bergs crowding into the shipping lanes. Hazelwood radioed the Coast Guard that he wanted to turn left from the outbound tanker lane to the vacant inbound lane to avoid the icebergs. They approved;

the tanker was moving out of range for their tracking instruments anyway.

Midnight approached. Second Mate Lloyd LeCain was due on shift but was still asleep in his bunk after working overtime. Captain Hazelwood complained that he had paperwork to do. Would Third Mate Gregory Cousins feel comfortable taking over for a while?

The captain left Cousins specific instructions to turn the ship right again, parallel with the tanker lanes, as soon as they pulled up even with the marker light on Busby Island.

Hazelwood went down one flight of stairs to his cabin, pulled out a bottle from his cache of low-alcohol beer that the mariners called "mousy," and took a pen out of his shirt pocket.

Minutes later, Cousins phoned down confirming that he had ordered the helmsman, Robert Kagan, to make the turn. The Third Mate then double checked the instruments and saw that the boat was not yet turning as it should. He assumed that the helmsman, who had a reputation for bungling, had been too cautious and he ordered Kagan to turn harder.

Then, the door to the bridge flung open and the lookout rushed in. She reported that the Bligh Reef buoy, which should have been blinking its red light on the ship's left, was instead on the right. Cousins stepped outside to look for himself, then ran in and ordered the helmsman to steer a hard right.

He grabbed the intercom to Hazelwood's cabin. "I think we are in serious trouble!"

As he finished, there was a rattling sound, a bumping sensation, and six distinct jolts. The subterranean ridge of Bligh Reef chewed into the seven-eighths-inch thick steel hull.

Cousins, terrified that the swinging stern of the ship would rip open, trapping people in the staff quarters and the engine room, yelled at Kagan to make a hard left. The stunned helmsman just gaped at him. The mate grabbed the wheel himself and spun it.

Chief Mate Kunkel tumbled out of his bunk and awoke to the terror of a shipwreck. The tanker shuddered to a halt and the smells of inert storage gas and crude oil began filling the night air. It was seven minutes after midnight, Friday, March 24, 1989.

Kunkel threw on his clothes and rushed, white-faced, to the bridge. The ship was listing four to five degrees to starboard. Cousins told him what had happened, and Kunkel ran to the cargo control room to assess damage. The spinning dials showed they were gushing oil at the rate of 20,000 barrels per hour.

Back on the bridge, a shaken Captain Hazelwood resumed command. Chain smoking, he ordered Kagan to make a series of hard turns with the rudder to see if he could get the vessel off the reef. The depth fathometer registered "zero." As Kunkel returned with the bad news about the ruptured hull, Joe Hazelwood threw him a sardonic smile and then stared out into the night.

"Well," he said, "it's one way to end a career."

* * * * * * * * * *

Good Friday has a grim reputation in Valdez. In 1964, the Good Friday earthquake and the tsunamis following it devastated the town. Thirty-three people died. Damage was so extensive that old Valdez was abandoned, and a new town built in a safer area miles to the west. As Easter weekend approached in 1989, the town prepared to remember the somber 25th anniversary.

At 27 minutes after midnight, the Coast Guard's traffic control center in Valdez received a call. A slurred and hesitant transmission came from Hazelwood:

"Yeah, ah, Valdez back. We've -- should be on your radar there -- we've fetched up, uh, hard aground north of Goose Island, off Bligh Reef and, uh, evidently leaking some oil and we're gonna be here for a while. And, uh, if you want to say, you're notified. Over."

The curse of Good Friday unfolded before dawn, as phones began to ring in Valdez, then in Cordova, Anchorage and Houston. People awoke to a nightmare. This was the accident they said could not happen. This was the big one.

Kenai Peninsula Online

Powered By Peninsula Clarion

Web posted **Friday, January 26, 2001**

Scientists investigate dietary quirks of captive caribou

*Got **nitrogen**?*

A caribou calf cozies up to John Crouse, a wildlife technician at the Kenai Moose Research Center. Crouse and other researchers are raising the animals to help in wildlife nutrition studies.
Photo by Shana Loushbaugh

By SHANA LOSHBAUGH
Peninsula Clarion

This is the warm and fuzzy side of wildlife biology -- nine little caribou calves clustered around Alaska Department of Fish and Game Wildlife Techni-cian John Crouse.

The youngsters, with their gangly legs and Bambi eyes, live in a pen at the Kenai Moose Research Center, in the Kenai National Wildlife Refuge near Swanson River. They share lodgings with 26 moose and a lone Dall sheep lamb.

But this is no petting zoo. The people and the animals are there for scientific research purposes.

As much as Crouse enjoys the fuzzy fawns, what he's really after is their urine.

"Caribou are a little different," he said. "Nothing seems to subsist on a diet so low in **nitrogen** as caribou."

During the winter in the wild, he explained, the animals subsist on lichens. The specialized plants, which thrive in harsh arctic and subarctic climates, are rich in carbohydrates but lack **nitrogen**, one of the basic building blocks of life.

Dietary **nitrogen** is necessary for animals to make protein, the

biochemical basis of muscles, enzymes and other essential bodily ingredients. As a body functions, it builds up and breaks down diverse proteins, excreting discarded **nitrogen** as urea in urine.

Most animals, including people, waste away without protein in the diet. But caribou survive.

"The question is, how does an animal maintain its muscle on a diet with no protein?" Crouse said.

Biologists are discovering intriguing eccentricities in the way caribou use **nitrogen**.

"Rather than excrete the urea, they can recycle it," he said. "But we don't know to what extent they do it."

Tom Stephenson, who directs research at the center, said scientists are finding clues to the puzzle.

For one, the structure of caribou's kidneys differ from those of other mammals. For another, the caribou and other deer are ruminants, a large group of vegetarian mammals, including cattle and sheep, that have extra stomachs and chew cuds. Ruminants make and swallow lots of saliva, and reabsorb an unusually high amount of nutrients in their digestive tracts.

The Kenai Peninsula researchers want to understand more about how caribou use **nitrogen** and how it affects the welfare of wild herds. Across the state, caribou populations sometimes fluctuate wildly. People are concerned about human impacts on them through development, hunting and wildlife management.

To get their questions answered, the biologists feed the caribou controlled diets with manipulated protein levels. Then they monitor the animals' urine and blood looking for traces of metabolites, the biochemical remnants of reactions in cells.

Along the way, the researchers plan to experiment with varieties of artificial feeds for keeping caribou and reindeer, the domesticated Old World breed of caribou, healthy while in captivity.

The project ties in with the broader goals of the research center. It uses semi-tame animals in large, naturally vegetated pens to approximate how wild animals interact with their environment, especially with respect to their nutrition.

One challenge is keeping wild species in natural habitat yet getting close enough to them to study such intimate details of their lives.

The center was founded in 1968. The first caribou were moved there in 1991 from the Nelchina herd, but the biologist who planned to study them left the center, and for years the little herd loafed around. In 1995, Stephenson began the current project.

But the caribou, more skittish and high strung than moose, proved difficult to work with. Getting samples from them usually involved tranquilizer darts or wrestling them to the ground, stressful for humans and deer alike.

A couple of years ago, when the caribou project moved into high gear, the research team hit upon a better way. They resolved to domesticate calves from an early age.

"We wanted to bottle-raise them so we would have a herd that was more tractable, less excitable around people," Stephenson said.

Two years ago, they captured a caribou calf to make sure they could care for it. Last spring, the biologists traveled to the Interior and stole nine more from their mothers and transported them to the Kenai Peninsula. The youngsters have been fed, coddled and taught to wear halters.

"We're trying to halter train them so we can load them in and out of trailers," Crouse said.

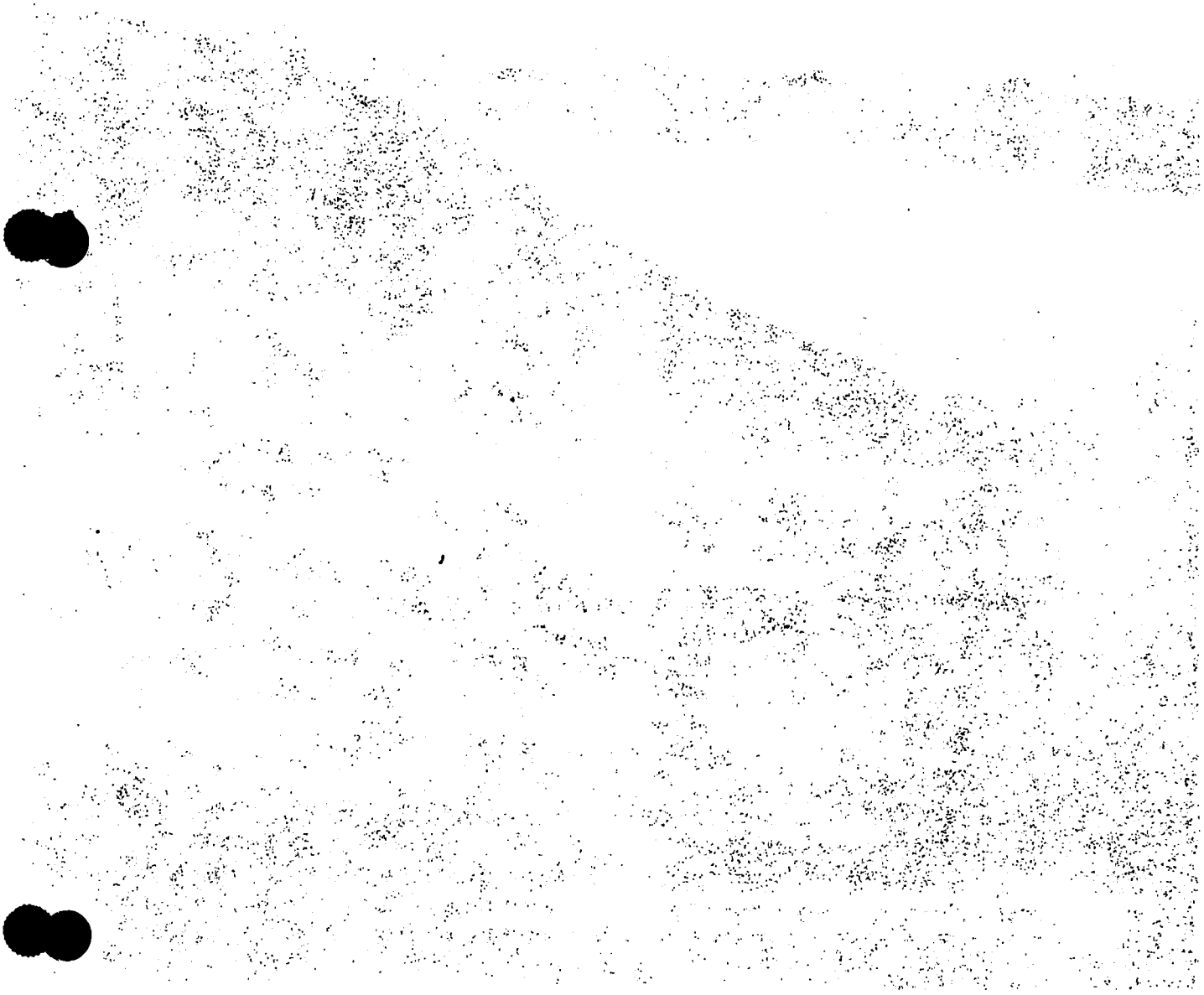
Now, 10 of the center's 23 caribou grew up there with extensive handling. The researchers plan to collect more calves in May.

It will be a few years before they will know if the behavior experiment succeeds. How the caribou will act after they pass through the changes of puberty is unclear, but so far the calves are docile and friendly.

Crouse said his great hope is that in years to come, all he will have to do to collect their urine samples is to have a cup handy at the right moment.

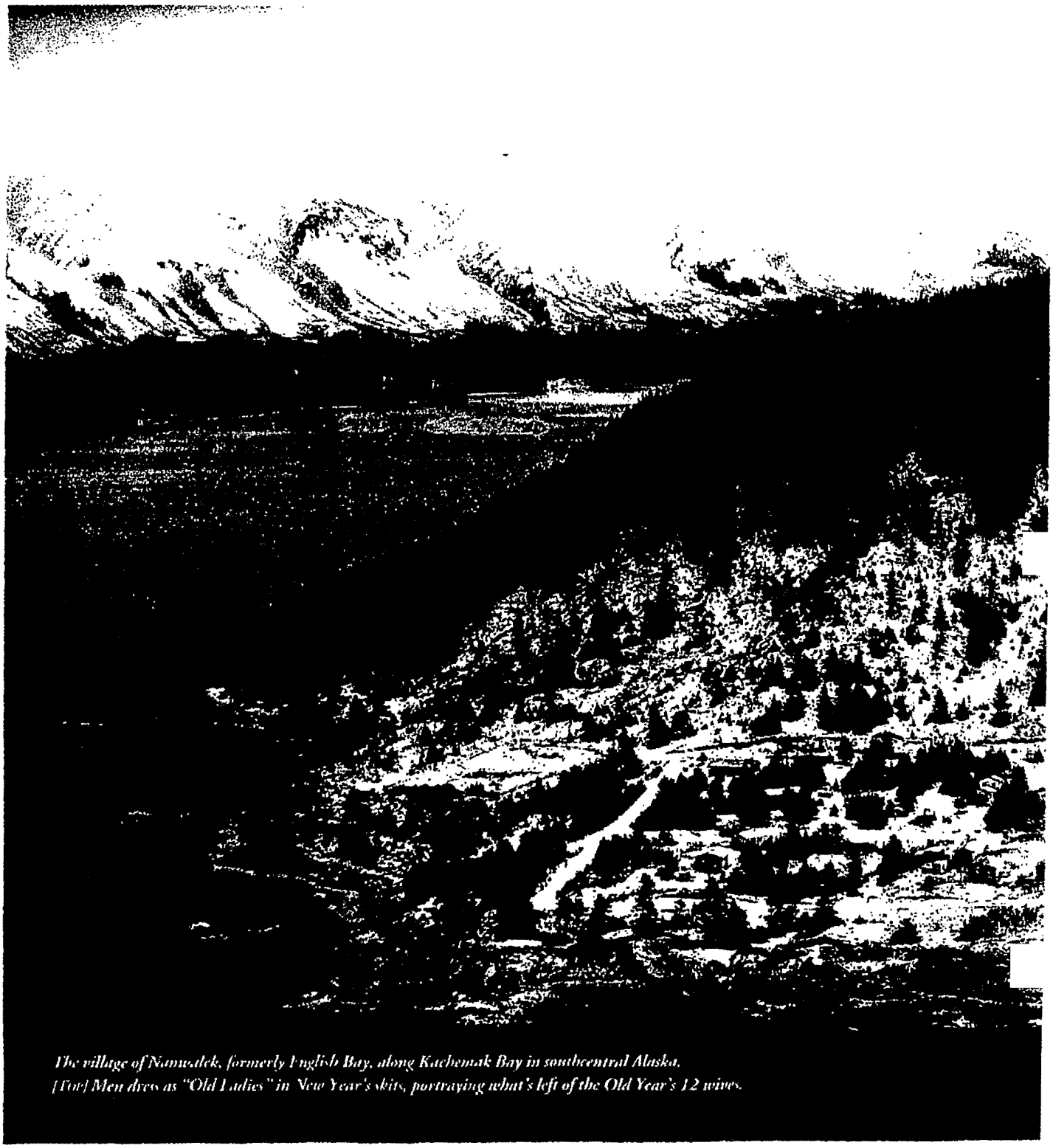
ALASKA MAGAZINE

DEC-JAN 1996



NEW YEAR'S I

Russian customs mingle with Eskimo traditions for an ann



The village of Nanwalek, formerly English Bay, along Kachemak Bay in southcentral Alaska.
[For] Men dress as "Old Ladies" in New Year's skits, portraying what's left of the Old Year's 12 wives.

N NANWALEK

ual party that seems more like Halloween than New Year's.

THE SOUTHCENTRAL AIR bush plane reeks of pizza. As it banks off the tip of the Kenai Peninsula for its final approach to Nanwalek, I recall the pilot's words on my first flight to the village: "Has anyone warned you about their airport?"

We skim the top of the spruce, straight at Mount Bede, bank 90 degrees and drop onto the narrow bar between Cook Inlet and the slough. Later, I learn that the previous plane had clipped its wheels on the snow berm and had nearly lost its landing gear. A welcoming committee whisks the privileged pepperoni away in the village's only car. The cold wind nips my heels as I trudge up the hill to the village. In the blue twilight,

✦

STORY BY SHANA LOSHBAUGH

PHOTOS BY AL GRILLO

Nick Tunape Sr., as the New Year, takes a swipe at an old hag, to chase "her" out of the building. [BELOW] Saints Sergius & Herman Russian Orthodox Church is decked out for the Christmas and New Year's celebrations.

holiday lights wink on the houses and the arch before Saints Sergius & Herman Orthodox Church.

A four-wheeler clatters down the road. "Need a lift?" teen-ager Emerson Kvasnikoff offers.

It's Jan. 14, Russian New Year. The pizzas, most of Nanwalek's 160 residents and I converge on the community hall for *Nuu'ikutaq*—the traditional masquerade ushering out the old year and welcoming the new.

Remnants of a stunning sunset silhouette Augustine volcano and mountains of the Alaska Peninsula through the picture windows. Sally Ash consults with volunteers casting parts for the 12 months. Mothers lug props and costumes—party-favor tiaras with white veils glued on, billows of white fabric, splashes of silver glitter and feathery plumes—next door to the dressing room in the clinic.

Sally's 18-year-old son, Sperry, has a major role for the first time. He's so nervous he has a headache. CB radios crackle and people chat on the gravel lanes. Everyone's asking—when does it start?

When *did* the first Nuu'ikutaq start?

No one knows. Village matriarch Juanita Melshiemer, Sally's mother, was born in 1919. She remembers *her* mother talking about how it was in the old days.

Nuu'ikutaq is part of a constellation of ceremonies surrounding the holidays. After three days of celebrations for Russian Christmas, which is Jan. 7, "masking" begins. *Maskalataq*, as Nanwalek residents call it, grows from ancient roots. Juanita's grandfather, Peter Macha, used to say that people at Yalik, the now-abandoned village on the outer Kenai coast, danced in mid-winter for 12 days wearing masks of wood and feathers.

The Russians, who built Fort Alexandrovsk in 1785 on the spit that's now the Nanwalek airstrip, introduced European masquerades. The Orthodox Church linked the maskers to Herod's disguised soldiers searching for the baby Jesus. Villagers from the Aleutians to Prince William Sound still mask from Christmas to New Year's, dancing in disguise far into the long winter's night.

But now the special masquerade of Nuu'ikutaq is observed only in Nanwalek (formerly English Bay) and nearby Port Graham, homes to Pacific Eskimos variously called Alutiiq, Sugpiaq, Unegkurmiut or Chugachmiut.

The full moon rises over the Kenai Mountains. On foot or four-wheelers, people stream to the community hall. Children pile on the bleachers or race around the dance floor. Adults fill chairs along the walls, yielding prime seats to elders. Teens climb to the loft. The teapot is heating.

The musicians adjust the sound system. Sally's brothers, John and Wally Kvasnikoff, are playing tonight. They strike up the foot-stomping dance tune "Praznik," which means "holiday" in Russian. The audience claps in time.

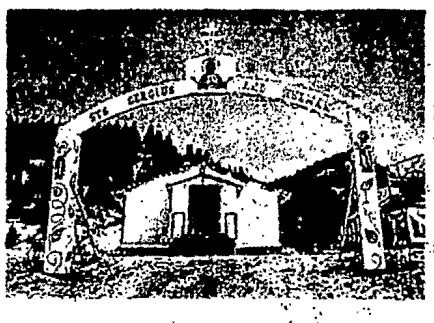
The New Year strides in, resplendent in his white uniform, brandishing a paddle. His assistant, the "MP" or *palitesmanaq* (policeman) joins him with a toot on his whistle; the crowd cheers. A dozen damsels in white follow, wearing sashes naming the months in Sugtestun, a language that's related to Yup'ik Eskimo and sprinkled with Russian. The Old Year, bent, bearded and bearing a staff of spruce, hobbles in. Last come the three Old Ladies—men dressed as comic hags, the wives or daughters of the Old Year.

The cast parades around the room, files out, then returns. The music speeds up as the audience claps. The procession exits and returns again.

The Old Year dances with the months. The hags intrude, making jealous motions and complaining in falsetto Sugtestun. One jumps on the Old Year. The New Year whacks the distracted Old Year's padded back. Two hags rush to his defense, then leave with the New Year in pursuit. The MP scans the crowd—the third hag hides among giggling children. He drags "her" kicking and shrieking from the hall.

Each time the cast returns, the skit

The Russians, who built Fort Alexandrovsk in 1785 on the spit that's now the Nanwalek airstrip, introduced European masquerades.



gets wilder. The Old Ladies steal every scene. They infiltrate and tease the audience, harass the cast, toss candy to the children and dance up a storm. One steps into plastic gloves like duck feet. Another waves dirty underwear at the crowd.

An Old Lady jumps into the lap of Sally's husband, Marlon, and tries to steal his iced tea. "She" coos in his hear. "I love you too, man," Marlon says, blushing. The hag plants a sloppy kiss on his cheek. Marlon wipes his face in disgust and pushes the creature away. People guffaw.

Sally translates: "He told Marlon, 'We're going to get married now!' "

Tradition dictates that the Old Ladies speak only Sugtestun. The language flourished until 1958, when the Bureau of Indian Affairs' white teachers forbade children to speak it in school.

Sally's generation was forced to speak English. She married Marlon, a white Californian working in Seldovia, and left. When the family moved back in 1990, none of the village children spoke Sugtestun. Now she teaches it in the school and to her children. But Marlon doesn't speak it, and the children, though they understand, find it easier to reply in English.

[Top Left] A monkey mask disguises one of the celebrants. [Top Right] Emilie Swenning helps one of the men into his hag costume for the dance. [Below] The Old Year, hunched and bearded, leads a parade followed by the 12 wives of the New Year.

The celebration called Nuu'ikutaq nearly died in the 1960s and 1970s. People moved away seeking work and were embarrassed about Native ways. Juanita remembers when there weren't enough women to act the 12 months, so they disguised men to fill in.

In the late 1970s, villagers pushed for bilingual education. The 1980s brought oil money, government housing, Native land claims, a new school. Life trickled back into Nanwalek and its traditions. Now teachers like Sally work with elders to pass on the culture. Only 10 villagers speak Sugtestun fluently, but for children the language is suddenly "in."

Nùu'ikutaq helps. As years pass, the hags age, puffing through the physically demanding hijinks and improvising jokes most of the audience can't translate. In 1994, Nanwalek even drafted a

One-year-old Christopher Anahonak doesn't want anything to do with a playful old hag.

linguist from Fairbanks to play a part.

Sally said little girls want to be months and little boys copy the Old Ladies' antics. The past few years, they've done a children's Nuu'ikutaq the day after New Year's. Tomorrow there will be seven Old Ladies, more athletics and less dialogue.

Sperry works hard on Sugtestun. Tonight, he plays an Old Lady for the first time. He sneaks up to his grandmother to ask how to say things. She's disappointed at his lack of fluency.

The performance grows raucous.

Energy and goofiness infect the audience. People sneak into the cold moonlight for a nicotine fix during breaks. Toddlers, wired and ecstatic, run in circles and try to reach dangling crepe paper streamers.

The cast returns. The Old Year grows weary, kneeling at the side until the New Year pushes through the defending months, brushes aside the Old Ladies and thumps him. The hags leap on each other, falling over. The MP tries to round them up and drag them out; they screech and squawk and run.

Sackman is still the bogeyman, the subject of endless speculation among the small children after New Year's Day.

The roles aren't easy. The pillow beneath the Old Year's hunched back isn't only a joke—it's necessary padding. He and the hags will nurse bruises for days.

But they have it easy compared to the old days. Juanita dismisses tonight's performance as "tame."

"When I was a little girl, there was a devil in it, but I guess the priests didn't like it," Juanita said. Old-timers talked of devils who danced atop hot stoves without burning their feet and clawed the faces of dancers who unveiled.

Christian influence replaced devils with Old Ladies but the season still has a dark side. People see strange things—little people with fiery eyes, lights on the ice, shapes moving in and out of the bluffs, people where there can't be any.

Stories of Sackman snatching naughty children in the dark terrified kids of Juanita's generation. Silent figures carried big knives and sacks of bloodied meat. She remembers one large fellow in white who gave her "the creeps." He sat by the outhouse and wouldn't speak or move. When she peeked later, he'd vanished.

Sackman is still the bogeyman, the subject of endless speculation among the small children after New Year's Day when they can join the masking. Adults smile indulgently but look over their shoulders in the dark.

I worry myself later, when Sally gives me a ride to her house. From the four-wheeler, I glimpse a hulking shadow behind the water tank, gripping a sack and a hatchet. The hair stands up on the back of my neck. Perhaps it was somebody in costume.

The villages and the church remain

[Clockwise] A masked villager dances during the Masking March. Village matriarch Juanita Melshiemer watches the march with a great-grandchild on her lap. An old hag tries to hide in the audience to escape being kicked out of the party. [Below] Sergay Moonin, who played New Year in the children's party, dances The Waltz of Forgiveness with Conan Kvasnioff, an unmasked hag.

ambivalent about the supernatural intrusions. After Nuu'ikutaq, masking for all ages continues through Jan. 17. Then participants burn all the masks lest they draw evil spirits.

Before Juanita's father, Nicholas Moonin, became the village priest, revelers ended Maskalataq by tearing off their disguises, running down to the beach, and leaping into the sea to wash. Then they went to church to be sprinkled with holy water.

"Their heads would be frozen, going into church," Juanita said. Chills and pneumonia sickened and even killed some. Father Moonin instead had participants kneel 100 times in penance. The number has since been reduced to 25.

It's late. People are tired but reluctant to end the fun. The cast returns for the 12th and final time. The Old Ladies flog the New Year with burlap purses; he gooses them with the paddle. The hags begin a stomping dance; the music accelerates. Midnight approaches; excitement builds.

The New Year runs the Old Year out the door. They run back and everyone grows louder. People stand clear, because tradition says that any bystander pushed out with the Old Year will die soon. The Years rush out and in again. They run out a third time. A shot is heard. They don't return.

The music stops. The MP and the months lift their veils. The audience whispers. Then the unmasked actors return to cheers and glittering confetti.

People rise, face the icon on the east wall and cross themselves. They sing the hymn, "God Grant You Many Years," in Slavonic, English and Sugtestun.

The musicians pick up guitars and begin a slow waltz. Nick Tanape Sr. and Conan Kvasnikoff, who played the New and Old Years, share the first dance. Then they dance with each month and the other cast members. Children join, tossing glitter in each other's hair.

They call it "The Waltz of Forgiveness." A new year begins; grievances and regrets are put away. Sally and Marlon dance; Sperry leads his grandmother to the floor. A couple, divorced in the past year, dance. A dad takes his toddler for a spin.

The music is sweet. The dance stretches across centuries of New Years and cultures. Nuu'ikutaq ends in the dance of the ghosts and the living, Natives and whites, past and present, present and future. ★

Shana Loshbaugh *is a free-lance writer based in Homer. Photographer* Al Grillo *covers Alaska from his home in Anchorage.*

A new year begins; grievances and regrets are put away.

Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound - Submitted Under the BAA

Project Number:	02574 - BAA
Restoration Category:	Research and General Restoration
Proposer:	Dennis C. Lees, Littoral Ecological & Environmental Services
Lead Trustee Agency:	
Cooperating Agencies:	None
Alaska SeaLife Center:	No
Duration:	1st year, 2-year project
Cost FY 02:	$88,481
Cost FY 03:	$33,045
Geographic Area:	Prince William Sound
Injured Resource Services:	Clams, Intertidal Communities, Sediments, Sea Otters, Harlequin Ducks, Subsistence

ABSTRACT

Studies from 1989 through 1997 suggest that bivalve assemblages on beaches in PWS treated with high-pressure hot-water washing remain severely damaged in terms of species composition and function. This project will assess the generality of this apparent injury to these assemblages. A finding that our conclusions are accurate will indicate that a considerable proportion of mixed-soft beaches in treated areas of the sound remains extremely disturbed and that these beaches are functionally impaired in terms of their ability to support foraging by damaged nearshore vertebrate predators such as sea otters and harlequin ducks. The study will also provide insight into the need for remediation of beaches to restore biodiversity and function in these assemblages.

INTRODUCTION

The T/V *Exxon Valdez* ran aground in the northeastern part of Prince William Sound, Alaska, on March 24, 1989. Over the next several weeks, a substantial amount of the nearly 41 million liters of spilled Alaska North Slope crude oil was deposited on beaches in the southern and western portions of the sound and on Gulf of Alaska beaches to the southwest. Shoreline cleanup activities were carried out with varying degrees of intensity throughout the summer of 1989 on about 560 km (Harrison 1991) of the 780 km of oiled shoreline in the sound. A primary method of shoreline treatment in 1989 was hydraulic flushing with water heated to moderate to high temperatures (Lees et al. 1996).

In Prince William Sound, most of the oiled beaches were "cleaned," typically using high-pressure, hot-water washing techniques. The technique involved various methods of dislodging the oil by spraying the intertidal zone with heated sea water (40-60° C) and then skimming up the oil as it flowed down the beach and refloated on the tide. Commonly, the hot water was directed at the beach using hose nozzles or a large spray-head mounted on a mechanical arm.

Recent analyses of infaunal data from the NOAA study of treatment effects and recovery in intertidal sediments in the sound have suggested that infaunal assemblages remained fundamentally impaired as late as 1997. This impairment was most evident in bivalve assemblage but was generally apparent for most major infaunal taxa. While not always apparent from the perspective of overall abundance, the impairment is quite conspicuous from the perspective of species composition and biological function or trophic structure. For bivalves, it appears that larger burrowing suspension and deposit feeders that dominate at unoiled (reference) and oiled but untreated sites have been replaced at sites exposed to high-pressure hot-water (HP-HW) washing by smaller surficial suspension feeders. This means that valuable and preferred species that typically dominate at undisturbed beaches (e.g., the littleneck clam *Protothaca staminea*, and the butter clam *Saxidomus giganteus*, which are favored by sea otters, harlequin ducks, and subsistence gatherers, and various species of *Macoma*) are replaced by a small opportunistic species (i.e., *Hiatella arctica* and a tiny nestling clam *Rochefortia* (= *Mysella*) *tumida*. that are of little or no value to nearshore vertebrate predators. In addition to bivalves, this pattern was still apparent as late as 1997 for polychaetes, echinoderms, snails, and crustaceans. In fact, whole classes or families of invertebrates that dominated at reference and oiled but untreated beaches are lacking in the infauna at treated beaches. Moreover, our studies indicate that a return to the apparent climax assemblage is occurring very slowly, apparently from lack of recruitment by the more favored bivalves, and suggest that recovery is probably delayed by the slow rate of recovery in sediments, which were also seriously disturbed by the effects of HP-HW washing. The impaired condition of intertidal bivalve assemblages may be a contributing factor in the failure of sea otters and harlequin ducks to achieve significant recovery in some areas that were oiled and may be a critical issue in the restoration of those damaged resources. .

NEED FOR THE PROJECT

The primary reason we are proposing this study is that we became concerned about the implications of differences in condition of intertidal infaunal assemblages that we have observed

between oiled and treated, oiled but untreated, and unoiled reference sites in western Prince William Sound since 1989. We observed that the assemblages at the treated sites were substantially impoverished relative to those at the reference sites and that they displayed fundamental differences in functional capabilities. Moreover, we postulated that these differences were due primarily to differences in inorganic and organic sediment characteristics rather than hydrocarbons in the sediments.

As a consequence of these differences, the treated beaches that we observed were far less able to support foraging by organisms from higher trophic levels or to serve as subsistence harvest areas for the native or tourist populations in Prince William Sound. The impoverished condition of the bivalve assemblages may, in fact, be an important contributing factor in the failure of sea otters and harlequin ducks to demonstrate recovery in many oiled parts of the sound. Moreover, the increase in harlequin duck populations in other parts of the sound may be a consequence of movement to areas with more adequate food resources.

The geographic scope of our previous studies was, unfortunately, limited and cannot our findings cannot be extrapolated to the rest of the sound. Consequently, we are proposing this study to assess if the conditions that we observed in the intertidal infaunal assemblages and sediments occur generally in sediments on beaches exposed to high-pressure hot-water wash in western Prince William Sound. Determining the answer to that question could also provide helpful information in understanding the dynamics of sea otters and harlequin ducks in areas of the sound that were oiled and treated in 1989-90.

A. Statement of Problem

A large proportion of the mixed-soft sediment habitats in Prince William Sound was exposed to the spilled oil from the *Exxon Valdez* oil spill. Most of the oiled areas, however, were subsequently subjected to either warm- or hot-water washing. This process washed a considerable amount of the oil out of the area but mixed low concentrations of oil into the sediment column. Moreover, the process also flushed the finer sediment fractions and associated organic materials out of the sediment into the water column. Most of these materials were then carried away by the currents, leaving the sediments substantially altered in terms of particle grain size distribution and organic content. This process also flushed large numbers of the infaunal organisms out of the sediments and displaced or damaged them to a point where they were killed (Lees et al. 1996), leaving the infaunal assemblages greatly impoverished (Driskell et al. 1996).

A major objective of the infaunal study was to describe the differences in the structure of the infaunal assemblages existing among these treatment categories. This analysis focuses on the bivalve assemblages. The location of the various sampling sites is shown in Figure 1. Infaunal invertebrates were identified in sediment samples collected from oiled and treated, oiled but untreated, and unoiled (reference) intertidal sediments in Prince William Sound from 1989 through 1997. Invertebrate groups most commonly observed were, in decreasing order of abundance, Mollusca, Polychaeta, and Crustacea. Snails and clams were the most abundant mollusks.

Species composition and functional characteristics of intertidal infaunal assemblages at sites in Prince William Sound exposed to crude oil from the *Exxon Valdez* oil spill appear to have been influenced more by exposure to shoreline treatment than by exposure to oil. Dominance patterns of the infaunal invertebrates, which varied according to type of treatment, appear to provide

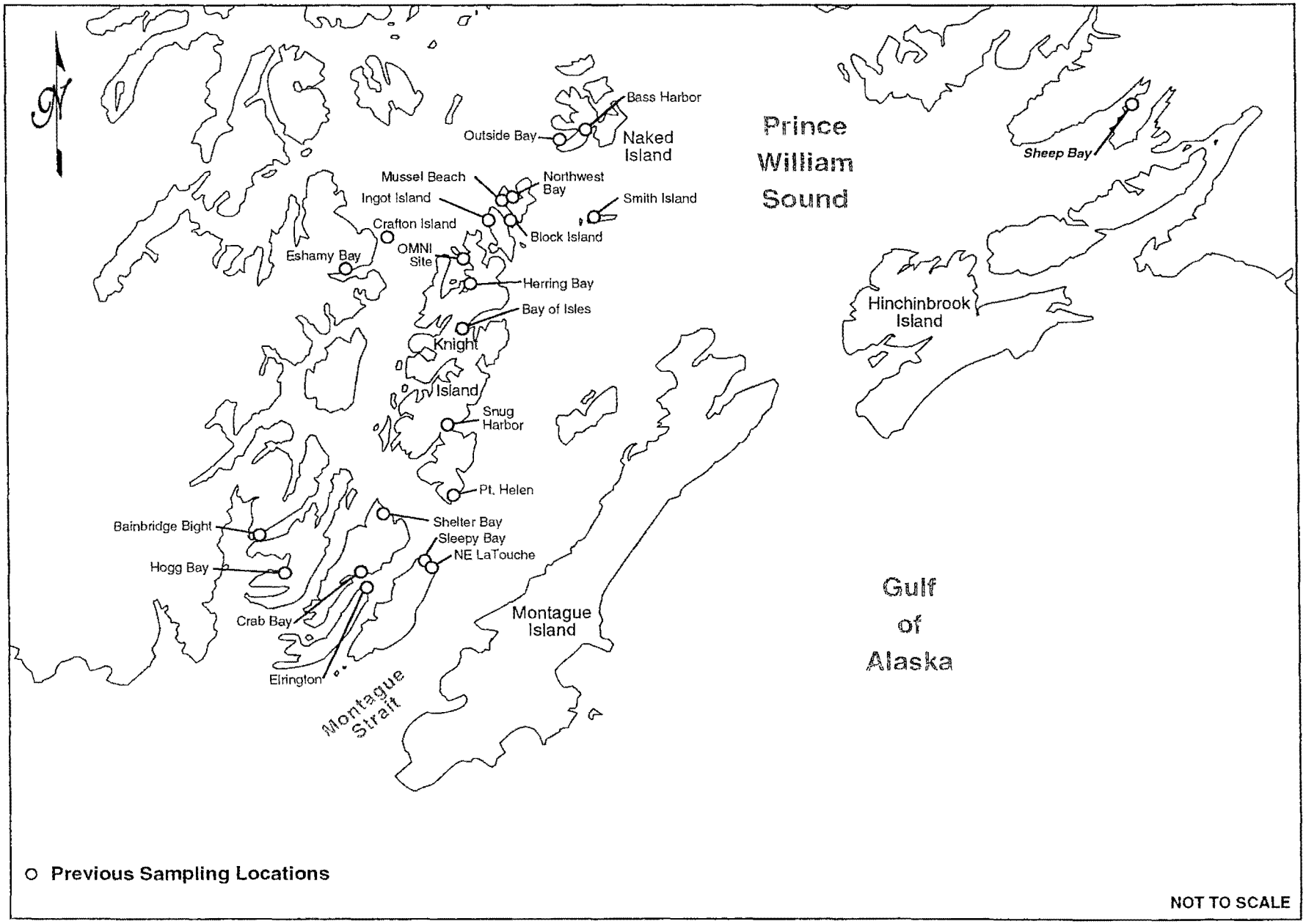


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Figure 1. Prince William Sound study area and sampling locations in previous studies.

important insights into the effects of the spill, the ensuing treatment, and the recovery process. Life histories and ecological characteristics of the individual species suggest a rationale for the differences in dominance patterns seen among treatments. These patterns suggest that failure to achieve recovery is a consequence of lingering secondary effects from the spill rather than its primary effects.

These patterns are apparent in most of the major taxonomic groups that occur as infauna. For infaunal bivalves, lower values were typically observed at oiled and treated sites whereas highest numbers were observed at reference sites. Species richness, very similar at reference and oiled but untreated sites after 1990, declined slightly during the study. Abundance, also quite similar at reference and oiled but untreated sites, peaked in 1992 or 1993 and then gradually declined through the remaining years. In contrast, averages for species richness and abundance were substantially lower at oiled and treated sites and exhibited no apparent trends representing recovery (Figures 2a and 2b) . Differences in both variables were highly significant between reference and oiled but untreated sites, on one hand, and oiled and treated sites on the other. Similar patterns were observed in polychaetes, snails, and echinoderms. In contrast, these numerical characteristics were similar among the treatment categories for microcrustaceans.

Species richness and abundance of bivalves were significantly higher at reference and oiled but untreated sites than at oiled and treated sites, suggesting that community succession has reached a higher level at the former sites than at oiled and treated sites. All of the bivalve taxa observed were encountered at either reference or oiled but untreated sites whereas only eight taxa were observed at oiled and treated sites.

Dominance patterns and functional characteristics provide further important insights into the effects of the spill, shoreline treatment, and the recovery process. For bivalves, *Mysella tumida, Macoma* spp., and *Protothaca staminea* dominated at reference (unoiled) and oiled but untreated sites but they were far less common at oiled and treated sites. *Mysella* is typically commensal with larger burrowing species that were mostly absent or uncommon at oiled and treated sites. Although small, *Mysella* is relatively long-lived and reproduces slowly. In the absence of the burrowing hosts, it apparently nestles on the surface of the sediment. The other bivalve dominants generally are relatively long-lived, slowly reproducing species that bury up to several centimeters below the surface of stable sediments. In contrast, *Hiatella arctica*, the dominant bivalve at oiled and treated sites, is an opportunist that nestles on the surface of disturbed sediments or newly available substrate.

Species Composition

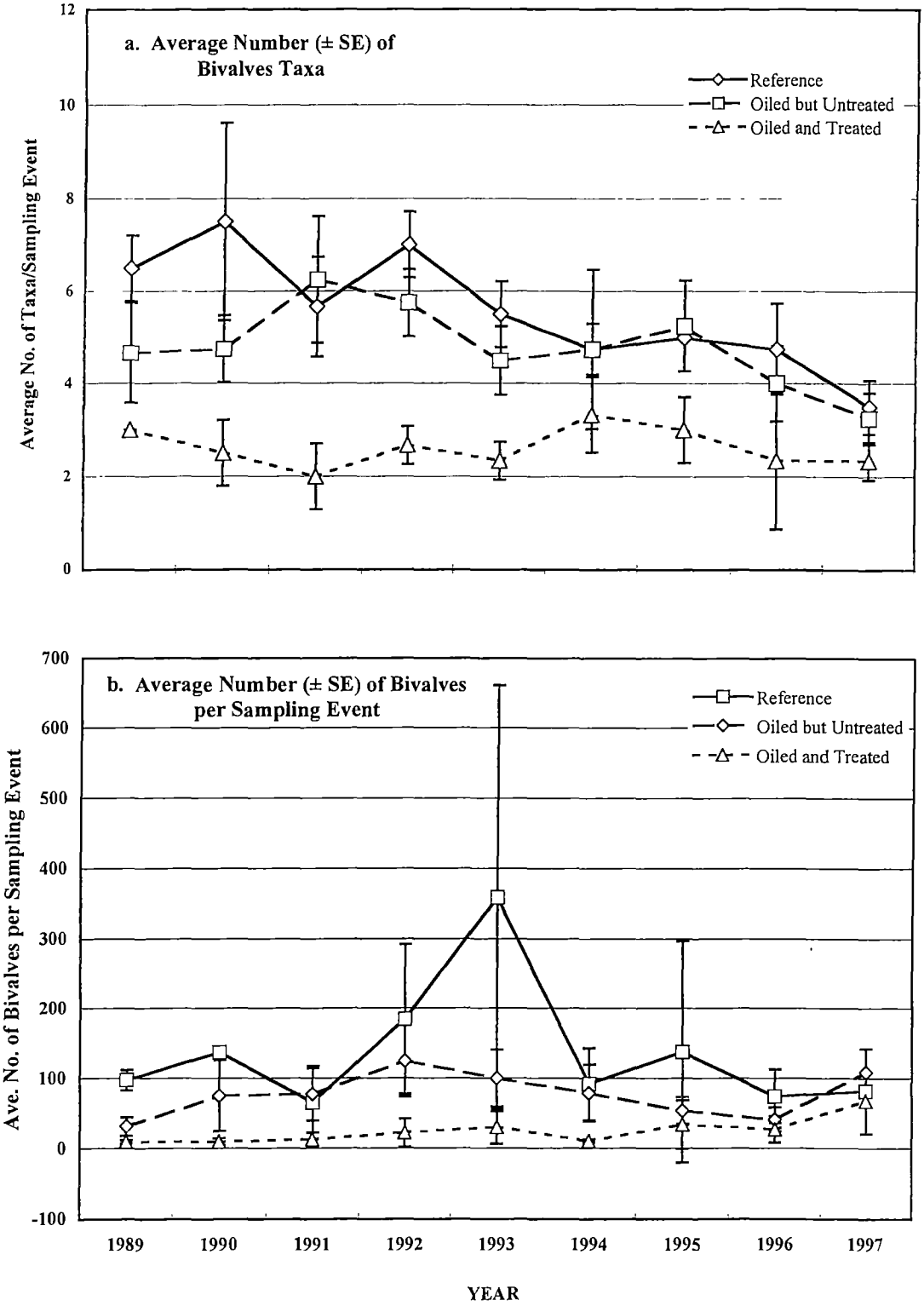
Bivalve assemblages observed in reference and oiled but untreated sites during this study were dominated by species of the bivalve families Montacutidae (a single species), Tellinidae, and Veneridae, both of the latter families represented by several taxa. Thus, reference and oiled but untreated sites have been dominated by relatively long-lived clams, mainly *Mysella tumida, Macoma* spp., and *Protothaca staminea* (Table 1). Most of these taxa characteristically burrow in stable sediments (e.g., *Macoma* and *Protothaca*; Peterson and Andre 1980; Houghton 1973; McGreer 1983). In contrast, members of the genus *Mysella* usually live in a commensal relationship in semi-permanent burrows with large burrowing infaunal organisms such as sea cucumbers, sipunculids, echiurans, or shrimp (Ockelmann and Muus 1978). In fact, abundance

Table

Dominance Patterns of Infaunal Bivalves in Treatment Categories

Taxon	Reference Sites			Oiled but Untreated Sites			Oiled and Treated Sites			Totals
	Total Number of Individuals	Percent Abundance in Category	Ave. No. per Sampling Event	Total Number of Individuals	Percent Abundance in Category	Ave. No. per Sampling Event	Total Number of Individuals	Percent Abundance in Category	Ave. No. per Sampling Event	
Clinocardium ciliatum	2	0.06	0.1							2
Compsomyax subdiaphana	2	0.06	0.1	3	0.1	0.1				5
Cryptomya californica	3	0.1	0.1							3
Diplodonta aleutica				19	0.7	0.5	2	0.3	0.1	21
Hiatella arctica	90	2.8	3.5	298	10.9	8.5	**460**	**71.0**	**18.4**	848
Macoma spp.	30	0.9	1.2	80	2.9	2.3	1	0.2	0.0	111
Macoma balthica	176	5.5	6.8	148	5.4	4.2	19	2.9	0.8	343
Macoma inquinata	295	9.2	11.3	299	10.9	8.5	1	0.2	0.0	595
Macoma obliqua	6	0.2	0.2	1	0.04	0.0				7
Mactridae, unid.				2	0.07	0.1				2
Mya arenaria	4	0.1	0.2	1	0.04	0.0				5
Mysella tumida	**2139**	**66.7**	**82.3**	**1327**	**48.5**	**37.9**	129	19.9	5.2	3595
Protothaca staminea	423	13.2	16.3	493	18.0	14.1	34	5.2	1.4	950
Saxidomus giganteus	33	1.0	1.3	58	2.1	1.7	2	0.3	0.1	93
Semele rubropicta				2	0.07	0.1				2
Tellina spp.	1	0.03	0.0							1
Tellina modesta	3	0.1	0.1	1	0.04	0.0				4
Tellinidae, unid.				5	0.2	0.1				5
Veneridae, unid.				1	0.04	0.0				1
Total Taxa in Category	14			16			8			
Total Individuals	3207			2738			648			6593
Ave. No./Sampling Event			123.3			78.2			25.9	76.7

Figure 2
Average Numbers of Bivalve Taxa and Individuals by Treatment Category



of *M. tumida* and two burrowing sea cucumbers, with which *Mysella* could have a commensal relationship, exhibited a significant positive correlation.

In contrast, oiled and treated sites were strongly dominated by a single species of the family Hiatellidae (Table 1). *Hiatella arctica*, an opportunistic, widely distributed "weed" species, nestles on the surface of disturbed sediments, on new rocks, or synthetic substrates (Morris et al. 1980; Gulliksen et al. 1980; MacGinitie 1955) and frequently dominates the biota in those habitats.

Temporal Changes of Dominant Taxa

Comparison of abundance patterns for the major species provides little evidence that dominance patterns have been changing in any of the treatment categories, especially at oiled and treated sites. In terms of raw abundance, none of the four species that dominated at reference or oiled but untreated sites showed any indication of significant increases at oiled and treated sites during the eight-year period following EVOS (Figures 3 through 6). In contrast, *Hiatella arctica* remained consistently the dominant species at oiled and treated sites (Figure 7, Table 2). When viewed in terms of relative abundance to reduce the influence of variation in overall abundance, it is still clear that dominance relationships at oiled and treated sites were not changing to any great extent (Table 2).

Mysella tumida

This small long-lived suspension-feeding clam lives near the surface of the sediment or in burrows of burrowing forms such as sea cucumbers, sipunculids, echiurids, or shrimp (Ockelmann and Muus 1978). It was by far the most abundant species at reference and oiled but untreated sites, comprising 66 and 43 percent, respectively, of the total bivalves collected in sites from these categories. Nevertheless, the average number of *Mysella* per sampling event (94.2 individuals) was nearly three times higher in reference sites than at oiled but untreated sites (35.2 individuals; Table 1). *Mysella* was particularly abundant at Outside Bay (Figure 3). The species was twice as abundant as *Protothaca staminea*, the next most abundant species in both categories. In contrast, overall abundance of *Mysella*, comprising only 28 percent of the total number of bivalves at oiled and treated sites, was an order of magnitude less abundant in this category. The average number of *Mysella* per sampling event in oiled and treated sites were an order of magnitude lower than in reference and oiled but untreated sites (Table 1).

Protothaca staminea

The little-neck clam *Protothaca staminea*, a suspension feeder (Morris et al. 1980; Peterson and Andre 1980), burrows to moderate depths. It probably lives at least 10 years. It was the second most abundant bivalve at reference and oiled but untreated sites, comprising 13 and 19 percent, respectively, of the total bivalves collected in these categories. The average number of *Protothaca* per sampling event, averaging 18.7 and 15.8 individuals per sampling event, respectively, was nearly the same in both categories (Table 1). It was relatively quite abundant at Outside and Sheep Bays, Block Island, and Mussel Beach South but an order of magnitude less abundant at the remaining reference, oiled but untreated, and oiled and treated sites (Figure 4). Although the abundance of *Protothaca* was patchy among reference and oiled but untreated sites, it was consistently sparse at oiled and treated sites, where density was about one-tenth that

Figure 3
Trends in Numbers of *Mysella tumida* at Variously Treated Sites in Prince William Sound in Years Following EVOS

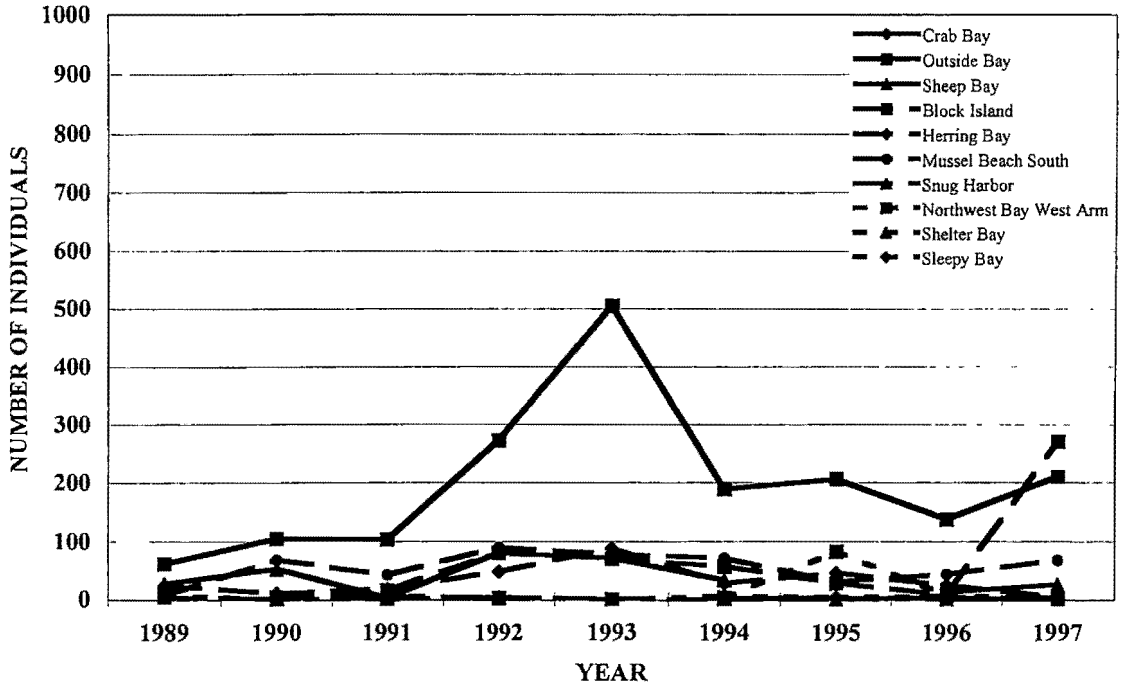


Figure 4
Trends in Numbers of *Protothaca staminea* at Variously Treated Sites in Prince William Sound in Years Following EVOS

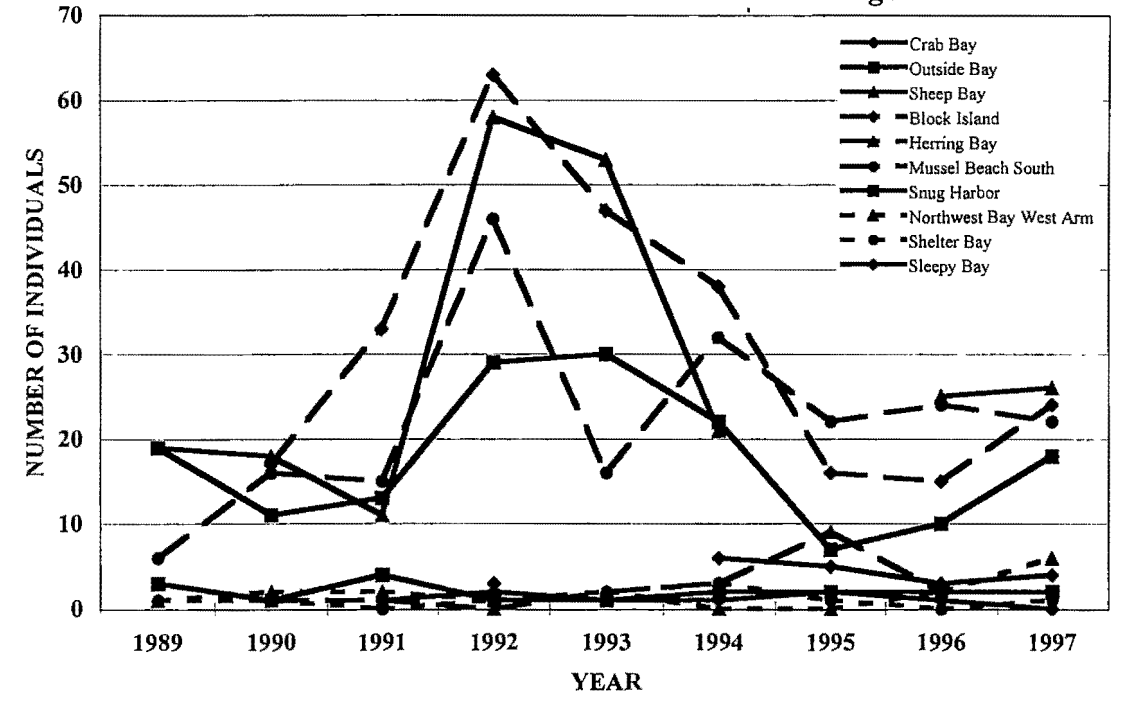


Figure 5
Trends in Average Numbers of *Macoma inquinata* at Variously Treated Sites in Prince William Sound in Years Following EVOS

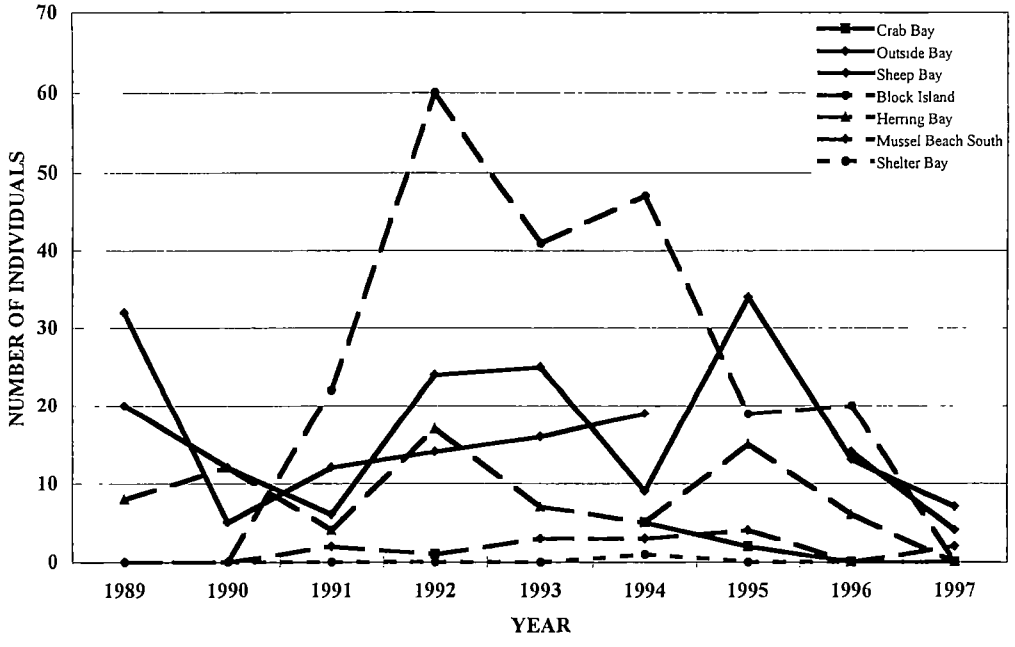
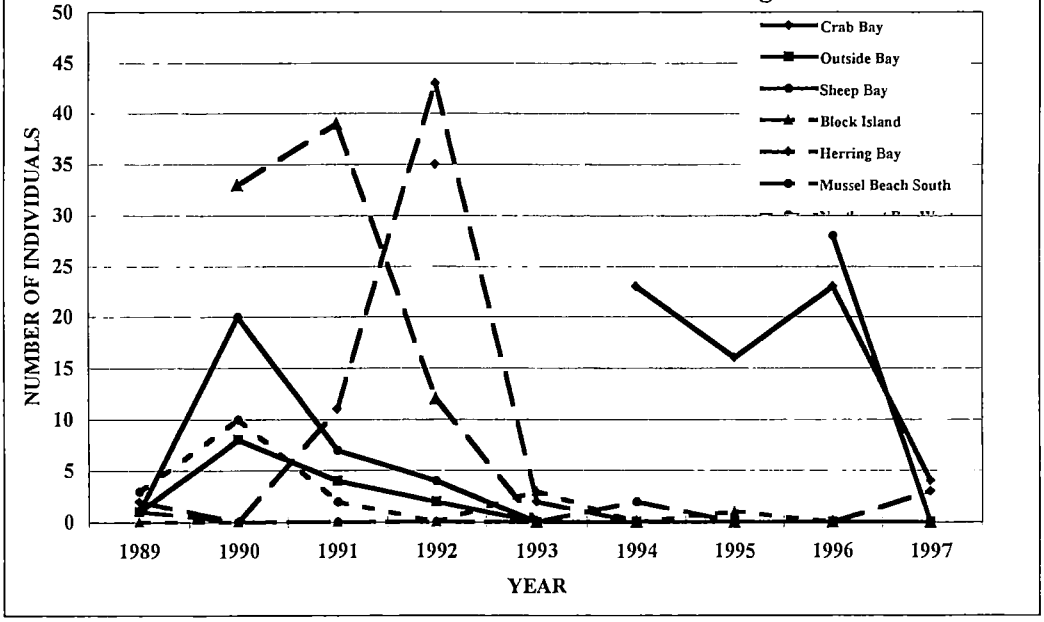


Figure 6
Trends in Numbers of *Macoma balthica* at Variously Treated Sites in Prince William Sound in Years Following EVOS



Tabl

Temporal Patterns in Relative Abundance of Infaunal Bivalves
Relative to Treatment Category

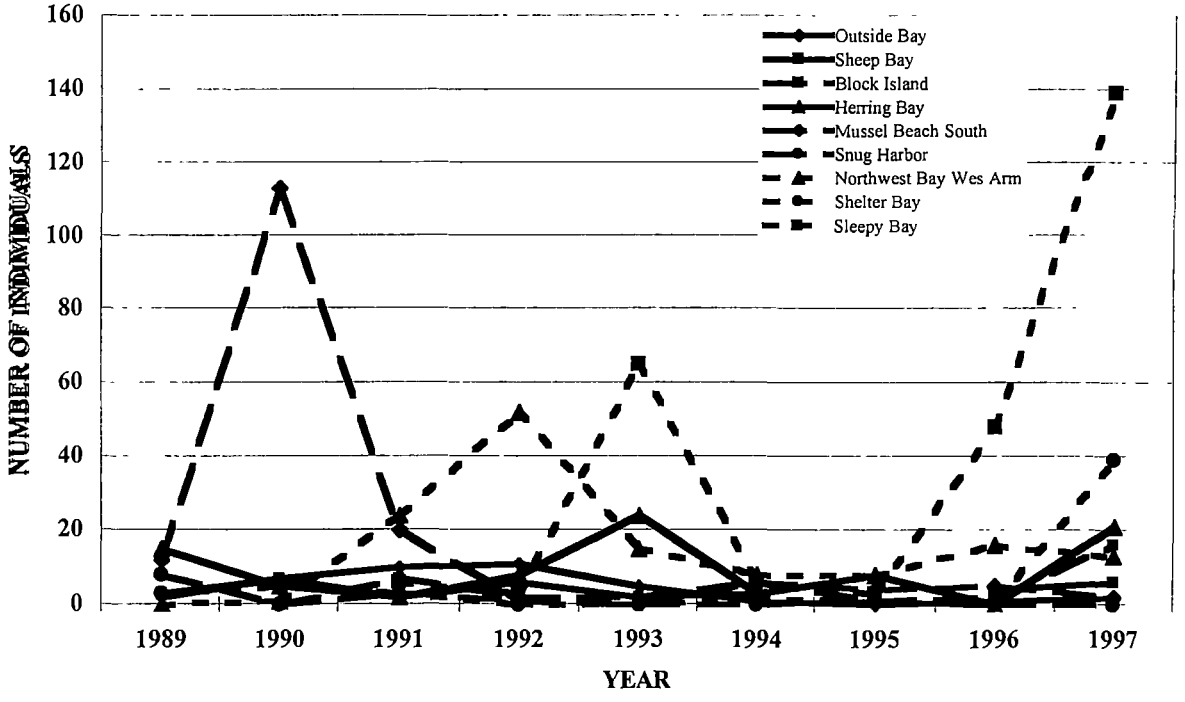
Percent of Total Abundance in Category by Year

Category/Taxon	1989	1990	1991	1992	1993	1994	1995	1996	1997	Average	Std. Error
Reference Sites											
Hiatella arctica	2.6	5.1	7.7	3.2	1.0	1.9	0.0	4.0	3.7	3.2	0.81
Macoma balthica	1.0	10.2	5.6	7.4	0.0	6.3	5.8	17.1	1.2	6.1	1.88
Macoma inquinata	26.7	6.2	11.7	7.0	5.7	10.6	13.0	10.7	4.9	10.7	2.35
Mysella tumida	44.6	56.9	58.7	63.9	80.4	65.2	75.4	52.0	75.3	63.6	4.19
Protothaca staminea	19.5	10.6	12.8	16.2	11.6	14.7	4.3	14.4	14.9	13.2	1.50
Saxidomus giganteus	5.1	1.8	1.0	0.7	0.7	1.1	0.4	0.7	0.0	1.3	0.54
Total Individuals by Year	195	274	196	554	718	368	276	298	328	356.3	61.13
Ave. No./Sampling Event*	97.5	137.0	65.3	184.7	359.0	92.0	138.0	74.5	82.0	136.7	
Oiled but Untreated Sites											
Hiatella arctica	37.2	39.2	10.4	2.4	6.5	4.7	6.5	4.2	8.9	13.3	5.06
Macoma balthica	3.2	11.0	16.2	11.0	0.5	0.6	0.0	0.0	0.7	4.8	2.20
Macoma inquinata	8.5	4.0	9.1	15.6	12.7	17.4	18.1	15.8	0.5	11.3	2.19
Mysella tumida	35.1	26.9	25.6	44.2	58.6	48.9	47.7	47.3	78.4	45.9	5.76
Protothaca staminea	12.8	11.6	17.2	22.0	16.5	23.7	22.7	26.1	11.5	18.2	1.97
Saxidomus giganteus	1.1	2.0	2.6	1.4	2.0	0.3	0.9	2.4	0.0	1.4	0.32
Total Individuals by Year	94	301	308	500	401	317	216	165	436	304.2	46.20
Ave. No./Sampling Event*	31.3	75.3	77.0	125.0	100.3	79.3	54.0	41.3	109.0	76.9	
Oiled and Treated Sites											
Hiatella arctica	15.8	31.6	86.8	83.3	89.9	51.6	11.8	79.0	94.1	60.4	11.75
Macoma balthica	15.8	52.6	5.3	0.0	3.4	0.0	1.0	0.0	0.0	8.7	6.10
Macoma inquinata	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.4	0.38
Mysella tumida	57.9	0.0	0.0	10.6	0.0	29.0	83.3	14.8	2.5	22.0	10.54
Protothaca staminea	10.5	15.8	7.9	6.1	5.6	12.9	2.9	3.7	3.4	7.7	1.60
Saxidomus giganteus	0.0	0.0	0.0	0.0	1.1	3.2	0.0	0.0	0.0	0.5	0.39
Total Individuals by Year	19	19	38	66	89	31	102	81	203	72.0	20.51
Ave. No./Sampling Event*	9.5	9.5	12.7	22.0	29.7	10.3	34.0	27.0	67.7	24.7	

* Number includes taxa not included in this summary table

of *Hiatella* (Table 1). Also, with an average of 1.4 individuals per sampling event, it was about an order of magnitude less abundant in oiled and treated than at reference and oiled but untreated sites (Table 1).

Figure 7
Trends in Numbers of *Hiatella arctica* at Variously Treated Sites in Prince William Sound in Years Following EVOS



At the four sites at which *Protothaca* was more abundant (noted above), its abundance peaked in 1992 and 1993 (Figure 4) and then appeared to decline in the following years. Nevertheless, the abundance of *Protothaca* appeared to remain at a higher level at these stations than at the other stations both before and after this period of peak abundance. It was consistently second or third most abundant at reference and oiled but untreated sites.

Macoma inquinata

This long-lived deposit-feeding clam, likely the deepest burrower of the more abundant bivalve species considered in this discussion, probably lives more than 5 years. It was the third most abundant clam at reference and oiled but untreated sites, comprising 9.5 and 12.9 percent, respectively, of the total bivalves collected in sites from these categories. The average number of individuals per sampling event was also basically the same (13.7 versus 10.6 individuals per event). *Macoma inquinata* was particularly abundant at Outside, Sheep, and Herring Bays and Block Island (Figure 5). Shelter Bay was the only oiled and treated site at which this species occurred.

Macoma balthica

This deposit-feeding clam (Newell 1965: Taghon 1982) burrows to shallow or moderate depths and can live at least five years (McGreer 1983). The average number of *Macoma balthica* per

sampling event ranged from 9.1 at reference sites to 1.0 at oiled and treated sites. This shallow-burrowing clam was most abundant at Block Island and Crab, Herring, and Sheep Bays. It was not observed at either Snug Harbor or Sleepy Bay (Figure 6). It was relatively uncommon in 1989, increased considerably at several stations in 1990 through 1992, and then declined dramatically at most stations from 1993 through 1996 (Figure 6).

Hiatella arctica

This suspension-feeding clam nestles in crevices on rocks at the surface of the substrate (Gulliksen et al. 1980). It was the third most abundant bivalve observed in the infaunal samples. It was the most abundant bivalve at oiled and treated sites, where it was twice as abundant as *Mysella tumida*, the next most abundant bivalve at oiled and treated sites (Table 1; 13.5 versus 6.2 individuals per sampling event). However, it only ranked fourth or fifth in the other categories.

Based on temporal abundance patterns observed in this study, it probably lives less than 3 years. *Hiatella* apparently failed to establish persistent populations wherever it appeared, instead exhibiting one- or two-year pulses at sites when it appeared (Figure 7). Even at oiled and treated sites, *Hiatella* only dominated the bivalve assemblage in 1991 through 1994 and in 1996.

Patterns in Sediment Characteristics

Several physical and chemical characteristics of sediments that can influence development of infaunal assemblages include particle grain size (PGS), total organic carbon (TOC), total Kjeldahl nitrogen (TKN), and polycyclic aromatic hydrocarbons (PAH) were measured.

Generally, sediments at all sampling sites were relatively coarse and most contained substantial quantities of pebbles. Average median grain size was finest at reference sites, where PGS averaged 1.9 mm, and coarsest at oiled but untreated sites, where PGS averaged >5.8 mm. Concentrations of fines in the sediments were generally low, ranging from 21.4 percent at reference sites to 5.0 percent at oiled and treated sites (Table 3).

In addition to fine particulates, sediments at reference and oiled but untreated sites were characterized by higher concentrations of total organic carbon (TOC) and total Kjeldahl nitrogen (TKN) than oiled and treated sites (Table 3). Highest concentrations of organics were measured at oiled but untreated sites and lowest at oiled and treated sites. This condition is probably partially related to whether or not the specific beaches experienced beach washing. These differences are significant except for the comparison of TOC between the reference and oiled and treated sites, percent fines between the reference and oiled but untreated sites, and PGS between reference and oiled and treated sites. The significant differences between reference and oiled but untreated sites in TOC and TKN are probably related to the oil residuals in the sediments and the bacterial flora operating to metabolize the oil.

Comparison of carbon:nitrogen (C:N) ratios provides further insight into the sediment quality at these sites. C:N ratios at reference and oiled but untreated sites are about 50 percent lower than at oiled and treated sites. This indicates that, per unit of carbon, nitrogen concentrations (largely contributed by bacteria on particulates) are lower at oiled and treated sites than elsewhere. This suggests that nutrient quality is poorer for deposit feeders (and selected suspension feeders) at oiled and treated sites than at reference or oiled but untreated sites (e.g., Newell 1965).

Table 3

Comparison of Sediment Characteristics at Infaunal Stations

Category/Site	Elevation Relative to MLLW (feet)	Median Grain Size (mm)	% Fines	PAH (ng/g)	TOC (%)	TKN (%)	C:N Ratio
Reference							
Bainbridge Bight	1.3	2.4	21.5	0.6	1.7	0.041	42.5
Crab Bay	–	1.5	18.6	5.4	2.4	0.047	49.8
Outside Bay	0.3	2.4	20.6	1.4	1.3	0.032	42.1
Sheep Bay	1.3	1.2	24.9	1.4	1.2	0.043	26.5
Average	1.0	1.9	21.4	2.7	1.6	0.041	40.2
Std. Error	0.3	0.4	1.5	0.8	0.3	0.004	5.7
Oiled but Untreated							
Block Island	3.6	2.8	14.6	2547	1.9	0.041	45.7
Herring Bay	-0.1	1.9	24.4	18	1.5	0.040	38.3
Mussel Beach South	-0.7	5.8	9.0	47	2.9	0.079	37.0
Snug Harbor	-0.4	>12.5	14.1	220	3.8	0.196	19.2
Average	0.6	>5.8	15.5	807	2.5	0.089	35.1
Std. Error	1.2	>2.8	3.7	431	0.6	0.043	6.5
Oiled and Treated							
Northwest Bay West Arm	0.5	3.9	3.4	19	0.8	0.009	88.1
Shelter Bay	0.5	3.1	7.2	67	0.8	0.013	57.9
Sleepy Bay	-0.8	3.9	4.2	77	1.9	0.025	76.0
Average	0.1	3.6	5.0	54	1.2	0.016	74.0
Std. Error	0.4	0.3	1.2	17	0.4	0.005	8.8

Because of the remoteness of these beaches from substantial sources of fine particulates, it is likely that the recovery to pre-treatment grain-size distributions could require at least several decades (pers. comm., Dr. M. O. Hayes). All of these beaches are relatively protected from wave action so the coarseness of the sediments on the beaches not exposed to washing is a strong indication that deposition rates are very slow. Although a strong relationship is frequently observed between fine particulates and organics (e.g., Newell 1965; Hartman 1965), it was not apparent is these data. However, as Cammen (1982) reported, neither TOC nor TKN exhibited an appreciable relationship to percent fines.

Average concentrations of PAH in sediments were lowest at reference sites sand highest at oiled but untreated sites and differed substantially among the three categories. Nevertheless, PAH concentrations at oiled but untreated sites (Table 3) are three to four orders of magnitude below concentrations used by Pearson et al. (1981) to assess effects of crab predation on *Protothaca* due to behavioral changes following exposure to oiled sediments. They are also below concentrations reported by Bernem (1982) as not causing mortality in *M. balthica*. The NOAA ER-L for PAH is 4022 ppb (Long et al. 1995), almost two times that of the highest average observed. Furthermore, PAH concentrations at both oiled but untreated and oiled and treated sites were declining by about 25 percent per year.

Possible Factors Influencing Composition Differences

The biological characteristics of the bivalve assemblages differed considerably among the treatment categories (Table 4). Reference and oiled but untreated sites supported relatively diverse robust populations of both suspension and deposit feeders and burrowing species appeared to thrive. In contrast, the relatively impoverished bivalve assemblages at oiled and treated sites were strongly dominated by suspension feeders, especially *Hiatella*, that live mainly at the surface of the sediments (Tables 1 and 4). Abundance of deposit feeders and burrowing species was low. Notably, *Hiatella* was substantially more abundant at oiled but untreated sites than at reference sites.

It is likely that several physicochemical and ecological factors are combining to cause the observed differences in community structure. Possibly physicochemical factors influencing larval recruitment and growth and survival of suspension- and deposit-feeding bivalves at oiled and treated sites include: 1) reduced fines, 2) nutrient concentrations, and 3) nutrient quality. Larvae for the species that dominate at the reference and oiled but untreated sites are more likely to settle out (recruit) in sediments with higher rather than lower concentrations of fine particulates or organics (TOC and/or TKN; e.g., Ockelmann and Muus 1978; Thorson 1957). In fact, except for *Hiatella*, significant recruitment events were lacking at oiled and treated sites (Figure 7). In contrast, they were commonly observed at most reference and oiled but untreated sites for all other dominant bivalve species (Figures 3 through 6).

Deposit feeders require large quantities of fines in order to survive and support growth (Lopez and Levinton 1987). Taghon (1982) reported than many deposit feeders effectively select smaller particles with a protein coating. Based on concentrations of carbon, nitrogen, and the C:N ratio (Table 3), nutrition conditions are considerably more favorable for suspension and deposit feeders at reference and oiled but untreated sites than at oiled and treated sites.

Table 4

Comparison of Relevant Biological Characteristics of Dominant Bivalve Species

	Clam Species				
Characteristic	*Mysella tumida*	*Protothaca staminea*	*Macoma inquinata*	*Macoma balthica*	*Hiatella arctica*
Potential Longevity (Years)	Up to 7	> 10	> 5	> 5	< 3?
Feeding Type	Suspension	Suspension	Deposit	Deposit	Suspension
Common Burrowing Depth (cm)	Surficial or nestles in host burrows	5 to 8	5 to 15	1 to 15	Nestles on surface of substrate
Dominance Pattern	All Types of Sites	Reference and Oiled but Untreated Sites	Reference and Oiled but Untreated Sites	Reference and Oiled but Untreated Sites	Oiled and Treated

Potentially relevant ecological factors include: 1) the paucity of host species to support *Mysella*, 2) paucity of adult populations to stimulate recruitment, 3) decreased predation on *Hiatella* at oiled but untreated and oiled and treated sites, and 4) predation and/or interference exclusion of the other bivalves by *Hiatella* at oiled and treated sites. The paucity of potential hosts at oiled and treated sites probably accounts in part for the failure of *Mysella* to recolonize these recently disturbed areas. Burrowing organisms such as sea cucumbers, sipunculids, echiurans, and shrimp were considerably less abundant at oiled and treated sites than at reference or oiled but untreated sites (Houghton et al. 1997). Moreover, the presence of adult infaunal organisms has been shown to facilitate recolonization of depauperate sediments (Thrush 1992), but these forms were generally lacking at these sites. Gulliksen et al. (1980) observed that *Hiatella* became dominant in areas with reduced predation. It is possible that the increased density observed for *Hiatella* at oiled but untreated and oiled and treated sites is a consequence of losses of predators following exposure to crude oil and, at oiled and treated sites, shoreline cleaning activities.

Recovery Predictions

Based on apparent patterns in community structure and sediment characteristics, habitats in greatest need of recovery are sites that were treated similarly to oiled and treated sites, i.e., washed with high pressure hot water. None of the sediment characteristics except PAH appeared to exhibit temporal patterns indicating recovery by 1996. PAH concentrations, however,

generally decreased, on average, 25 percent annually at oiled but untreated and oiled and treated sites between 1990 and 1993.

Based on the apparent lack of recruitment in the dominant bivalve species, it is likely that recovery of the bivalve assemblages at the oiled and treated sites will be delayed for a long period of time. Recovery seems to be tied more to re-establishment of initial sediment conditions and community structure disturbed by the shoreline treatment program than to reductions of PAH concentrations.

Conclusions

1. Bivalve assemblages at reference and oiled but untreated sites had significantly higher numbers of species and individuals than those at oiled and treated sites.

2. Species composition and dominance patterns at reference and oiled but untreated sites were very similar but differed markedly from those at oiled and treated sites.

3. Thus, it appears that exposure to oil, by itself, did not result in a significant long-term influence on infaunal bivalve assemblages in intertidal sediments in Prince William Sound.

4. However, it appears that exposure to shoreline treatment aimed at removing oil from the intertidal zone was accompanied by significant long-term impacts to infaunal bivalve assemblages. These impacts are partly a consequence of disruptions to the assemblages existing at the sites prior to the oil spill and to significant alterations of sediment conditions at the sites.

5. Because of the distance from these areas to regions producing substantial quantities of fine particulates, recovery of the sediment structure may take several decades.

6. Because recovery is based on, at least, re-establishment of: 1) complex interspecific interactions in the infaunal assemblages; and 2) sediment conditions, it is likely that recovery of the bivalve (and, concurrently, other components of the infaunal) assemblages in the intertidal zone at treated sites will require many generations of the invertebrate species before it is complete.

B. Rationale/Link to Restoration

What is described above is what we have found for a limited number of sites. At this point, no other studies have been continued long enough to observe the conditions that concern us and these conditions have not been reported elsewhere. Consequently, no other studies have suggested that sediment conditions such as reduced concentrations of fine particles, reduced availability of organic debris, or depressed microbial biomass, may be limiting the nature and rate of recovery of the intertidal infaunal assemblage. However, the implications of these conditions are momentous in terms of the ability of treated beaches to support foraging by higher trophic levels, especially nearshore vertebrate predators such as sea otters or harlequin ducks, and in terms of recovery rates,. We believe they are potentially significant and they need to be investigated to ensure the sound becomes whole again in less than geologic time.

This program is linked closely to the Nearshore Vertebrate Predator program. Personal observations and photographs from western Prince William Sound indicated that sea otters and sea ducks foraged intensively in intertidal areas before the spill. However, sea otters populations are not recovering in bays on northern Knight Island (pg 17, FY 02 Invitation). Harlequin ducks are also not recovering in parts of the sound that were oiled. Inadequate clam resources could be one contributing factor in these recovery failures. However, this has not been investigated satisfactorily for intertidal habitats and may be a critical issue in the restoration of these other damaged resources.

This program provides an important linkage between the basic impact study that was designed to assess the nature of impacts and the rate of recovery, on one hand, and restoration efforts, on the other. Our initial studies have suggested the potential nature of the impacts in infaunal assemblages and have suggested mechanisms that could be responsible for the observed impacts. This program will provide insight into the generality and extent of the reported impact. Moreover, it will provide a detailed examination of some of mechanisms that could be driving the observed impact and could be the key to a restoration effort.

Within the framework of the goals of the Gulf Ecosystem Monitoring (GEM) program planned by the EVOS Trustee Council, this program would address Shorter-term Focused Research (i.e., the lingering effects of EVOS discussed on pg 29 of the GEM Review Draft, March 7, 2000) and long-term monitoring. It would provide insights into whether general restoration projects should be carried out on mixed-soft substrates in order to bring about recovery of intertidal bivalve and other infaunal resources important to nearshore vertebrate predators and human subsistence fishing.

In terms of the long-term monitoring aspects of the planned GEM program, this program can be viewed as a first step for establishing long-term monitoring of intertidal bivalve resources in the region. It would establish a network of sampling sites in Prince William Sound that could be expanded into the Gulf of Alaska (Blying Sound and the Outer Kenai Peninsula), Cook Inlet, and onto Kodiak Island, as discussed on pg 79 of the draft document.

C. Location

Prince William Sound is a protected fjord system located on the southcentral coast of Alaska (Figure 1). The shoreline is heavily dissected and irregular, providing a high diversity of shoreline types and a wide range of exposure. We are proposing to conduct these studies in central, western, and southwestern portions of Prince William Sound, which lay in the path of the oil slick as it flowed through the sound. Areas where sites may be selected include: the Naked Islands, Perry Island, islands in the Knight Island archipelago (i.e., Knight, Eleanor, and Disk Islands, and the smaller islands on the west side of Knight Island), Chenega, Bainbridge, Evans, Elrington, Latouche, and Green Islands, and the mainland bordering the west side of the sound from Port Nellie Juan to Port Bainbridge.

Many beaches on the islands and mainland in this area were oiled. We propose to focus on areas that were moderately to heavily oiled and subsequently exposed to shoreline treatment involving high-pressure hot-water washing. We propose to concentrate our efforts on beaches in protected embayments and small coves that are primarily composed of a mixture of gravel, sand, and silt

(mixed-soft). However, we will also sample in relatively more exposed beaches such as Sleepy Bay. We also propose to intersperse reference (unoiled and untreated) sites throughout the sampling area to the degree possible.

The semi-diurnal tides have an extreme tidal excursion of about 5.5 m. We propose to sample the beaches between Mean Lower Low Water (MLLW = 0 meter) and 0.8 m above MLLW. While the treated sites that we examined during the NOAA study ranged from –0.25 m to +0.15 m relative to MLLW, we are aware that shoreline cleanup crews attempted to avoid washing the lower intertidal. Therefore, we are proposing to sample at a higher level to increase the likelihood of sampling at elevations that were treated. Densities of the littleneck clam and other species were common within or above this elevation range at most of the untreated or reference sites sampled during our NOAA studies. In contrast, infaunal assemblages were impoverished at sites above +1.3 m.

Prince William Sound was recently subjected to another catastrophic event when it was uplifted by the 1964 Good Friday Earthquake. The portion of the sound in which our studies will be conducted was uplifted from ~4 feet in the vicinity of the western mainland and islands to ~10 feet on Latouche Island (Hanna 1971). Heaviest oiling occurred in areas that were uplifted from 4 to 8 feet.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

We propose to include a community involvement element for the regional native villages in this program. The purposes of this element are to: 1) disseminate the findings of our previous studies to the natives; 2) describe the objectives of the proposed study; and 3) solicit traditional knowledge from the natives regarding locations of beaches traditionally used for gathering clams. To accomplish the goals of this element, we propose to involve natives from New Chenega, Tatitlek, and possibly Valdez. We propose to contact the native communities by telephone and mail initially and, subsequently, conduct informal meetings in each location if this is deemed desirable. These meetings will be organized with the assistance of Ms. Sarah Ward, the Spill Area-Wide Coordinator for the Trustee Council and Dr. Henry Huntington, the Traditional Ecological Knowledge Specialist for the Council. In mailings, we will describe the findings of our previous studies, our conclusions, and their implications for recovery and restoration of bivalve assemblages on the affected beaches in the sound. We will describe our plans for this program, i.e., where we are going, and what we are trying to achieve. In order to identify historically productive beaches, we will solicit information from the native elders to identify traditional subsistence gathering beaches in and adjacent to the region exposed to the oil spill.

If deemed desirable, we will meet with native groups during our field studies to expand on the information that we have provided. At each meeting, we will make an informal presentation with slides and maps describing our findings.

PROJECT DESIGN

A. Objectives

The purposes of this program are to determine if the impoverished condition of intertidal bivalve assemblages observed in oiled and treated areas during the NOAA 1990-97 studies is general to treated sites throughout the western sound and to examine the sediment characteristics that may be causing it. The program will address two major objectives. The first is to evaluate whether the depressed condition of bivalve assemblages at treated sites observed in our earlier work is general to treated sites throughout western Prince William Sound. The second objective is to evaluate the role that three sediment characteristics may play in the apparent depression of bivalve assemblages in treated sediments. The four major hypotheses that will be tested to compare patterns in bivalve assemblages between oiled and treated and reference sites in western Prince William Sound are listed below:

Bivalve Assemblages

1. H_o = Numerical characteristics of the bivalve assemblage (numbers of taxa and individuals) are similar at treated and reference sites.

   H_a = Numerical characteristics of the bivalve assemblage exhibit lower values at treated sites that at reference sites.

2. H_o =Species composition of the bivalve fauna is similar at treated and reference sites.

   H_a = Species composition of the bivalve fauna is more complex and productive at reference sites than at treated sites.

3. H_o = Functional characteristics of the bivalve assemblage (dominance by deposit feeders, tubicolous or burrowing forms) are statistically similar at treated and reference sites. Deposit feeders and tubicolous or burrowing forms are equally abundant at treated and reference sites.

   H_a = Functional characteristics of the bivalve assemblage are dissimilar at treated and reference sites. Deposit feeders and tubicolous or burrowing forms are more abundant at reference sites than at treated sites.

Sediment Characteristics

4. H_o = Sediment characteristics are statistically similar at treated and reference sites. Percent silt/clay, Total Organic Carbon, Total Kjeldahl Nitrogen, , and C:N ratios are similar at treated and reference sites.

   H_a = Sediment characteristics are dissimilar at treated and reference sites. Total Percent silt/clay, Organic Carbon, and Total Kjeldahl Nitrogen are lower at treated than at reference sites., and C:N ratios are higher at treated than at reference sites.

B. Methods

Approaches

The approach we are proposing addresses whether the depressed condition of bivalve assemblages observed at treated sites in our earlier work is generally occurring at treated sites throughout western Prince William Sound. It examines species composition and ecological function for the intertidal bivalve assemblages. This study will involve 22 sites throughout western Prince William Sound that were oiled and subsequently treated with high-pressure hot-water wash techniques and 12 reference sites that have not been oiled or treated but are otherwise similar. For this study, we will focus on bivalves. We will also characterize several relevant sediment characteristics at all sampling sites.

Sampling Design

Based on the results of power analyses (see below), we propose to sample at 22 oiled and treated sites and 12 reference sites. We will collect five replicate samples for bivalves and sediment grain size at each of these sites. Samples for important sediment characteristics such as particle grain size, total organic carbon, and total Kjeldahl nitrogen will be collected for each replicate and composited for each site.

Random Selection of Sites

A large proportion of the sites will be selected in a stratified random manner. Several strata will be employed in order to reduce the potential variability that could be experienced if all beaches were considered together. The region will be stratified geographically into northern and southern strata. The east-west oriented portion of Knight Island Passage will act as the dividing line between the southern and northern strata. Each of these strata will be further stratified on the basis of oiling and treatment history. This study is focusing on intertidal mixed-soft sediments[1]. Because most beaches with this sediment type are located in embayments, the shoreline will be stratified to include primarily embayments. All of the identifiable embayments within each of the strata will be assigned a number. Within that area, only beach segments consisting primarily of mixtures of silt, sand, and pebbles will be considered. The Department of Natural Resources GIS database will be used to assist in this process. Finally, these beach segments will also be stratified on the basis of beach elevation. Only beaches on which the appropriate sediment type is found between 0 and 0.8 m above MLLW will be considered.

Six sites will be carried over into the sampling design from previous programs due to their historic value. These historic sites will include: reference (Outside Bay and Bainbridge Bight) and oiled and treated sites (Northwest Bay West Arm, Shelter Bay, and Sleepy Bay) from the NOAA recovery and treatment effects program; a high-pressure hot-water washed site from an Exxon beach cleaner study (Disk Island).

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[1] Sites with predominantly sandy or silty sediments, such as the northern end of Crab Bay, will be eliminated from further consideration because they typically support a substantially different bivalve fauna.

The proposed allocation of sites among strata is shown in Table 5. The number of sampling sites allocated to each cell is based roughly on the amount of shoreline available within each specific stratum. Allocation has also been tempered by the potential for finding suitable sites within a cell and the need to have at least three sites to provide reasonable estimate of variability.

Table 5

Allocation of Potential Sampling Sites Among Geographic and Spill Exposure Strata

Strata	Oiled and Treated	Unoiled Reference
Northern Insular	8 sites Northwest Bay West Arm, Disk Island + 6 random sites	3 sites Outside Bay + 2 random sites
Northern Mainland	3 random sites	3 random sites
Southern Insular	8 sites Shelter and Sleepy Bays + 6 random sites	3 random site
Southern Mainland	3 random sites	3 sites Bainbridge Bight + 2 random sites
Total Sampling Sites	22	12
Number of Historic Sites	4	2
Number or New Random Sites	18	10

Suitability Criteria for Site Selection

At least 50 sites will be visited and evaluated during the reconnaissance survey to evaluate their suitability as potential candidate sites. During the visit, the suitability of the sites will be evaluated on the basis of the criteria described below. Unsuitable sites will be omitted from further consideration. Final selection of the random sites will be made by randomly selecting the appropriate number of sites from among the remaining pool of acceptable sites for each stratum.

The following criteria will be evaluated for each site in order to determine its suitability for inclusion in this study.

- Does the site have mixed-soft sediment (mixed fines, sand, pebbles, and boulders) between 0 and +0.8 m (+2.6 feet) above MLLW?

- Is there a 30-m long expanse of suitable sediment available for sampling at the appropriate elevation?

- Is there a strong indication of oiling/treatment history in SCAT or shoreline treatment records?

- Is the site located suitability far from any stream, river, or glacier that could expose it to depressed temperatures or a strong or sustained freshwater influence?

- Is the site subject to strong anthropogenic influences other than the effects of the oil spill and shoreline treatment (e.g., mine tailings, log dumps, or marina activities)?

Note that the species composition and abundance of bivalves are not included as suitability criteria. Because two major hypotheses involve species composition and abundance, using these variables as site selection criteria would bias the results, especially for the reference sites.

Bivalve Sampling

Sample Collection and Handling

Samples for the bivalve assemblage will be collected with core samplers 10.7-cm in diameter (0.009 m^2) by 15-cm deep. Five of these cores will be collected at randomly selected locations along a 30-m horizontal transect placed at the appropriate elevation at each site. To the degree possible, the elevation sampled will be standardized among sites.

Each sample will field sieved through a 1.0-mm screen, washed into a double-labeled Ziploc bag, and fixed with buffered 10% formalin-seawater solution. After several days, we will replace the formalin-seawater solution with isopropyl alcohol. The preserved samples will be stored in water-tight plastic buckets and shipped to the taxonomic laboratory at the completion of the field work.

Lab Analysis

Following receipt of the samples in the laboratory, they will be washed by elutriation and the bivalves will be preserved in isopropyl alcohol. The remainder of each sample will be discarded. The bivalves subsequently will be sorted, identified to the lowest appropriate taxon, and enumerated.

A representative sample of each bivalve taxon will also be measured to provide insight into the size structure and biomass of the populations living at each site. Length measurements will be made with vernier calipers or ocular micrometers, as appropriate.

Sediment Characteristics

Whole sediment samples will be collected at all sites for analysis of particle grain size, total organic carbon (TOC), and total Kjeldahl nitrogen (TKN). These samples will be composited from surficial sediments scooped approximately 2 cm deep at points immediately adjacent to the randomly selected sampling locations for collection of the bivalve cores. Thus, the single composite sample will not provide a measure of within-site variance for the sediment variables

but this measure is not viewed as necessary for the purposes of this study. Each composited sample will be preserved by freezing.

These will be analyzed to provide information on a suite of pertinent sediment property covariates that appeared important to the development of infaunal assemblages in our previous studies.

Particle Grain Size

Particle grain size distributions will be determined using a pipette method (Plumb 1981) modified to correct for dissolved solids (i.e., salinity and the dispersant added to keep silt/clay particles from clumping).

Organic Nutrients (Total Organic Carbon and Total Kjeldahl Nitrogen

The samples used for analysis of organic nutrients in the sediments will be purged of inorganic carbon, dried at 70°C, ground, and sieved through a 120-mesh screen. TOC will be measured on a Dohrman DC-180 Carbon Analyzer using EPA method 415.1/5310B. TKN will be measured using EPA Method 351.4.

Statistical Analysis

Two types of statistical analyses will be used in this study, namely inferential and exploratory analyses. The inferential statistics will test, for example, specific values or indices (e.g., species richness or density of an indicator bivalve species) to measure the significance of the difference between the controls and treated sites. Where possible, an exact probability and the power of the statistic will be stated. Typically, we prefer to use randomization or permutation statistics (Edington 1987; Manly 1997) in contrast to the classical parametric techniques. These computer-intensive methods require none of the assumptions of equality of variance or normal distribution of data as do the parametric techniques. They rely solely on a truly random sample and the empirical distribution of the data to calculate the exact significance of the statistic.

Most of the inferential statistics will be either two-sample t-tests or simple ANOVAs although the procedures can be modified for more novel designs. The tests will be either one- or two-tailed, depending on our ability to predict the impacts from prior data. While acknowledging the inherent dangers of multi-comparison testing (i.e., you are likely to find some positive results based solely on probability rather than a real effect; also termed losing control of the alpha error), we will be looking for overall trends of significant effects and supporting evidence from the exploratory analyses rather than relying on any "critical" inferential decision result. Thus, Bonferroni corrections to experiment-wise alpha will not be used.

Exploratory analyses would include some appropriate combination of multivariate analyses. It might be as simple as graphically looking at various stratum- or species-specific histograms for the bivalve species or as complex as a full-blown ordination and clustering exercise using multi-species biological and physical data (Clarke 1993). This form of analysis can be quite useful to discern and interpret common or correlated patterns in the data but is difficult to quantify with probability values. However, exploratory analyses are invaluable for providing an understanding of the natural processes that is sufficient to interpret the inferential findings and to formulate testable hypotheses.

Statistical Power

Power analyses are useful to this project for two purposes: to estimate the number of replicates appropriate to study's statistical goals, and after data are collected, to understand the sensitivity of the inferential tests.

First, using as pilot data the latest available set of infauna data (NOAA, 1996), the sampling variances can be used to calculate the sampling intensity (number of replicates) required to detect an appropriate size of effect. The statistic of concern is the difference in individual species abundance (or species richness, total abundance, sediment fraction, TPAH, etc.) between reference and oiled and treated sites. The infauna pilot data set contains 3 sites (replicate means) in each category, n= 3, 3. Power analyses projected combinations of replication up to n = 25, 25 using the reported sampling variances. The species with the best power to detect an effect (i.e., highest power for lowest practical effect) are suggested as primary indicator species for discriminating the reference from the oiled and treated sites (Table 6).

Table 6

Power to detect proportional differences in species abundance between reference and oiled and treated sites. Calculations are based on 1996 data (n = 3,3), for a 2-sample t-test for the difference of means using alpha = 0.10, pooled variance and sampling intensity of n = 10 and 20 replicates, respectively, for reference and oiled and treated sites. Values with power exceeding 50% and potential indicator species are bold formatted.

	Reference		**Oiled and Treated**		**Proportionate Detectable Effect (percent)**				
Taxon	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**100**	**75**	**50**	**25**	**10**
Diplodonta aleutica	0.0	0.0	0.7	1.2	**81**	**60**	35	17	11
Mysella tumida	50.0	75.5	4.0	3.6	**83**	**62**	37	17	11
Macoma spp.	9.0	7.8	0.0	0.0	**100**	**98**	**81**	35	14
Macoma balthica	17.0	14.9	0.0	0.0	**100**	**98**	**81**	35	14
Saxidomus gigantea	0.7	1.2	0.0	0.0	**81**	**60**	35	17	11
Protothaca staminea	12.7	11.2	1.0	1.0	**100**	**100**	**97**	**54**	18
Mya arenaria	1.0	1.0	0.0	0.0	**100**	**97**	**76**	. 32	14
Hiatella arctica	1.7	2.1	21.3	24.4	**91**	**72**	44	19	11

The second utility of power analyses comes during *post-hoc* calculations wherein the actual power of the significant results is reported. For example, a difference in the abundance of a single species between two treatment categories may be statistically significant ($p < 0.05$); however, the ability to detect a meaningful change may not be very powerful. If the power analysis reported a power of 0.50 for a 100% change in a species abundance, it means that although you have only a 5% chance of wrongly proclaiming the change was real, you also have a 50% chance of missing a real change that was less than a 100% difference.

A concern arises in estimating power for randomization statistics; currently no formula are available s to use for the calculations. However, based on the knowledge that a randomization test produces precisely the same result as a comparable parametric test when applied to normally distributed data, the power of randomization tests is inferred to be equal to parametric tests in that ideal case. As a data distribution deviates from normality, the assumptions for the parametric test are violated and power is compromised. However, under these circumstances, the randomization test results are unaffected and power is assumed to remain roughly the same. For our purposes, we must rely on calculations of parametric power to estimate the power of the randomization tests.

Bivalve Variables

Inferential testing for comparing bivalve variables between reference and oiled and treated sites will be accomplished using 2-sample t-tests for the selected indicator species and population indexes. If needed, size frequencies will be tested using either a Kolmogorov-Smirnov test or the alternative weighted Anderson-Darling test. Two-way ANOVAs will be used to test for stratified category effects. Multivariate analyses will likely follow the combined NMDS and clustering techniques described in Clarke (1993).

Sediment Characteristics

Physicochemical sediment characteristics will be tested for category effects using 2-sample t-tests. The data will also be examined for correlations with various species and as covariates to the multivariate ordinations.

Comparison Between Site Categories

The following categories will be compared , using 2-sample t-tests or stratified 2-way ANOVAs:

- All oiled and treated vs all reference sites
- New oiled and treated vs new reference sites
- New oiled and treated and NOAA Category 3 (oiled & treated sites carried over from previous studies)

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Not Applicable

SCHEDULE

The first year of this project will focus on three major items. These include: 1) selection of appropriate sampling locations, 2) conduct of the field sampling program, and 3) laboratory analysis of bivalve and sediment samples. The field work (reconnaissance survey and field sampling program) will be conducted during the two spring tide series in June 2002.

The samples will be received by the laboratories in July 2001 so it is unlikely that results will be available until October 2002. Consequently, we do not anticipate completion of data entry and database development until December 2002.

A. Measurable Project Tasks for FY 02 (October 1, 2001 – September 30, 2002

October 1 –15, 2001 Arrange and finalize contracts with subcontractors

October 16 Commence sampling site selection process by review of appropriate SCAT and shoreline treatment records

January 14 - 23 (2 days) Attend Annual Restoration Workshop; initiate dialog with knowledgeable native regarding location of historical subsistence clam harvest sites

March/April Arrange air/vessel support logistics and contracts

April 13 Submit progress report; no data available for FY 02 at this point.

May 15 Finalize list of candidate sampling sites

June 9 – 16 Conduct reconnaissance survey to finalize selection of sampling sites

June 22 - 30 Conduct field sampling program

June 30 Ship bivalve and sediment samples to respective labs for analysis

July 15 – 30 October Analysis of bivalve and sediment samples

Most of the data analysis, report and manuscript preparation, and presentation of the results at the annual restoration workshop and at a national conference, will occur during the second year of the project (FY 03).

B. Project Milestones and Endpoints

The objectives for this program are to evaluate: 1) whether or not the depressed condition of bivalve assemblages at treated sites observed in our earlier work is general to treated sites throughout western Prince William Sound; and 2). the role that several sediment characteristics in may play in the apparent depression of bivalve assemblages in treated sediments. The objectives for this program will be addressed concurrently starting in June 2001 by collecting bivalve and sediment samples at numerous oiled and treated and unoiled reference sites in western Prince William Sound.

FY 02

January 14 - 23 (2 days) Attend Annual Restoration Workshop

April 15 Arrange air/vessel support logistics and contracts

May 15 Finalize list of candidate sampling sites

June 16 Complete reconnaissance survey.

June 20 Finalize selection of sampling sites

June 30 Complete field sampling program

July 2 Ship bivalve and sediment samples to laboratories

October 30 Complete analysis of bivalve and sediment samples

FY 03

November 1 Commence data entry and analysis

December 31 Complete analyses of bivalve and sediment data

January 15, 2003 Commence preparation of annual report describing findings of the FY 02 field survey

February 15 Commence preparation of presentation describing the findings of the bivalve studies

April 13 Submit annual report (FY 02 findings)

May 1 Commence preparation of manuscript for peer-reviewed journal describing the findings of the bivalve studies

Laboratory analysis of those samples will require at least 3 months, following which we evaluate the data to address the questions posed by the objectives.

C. Completion Date

The program described in this proposal will be completed in the 3rd quarter of FY 03, in time for presenting final results and conclusions in the annual report describing FY 02 findings. The findings will be submitted as a manuscript to a national peer-reviewed journal and at a national conference during FY 03.

PUBLICATIONS AND REPORTS

April 2003 annual report to EVOS Trustee Council for project activities in FY 2002. This annual report will be the final report for this program.

Response and Recovery of Intertidal Infaunal Bivalves Exposed to the *Exxon Valdez* Oil Spill and Related Shoreline Treatment at Selected Sites in Prince William Sound. D C. Lees, W. B. Driskell, and J. P. Houghton. This research was not funded by the EVOS Trustee Council. This will be submitted in Fall 2001 to Marine Ecology Progress Series or Spill Science & Technology Bulletin.

Long-term Recovery Patterns in Prince William Sound Intertidal Bivalves Following *Exxon Valdez* Oiling and Shoreline Treatments, 1989 through 2002. D. C. Lees and W. B. Driskell. This will be submitted in Fall 2003 to Marine Ecology Progress Series or Ecological Applications.

PROFESSIONAL CONFERENCES

No funds requested at this time. Probable attendance at the 2003 International Oil Spill Conference and the 2003 SETAC Conference to present papers on findings of this program.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We have coordinated with Dr. Henry Huntington to develop a Community Involvement program and gain access to traditional knowledge that we intend to use in selection of sample sites. Those aspects are described above in this proposal.

We anticipate sharing information with Steven Jewett, Univ. of Alaska, Fairbanks, James L. Bodkin, USGS, and Thomas Dean, Coastal Resources Associated, Inc. Furthermore, we will discuss our findings with Glenn VanBlaricom and Allan Fukuyama to exchange with information with their subtidal programs.

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Dennis C. Lees

With over 30 years of national and international experience, Mr. Lees has extensive capabilities in the study and evaluation of nearshore and intertidal benthic systems ranging from the Beaufort Sea and Chukchi Sea in Alaska to California, Micronesia, and the Arabian Gulf. He has been a pioneer in the research of intertidal and shallow subtidal ecology in Cook Inlet and Prince William Sound and has performed intertidal or subtidal surveys at numerous other locations in the state including Prudhoe Bay, the eastern Chukchi Sea, the Bering Sea, Unalaska, Akutan, Shelikof Strait, and the Outer Kenai Peninsula. He has participated in a variety of field, analytical, and reporting activities as a principal investigator or project manager. He has assessed or predicted impacts for a wide spectrum of industrial development activities on coastal marine habitats around the world. He has strong experience in evaluation of impacts from oil-and-gas and mining exploration and development, oil and ore spills and related clean-up and treatment activities, especially in Alaska, construction and operation of petrochemical, power, desalination, and wastewater treatment facilities, and port and airport construction and operation.

Specific experience related to oil spills and Alaskan marine systems includes:

- Recent experience in oil spill assessment and evaluation of treatment methodologies on the *Exxon Valdez* Oil Spill in Prince William Sound, the outer Kenai Peninsula, and Cook Inlet for NOAA and Exxon.

- Baseline studies of intertidal biota in Prince William Sound, Outer Kenai Peninsula, and upper and lower Cook Inlet.

- Current performance of an Ecological Risk Assessment evaluating risks to the water column and intertidal zone of coal-water fuel spills in upper Cook Inlet.

- Recent and continuing experience in pre- and post-abandonment (decommissioning) projects in the Santa Barbara Channel with special emphasis on surveying and restoration efforts for kelp, eelgrass, and surfgrass resources.

- Extensive experience in sampling and analysis of sediment contamination and benthic and demersal fish communities associated with rocky and soft substrates and kelp beds along the west coast of the United States and Alaska.

- Extensive experience with environmental assessments for the development phase of offshore and coastal oil and gas development and refinery operations in California, Alaska, and the Arabian Gulf

Mr. Lees obtained his B.A. in Zoology from UCSB, an M.S. in Biology from San Diego State University (SDSU), and completed all but the dissertation requirements for a Ph.D. in a joint doctoral program for SDSU and University of California, Riverside.

Mr. Lees participates in and manages a variety of marine science and environmental activities focusing on marine ecological risk assessment, habitat restoration, sediment and effluent toxicity testing, as well as traditional marine ecological assessment of benthic and nearshore fish

communities. His research experience has been concentrated in evaluation of contaminant impacts in intertidal and nearshore biological systems in bays, estuaries, and coastal regions ranging from Alaska and California to the Arabian Gulf. From 1989 to 1996, he served as a project manager and principal investigator on a series of multi-year marine biological studies of intertidal and shallow subtidal habitats in Prince William Sound to study: 1) the initial impacts of the *Exxon Valdez* oil spill; 2) biological costs and effects of shoreline treatment following the oil spill; and 3) long-term effects and recovery of the biota. He participated in a major ecotoxicological study to determine the effects of spilled copper ore on the biota in marine sediments in San Diego Bay. Other sediment quality studies in which he has participated include dredging feasibility studies at the Sub Base, 32nd Street, and Continental Maritime of San Diego, and PCB evaluations at Convair Lagoon. Recently, he has been involved in eelgrass and kelp resource assessments and subsequent restoration and mitigation programs. He has assessed or predicted impacts on nearshore marine habitats from a wide variety of industrial development activities, including construction and operation of port facilities, power, desalination, petrochemical, and wastewater treatment facilities, oil development, oil spills and related clean-up and treatment activities. He participated in development of ecological risk assessment programs for Pearl Harbor and Guam as part of Ogden's Navy CLEAN program for PACDIV. He was project manager and principal investigator on major biological studies of the demersal fishes, zooplankton, benthic assemblages, wetlands, and coral reefs in two regions in the Arabian Gulf to monitor the development of a major petrochemical industrial complex, associated large power and desalination plants, and operation of a major supertanker port.

OTHER KEY PERSONNEL

All of the key personnel worked together in Alaska on major projects reaching back to 1975. We have well established working relationships.

A. William B. Driskell – Sampling Design and Statistical Approach

Mr. William Driskell will design the sampling program for this study. Moreover, he will be in charge of the various databases required for the various kinds of data and statistical analyses. In 1988, Mr. Driskell began a computer and marine biological consulting business in Seattle dealing primarily with scientific databases and statistical analyses ranging from sampling designs to multivariate statistics. He has worked as a marine biologist for the past 25 years, principally in the south-central Alaska and the Puget Sound regions but interrupted by a three-year sojourn in the Middle East where he participated in major baseline and effluent effects studies. He has been working in Prince William Sound since 1977 and on the *Exxon Valdez* oil spill since March 1989. His specialties applicable to this program are statistics, data management and computer programming. His expertise also includes: taxonomy of North Pacific and Arabian Gulf marine invertebrates and fish; biological survey techniques including trawl, seine, diving, benthic grab, dredge and box core, underwater television and still photography; and bird identification.

B. Laboratories

Bivalve Assemblages – Littoral Ecological & Environmental Services

Sorting, identification, and measurement of the bivalves in the samples obtained in July 2002 will be conducted in the laboratory of Littoral Ecological & Environmental Services, under the direct supervision of Mr. Dennis Lees.

Sediment Characteristics – To Be Determined

The laboratories in which these routine analyses (particle grain size, total organic carbon, and total Kjeldahl nitrogen), will be conducted will be determined after contract award.

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FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$42.2						
Travel		$6.6						
Contractual		$37.5						
Commodities		$2.3						
Equipment		$0.0						
Subtotal	$0.0	$88.6	Estimated FY 2003					
Indirect								
Project Total	$0.0	$88.6	$33.0					
Full-time Equivalents (FTE)		0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Prepared: 4/9/01

Project Number: ~~Not Assigned~~ 02574-BAA
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4A
Non-Trustee
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2002
D. Lees	Principal Investigator, Infaunal Analyses		1.9563	12.8		25.0
W. Driskell	Sampling Design and Statistics		1.3563	9.6		13.0
Unid. Field Techs	Sample collection and processing		0.6563	6.4		4.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Subtotal			4.0	28.8	0.0	
					Personnel Total	$42.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
D. Lees, San Diego to Anchorage, annual Restoration mtng	0.8	1			0.8
D. Lees, San Diego to Anchorage, Travel to point of departure for field surve	0.8	1			0.8
W. Driskell, Seattle to Anchorage, Travel to point of departure for field survey	0.65	1			0.7
Field tech, San Diego to Anchorage, Travel to point of departure for field sur	0.8	1			0.8
Auto rental during meeting and field study	0.04	8			0.3
Per diem			27	0.12	3.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$6.6

FY02

Project Number: Not Assigned
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 4/9/01

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed
Description	FY 2002
Sediment Grain Size, 34 samples	5.4
Infaunal Analyses, 170 samples	8.5
Air Charter, 42 hours of air support for reconnaissance	11.6
Vessel Charter, 8 days charter, providing transportation, lodging, and food for field crew	12.0
Contractual Total	$37.5

Commodities Costs:	Proposed
Description	FY 2002
Shipment of equipment and samples	0.4
Film & Processing	0.1
Field Supplies & Expendables	0.8
Printing, xerox, and phone	1.0
Commodities Total	$2.3

FY02

Prepared: 4/9/01

Project Number: Not Assigned
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
Not Applilcable			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	
Not Applilcable		

FY02

Project Number: Not Assigned
Project Title: Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound
Name: Dennis C. Lees

FORM 4B
Equipment
DETAIL

Prepared: 4/9/01

The Marine Macrofauna of Prince William Sound: An Annotated List

proposal for a publication

Project Number: 02578

Restoration Category:	Monitoring
Proposers:	Nora R. Foster and Howard M. Feder
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	no
Duration:	1st year, 1- year project
Cost FY 02:	$35,829
Geographic Area:	Prince William Sound
Injured Resources/Service:	Nearshore Ecosystem

ABSTRACT

Data sets that present basic taxonomic and biogeographic information at the species level for 1645 animal species from Prince William Sound have been compiled as part of research on potential introductions of nonindigenous species. This proposal seeks funding to make this important information available to a wider group of users, including EVOS stake holders.

INTRODUCTION

Biological surveys in Prince William Sound have documented the presence of over 1645 animal species in Prince William Sound. However, most research and restoration efforts work have focused on a very small set of species. The scientific validity of long-term monitoring of biodiversity responses to environmental change (i.e. for GEM) depends on accurate species-level identifications, and better resolution of data on species distributions. The data sets describing biodiversity of Prince William Sound that have been compiled as part of research on potential introductions of nonindigenous species into Prince William Sound (Hines et al. 2000) could be an important contribution to research, restoration and monitoring if the data were made available to a wider group of users.

For this proposed project, Nora Foster and Howard Feder will verify the accuracy of the information already compiled, make any necessary corrections, add detail, and will write introductory and descriptive sections. Taxonomic experts will be asked to review several data sets. The proposers have appraoched several potential sponsors for final editing and distribution ofthe resulting publication.

NEED FOR THE PROJECT

A. Statement of Problem

In the summary of a major study on potential introductions of nonindigenous species into Prince William Sound, Hines et al. (2000) raise the points that: "Taxonomy and biogeography of species in Alaska marine ecosystems have received poor levels of study and understanding" and that: "In general the poor resolution of taxonomic and biogeographic data in Alaskan marine ecosystems is a substantial impediment for analysis of environmental impacts."

B. Rationale/Link to Restoration

The detailed species level information in these data sets will help anyone involved in an environmental monitoring project to select species by taxon, geographic distribution, or habitat, and to begin a literature search. Scientists working in other high-latitude regions where environmental stress and nonindigenous species are growing concerns, the Baltic Sea, for example, can use the data sets to compare species abundance, biogeographic patterns, and taxonomic composition.

C. Location

This work will be accomplished in Fairbanks, Alaska.

PROJECT DESIGN

A. Objectives

1. Contact additional taxonomic experts, send out draft data sets for their critique

2. Edit data tables:
   Add author of each species level taxon
   Search data sets for records that may not be adequately verified, and for missing information ammend as neeeded based on published literature and museum specimens databases

Review all taxonomic and biogeographic information

3. Send completed manuscript to publisher

B. Methods

To verify the accuracy of the information, we will contact additional taxonomic experts, send out draft data sets for their critique. The data tables will be refined by: adding author of each species level taxon; searching data sets for records that may not be adequately verified, searching the data sets for missing information.

We will add introductory and descriptive sections. Taxonomic experts will be asked to review data sets for Cnidaria, Nemertea, Bryozoa, Crustacea, Urochordata, "minor phyla", and fishes.

The data sets are described below:

Scope

Taxonomic: The publication will include free-living animals. Protists and endoparasites are outside the scope of the project

Geographic: Prince William Sound waters are well-defined. We have used literature and collecting records from Port Bainbridge, east to Orca Inlet, and south and east to the outer coasts of Montague and Hinchinbrook islands. However, for some taxa, (e.g. Bryozoa), the fauna of adjacent areas (northeastern Gulf of Alaska and Kodiak Island waters) are better documented and some records for those areas are included. Migratory animals (birds, some marine mammals) that use Prince William Sound waters only seasonally are included in the data set. Many planktonic Cnidaria and Crustacea from the northern Gulf of Alaska listed in the data sets may occur in Prince William Sound only rarely, depending on oceanographic conditions.

Size and Format

The data sets that comprise the bulk of the proposed publication are in the form of 10 separate Excel worksheets for Cnidaria and Ctenophora, Annelida, Mollusca, Arthropoda , Bryozoa, Echinodermata, miscellaneous invertebrate taxa, fishes, birds, and mammals. In their draft format, there are 58 pages of tables. A 15 page introduction to the report summarizes the projects purpose, scope and sources of information, and presents a summary of information for each major animal group. There are seven pages of bibliography.

Data are presented in tabular form, one species per row. The following data fields, as columns, are common to all data sets:

Family, Genus, Species
Source
Habitat
Distribution
A **Source** for distributional information

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The proposers have approached the Santa Barbarea Museum of Natural History and the Oil Spill Recovery Institute for support to cover costs associated with editing, indexing, proofreading, typesetting, marketing and distribution. Other Co- sponsors will be approached.

The following taxonomic experts have been involved with the nonindigenous species project and other fauna surveys, and will provide editorial comment on appropriate sections:

Jerry Kudenov (University of Alaska Anchorage, polychaete annelids)
Jeff Cordell (Santa Barbara State University, opisthobranch gastropods)
Jon Norenburg (Smithsonian, nemerteans)
Claudia Mills (University of Washington, Cnidaria)
Sarah Cohen (Harvard University, Urochordata)
Judy Winston (Virginia Museum of Natural History, Bryozoa)
Jeff Goddard (University of Washington, pericarid crustacea)
Katherine Mecklenberg (US Fish and Wildlife Service, fishes)

Schedule

A. Measurable Project Tasks for FY 02 (October 1, 2001- September 30, 2002)

October 15:	purchase and install computer
October 30:	contact additional taxonomic experts, send out draft data sets for their critique
January 14-23 (2 days):	attend Restoration workshop
January 30:	edit data tables
April 14:	Submit Annual Report
April 30:	Complete manuscript

B. Project Milestones and Endpoints

December 31:	Draft data sets due from taxonomic experts.
January 10:	Complete drafts of introductory sections.
March 15:	All changes in data tables completed.
April 30:	Transfer data to CD-ROM format, test.

C. Completion Date

PUBLICATIONS AND REPORTS

An annual report will be submitted by April 15.
The goal of this proposal is a publication: Marine Macrofauna of Prince William Sound

PROPOSED PRINCIPAL INVESTIGATOR

Nora R. Foster
NRF Taxonomic Services
2998 Gold Hill Road
Fairbanks, Alaska 99709

swamprat@mosquitonet.com

Qualifications of Principal Investigator

Nora R. Foster
2998 Gold Hill Road
Fairbanks, Alaska 99709
(907) 474-9557
swamprat@mosquitonet.com

EXPERIENCE:

1999-present	Coordinator, Aquatic Collection, University of Alaska Museum (part-time affiliate)
1997-present	Taxonomic consultant, self-employed
1997	Project Manager/Biologist, Prince William Sound Science Center, Cordova, Alaska
1981-1997	Coordinator, Aquatic Collection University of Alaska Museum

EDUCATION:
University of Alaska B. S. 1969 Biological Sciences
University of Alaska M. S. 1979 Biological Oceanography

Selected Reports and Publications

Hines, A. H., Ruiz, G. M., J. Chapman, G. I. Hansen, J. T. Carlton, N. R. Foster, and H. M. Feder. 2000. Biological Invasions of Cold-water Ecosystems: Ballast-mediated Introductions in Port Valdez/Prince William Sound, Alaska Final Project Report.

Foster, N. R. 1991. Intertidal Bivalves: A Guide to the Common Marine Bivalves of Alaska. University of Alaska Press. 152 pp.

Scheel, D., N. R. Foster, and K. Hough 1998. Habitat and Biological Assessment: Shepard Point Road and Port Project. Report to the City of Cordova, Alaska. Prince William Sound Science Center, Cordova, Alaska.

Feder, H. M., N. R. Foster, S. C. Jewett, T. J. Weingartner, and R. Baxter 1994. Distribution of Mollusks in the Northeastern Chukchi Sea. Arctic 47(2):145-163.

Juday, G. P. and N. R. Foster. 1990. A preliminary Look at the Effects of the Exxon Valdez Oil Spill on Green Island Research Natural Area.
Agroborealis 22 (1):10-17.

Lee, R. S. and N. R. Foster. 1985. A Distributional List with Range Extensions of the Opisthobranch Gastropods of Alaska. The Veliger 27(4):440-448.

Goddard, J. H. R. and N. R. Foster (in prep.) Range extensions for Saccoglossan and Nudibranch mollusca (Gastropoda:Opisthobranchia) to Alaska. (submitted to the Veliger, 19 March 2001).

OTHER KEY PERSONNEL

Howard M. Feder
Dr. Feder will write introduction sections to describe marine habitats in Prince William Sound. He will provide general editorial assistance.

LITERATURE CITED

Foster N. R. and H. M. Feder 2000. Biodiversity of Prince William Sound. Chapter 10 In Hines, A. H. et al. 2000. Biological invasion of cold-water ecosystems: ballast-mediated introductions in Port Valdez/Prince William Sound, Alaska Final Project Report.

Hines, A. H., Ruiz, G. M., J. Chapman, G. I. Hansen, J. T. Carlton, N. R. Foster, and H. M. Feder. 2000. Biological invasions of cold-water ecosystems: ballast-mediated introductions in Port Valdez/Prince William Sound, Alaska Final Project Report to Alaska Sea GRant College Program, U. S. Fish and Wildlife Service, and the Regional Citizens Advisory Committee for Prince William Sound.

Budget Category:	Authorized FY 01	Proposed FY 02
Personnel		28.80
Travel		0.44
Contractual		4.00
Commodities		0.60
Equipment		1.99
Subtotal		35.83
Indirect		
Project Total		
Full-Time Equivalents		0.5
Dollar amounts are shown in thousands of dollars		
Other Funds		

LONG RANGE FUNDING REQUIREMENTS
Estimated FY 03

Coments:
All travel is for attendance at the annual restoration workshop

FY 02

Project Number: 02578
Project Title: The Marine Macrobiota of Prince William Sound: An Annotated List
Name: Nora R. Foster, Howard M. Feder

FORM 4A

Non-Trustee SUMMARY

Prepared: 9-Apr-01

Personnel Costs:				Months	Monthly		Proposed
	Name	Position description		Budgeted	Costs	Overtime	FY 02
	Nora R. Foster Howard M. Feder	taxonomic consultant zoologist (no cost)		6	$4,800.00		$28,800.00
			Subtotal				
						Personnel Total	$28,800.00

Travel Costs:						
	Description	Ticket Price	Round Trips	Total Days	Total Per Diem	Proposed FY 02
	RT Fairbanks to Anchorage to attend Restoration Workshop	$200.00	1	2	$120.00	$440.00
					Travel Total	

FY 02

Project Number:

Project Title: The Marine Macrobiota of Prince William Sound: An Annotated List

Name: Nora R. Foster, Howard M. Feder

FORM 4B

Personnel and Travel DETAIL

Prepared: 9-Apr-01

Contractual Costs:	Proposed
Description:	FY02
Honoraria for 8 taxonomic experts @ $500 each	$4,000.00
Contractual Total	$4,000.00

Commoditions Costs:	Proposed
Description:	FY02
office supplies	$100.00
software: Office Mac 2001	$499.00
Commodities Total	$599.00

FY 02	Project Number: Project Title: The Marine Macrobiota of Prince William Sound: An Annotated List Name: Nora R. Foster, Howard M. Feder	FORM 4B Contractual & Commodities DETAIL

Prepared: 9-Apr-01

New Equipment Purchases	Number	Unit	Proposed
Description	of Units	Price	FY02
Computer: iMac DVT	1	$1,990.00	$1,990.00
Justification: the computer currently in use, a Mac Performa, cannot run the software necessary to read the large number of Excel files in which the data sets are formatted. The i Mac can run Office Mac 2001, so that files can be read and edited, as proposed.			
indicate replacement equipment with an R	**New Equipment Total**		$1,990.00

Existing Equipment Usage:	Number	
Description	of Units	

FY 02

Project Number:
Project Title: The Marine Macrobiota of Prince William Sound: An Annotated List
Name: Nora R. Foster, Howard M. Feder

FORM 4B

Equipment DETAIL

Prepared: 9-Apr-01

Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring

02584

Submitted under:	Innovative Tools and Strategies to Improve Monitoring; page 31 FY02 Invitation
Restoration Category:	Monitoring; GEM Transition
Proposer:	PI, Evelyn D. Brown, UAF SFOS IMS co-P.I. James H. Churnside, NOAA Environmental Technology Laboratory, Boulder CO
Lead Trustee Agency:	ADFG
Cooperating Agency:	NOAA
Alaska Sea Life Center:	No
Duration:	1st year of 3-year project
Cost FY02:	$114 K ($15K to NOAA, rest to UAF)
Cost FY03:	$240K
Geographic Area:	Spill Region (Prince William Sound, N. Gulf of Alaska, Kodiak, Lower Cook Inlet
Injured Resources:	Potential survey species include sea birds (common murre, marbled murrelet, pigeon guillemot) and fish (Pacific herring, pink salmon, sockeye salmon)

ABSTRACT

The main objective of this study is an evaluation of airborne remote sensing tools for EVOS GEM monitoring including a biological/ecological interpretation of the data collected. The instrument package consists of 1) a pulsed lidar to map subsurface biological features day to a maximum of 50 m, 2) an infrared radiometer to map SST day (similar to AVHRR), 3) two 3-chip digital video systems to map ocean color (chlorophyll), birds, mammals, surface fish schools, and ocean frontal structure, and 4) an infrared digital video to map birds and mammals at night. We will use shipboard and buoy data for validation and interpretation of remote sensed data.

INTRODUCTION

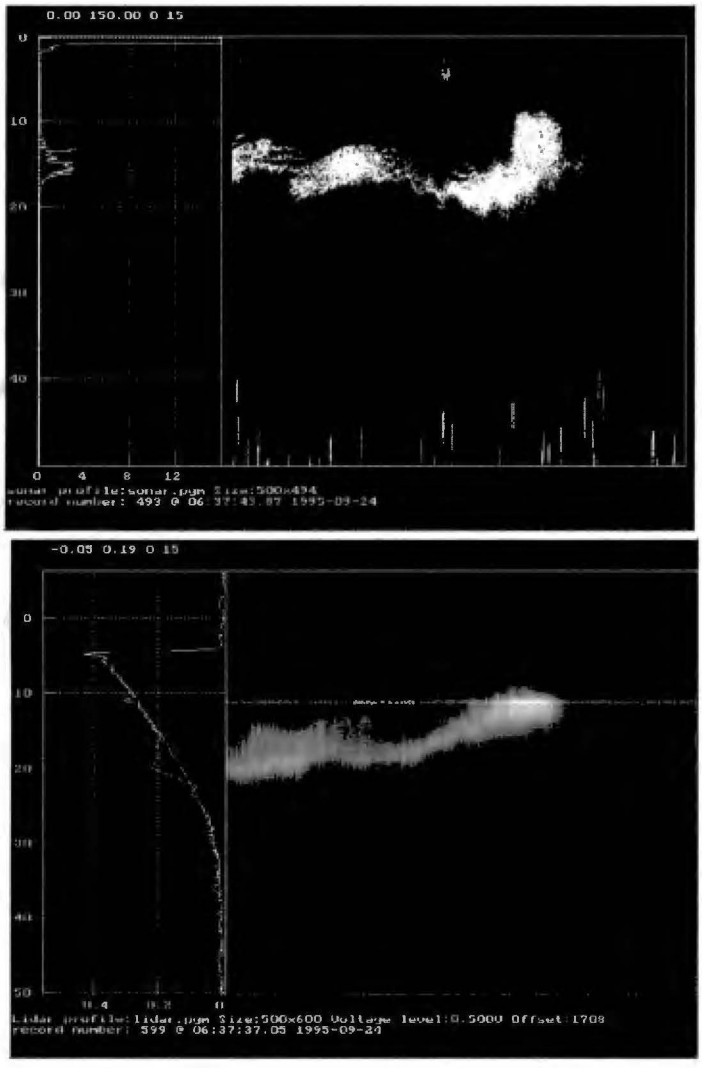
Biological assessment and ecological study of marine pelagic resources pose severe challenges from high cost and logistical difficulty to an inability to adequately address issues of spatial and temporal scale. Ship surveys in Alaska are severely limited by storm activity, are extremely costly, and research vessels are often "overbooked," often scheduled a year in advance. In addition, ships and acoustics have depth limitations, missing shallow, nearshore regions or the near surface. Ship avoidance behavior, by fish and their predators, affects results and sampling nets disturb biological features from their natural orientations. Finally, the slow speed of ship travel precludes understanding of short term or ephemeral events and cannot provide a synoptic view of the study region over short time scales. Biological relationships shift diurnally and with the tides; storm events restructure ocean fronts along with the biological structure that attracts fish and their predators, and predator-prey associations are often spatially patchy and short-lived. Data from satellites shows promise in helping to answer some of these problems, but frequent cloud cover is a problem in Alaska. The result of all of these issues is an increasing high-speed, cost-effective data collection tools that can document structure, in real time, without disturbance and that can be used to "fill-in" satellite data on cloudy days.

Airborne remote sensing and visual survey methods can meet many of these needs. The cost is less than 10% of a ship survey per survey kilometer and depth penetration has been improved to more than 3 times the visual range with the use of lidar (described here) The synoptic views aerial surveys provide are more appropriately coupled with satellite images in temporal scale than ship board results and data from airborne remote sensing instruments can be used to interpret and expand missing or low resolution from satellite data. Biological features are observed in "real space and time" without complications from ship avoidance behavior and disturbance of biological structure (as with net sampling). This instrument shows particular promise for the field of marine ecology in determining predator-prey relationships, capturing ephemeral biological events, and defining spatial and temporal scale. Accuracy of remote sensed data is improved by adaptive or "response-type" ship sampling. Using adaptive ship sampling and new technology in underwater digital video and plankton recorders, the overall cost of obtaining the information required could dramatically decrease.

Airborne lidar (light detecting and ranging) is a tool that shows promise for marine research. One form of lidar produces short pulses of green laser light, which pass through the water surface, reflect off fish and particles in the water, and returned to a receiver on the instrument. The strength of the returning pulse separates fish targets from small particles and the elapsed time indicates the range or depth of the object. When coupled on single platform with other instruments, such as multi-spectral imagers, infrared and/or microwave radiometers, and infrared cameras, physical and biological parameters can be collected simultaneously. Surface and subsurface features, such as zooplankton layers, fish schools, large individual fish, marine mammals, sea birds, oceanic fronts, sea surface temperature and salinity, and chlorophyll blooms are recorded to depths where light signals are attenuated.

The use of lidar and multi-spectral imagers are not new to ocean science. Squire and Krumboltz (1981) were among the first to experiment with optical lasers and other remote sensing devices for the purposes of fish surveys. Gauldie (1996) provided a review of lidar applications to fisheries management, mainly concerned with obtaining fish abundance and distribution

information. Krekova et al. (1994) provided a numerical evaluation of remote sensing fish schools with lasers; however, lidar applications are not limited to schooling fishes. Development of airborne lidar fisheries applications was greatly enhanced by Dr. James Churnside and his research team from the National Oceanic and Atmospheric Administration (NOAA) Environmental Technology Laboratory (ETL). They constructed and tested the Fish Lidar Oceanic Experimental (FLOE) system from off-the-shelf components and developed several signal processing techniques to discriminate between returns from fish and from small particles in the water (Churnside et al., in press). The FLOE system has been used off the coast of California to survey anchovies, sardines (Churnside et al. 1997; Hunter and Churnside, 1998; Lo et al. 1999) and more recently squid as well as sardines off the coast of Spain (Churnside et al., in press) and Pacific herring off the coast of Washington State. Comparisons of lidar to acoustic data has been very encouraging (Figure 1).

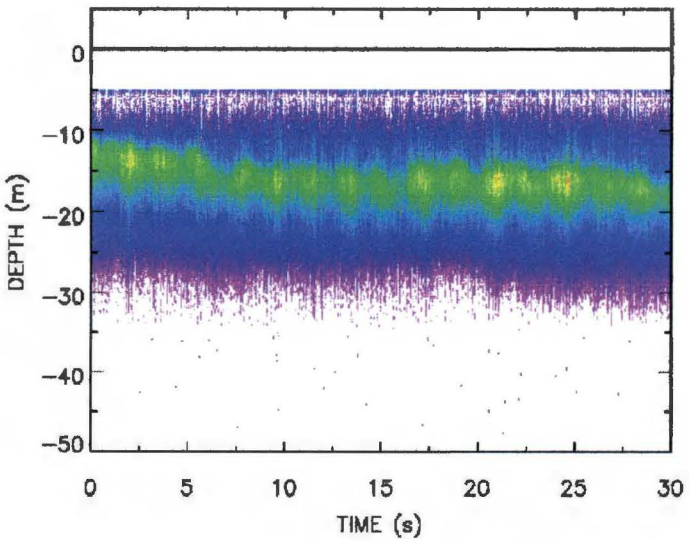


A.

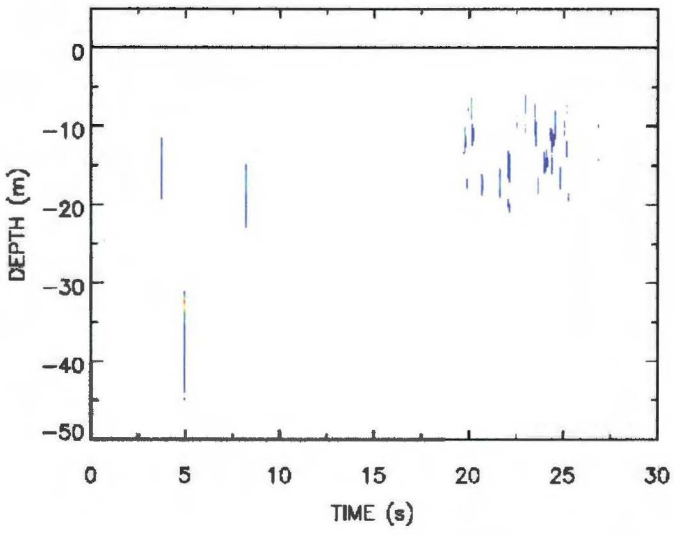
B.

Figure 1. A comparison of signal reflection from a school of anchovy by shipboard acoustics (A) and by lidar (B; post-processed image). The images were collected synoptically (Churnside et al. 1997; http://www1.etl.noaa.gov/lidar/index.html).

Airborne lidar has also been used to detect subsurface oceanic scattering layers (Hoge et al. 1988) as well as zooplankton layers and marine mammals (Figure 2).



A.



B.

Figure 2. Examples of plotted lidar output taken at approximately 200 m in altitude at 225 knots airspeed where time here represents linear space; zooplankton imbedded with scattered fish targets (A) and dolphins (B) are shown. Each image is 30 s of data and about 900 shots from the laser; traveling at 75 m/s, this is about 2.5 km.

Last summer (2000) the FLOE system was coupled with a digital imager and field tested in the North Pacific. Flown at 1000-ft altitude, the measured swath was about 5 m during the day and 7 m at night. The imager was a high-resolution video camera equipped with a tunable spectral filter capable of capturing 10 different bandwidths within the visual range and an adjustable focal length as well as frame-capture rate. The swath width of the imager is altitude and focal length dependent but ranged from 150-200 m at 1000 ft. altitude. Both instruments were mounted side-

by-side and angled down-looking at about a 10-degree angle from a camera port and window port in a twin-engine aircraft (Figure 3 and 4). Data from each instrument was stored electronically and processed later with custom software. The lidar data signal processing and output is similar to acoustic data. Flights were coordinated with three ongoing marine research programs with varying objectives. Surveys were flown in British Columbia, northern southeast Alaska, in Prince William Sound, Alaska, and over the continental shelf in the Gulf of Alaska. Surveying at 120 knots, 222 km was surveyed per hour. Features captured using the lidar included plankton and euphasid/amphipod layers, fish schools (Figure 5), larger individual predators, and fine detail of biological structural changes at ocean fronts. The penetration depth was 15-30 m in inside waters (non-silty) and up to 50 m in outside waters over the continental shelf. Penetration was much better at night due to an increased field of view with no background light interference. The imager captured sea bird and mammal configurations, fish schools (Figure 6), and changes in ocean color/front structure (Figure 7). Both data types are binned in cells with a 2-D array of image data underlain with a 3-D array of lidar data. A 3-D geo-referenced visualization is produced that can be analyzed using spatial statistical methods with linked GIS and spatial statistics software. We are in the process of completing analysis of the data from this study. However, the processing steps are listed here in methods since we propose to follow similar steps.

Figure 3. Aircraft used for the lidar/imager surveys in the North Pacific.

Figure 4. The photograph on the left is the NOAA-ETL fish lidar (telescope in the fore view with the hardware rack behind) mounted in the survey aircraft used in the summer of 2000. The photograph on the right shows the digital imager mounted in the window.

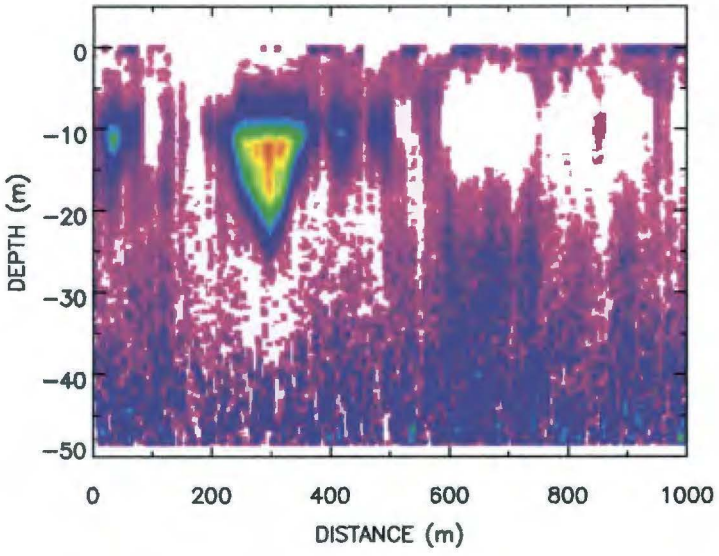


Figure 5. A raw data file output (displayed by shot number or distance with the background signal removed) of a fish schools in the Gulf of Alaska (attenuation depth here was approximately 40 m).

Figure 6. Near-surface fish schools (sand lance) captured by the digital imager (Airborne Technologies)

Figure 7. Image of oceanic regions captured with the imager; the binned lidar data is imbedded within this structure for analysis (Airborne Technologies, Inc.).

Following the encouraging results of the NPMR pilot study, we now propose to evaluate the potential use of these tools for GEM monitoring. The evaluation for this project will require

cooperation with other researchers. Working with an ongoing, and separately funded ship-board research program (GLOBEC), we will survey onshore to offshore transects overlapping and expanding the GLOBEC ship tracks. We may also exchange information with other EVOS and non-EVOS researchers working in the same area (see list below) for validation, interpretation and assessment of the usefulness of our data to their respective programs. For this project, we propose to work with a single cruise, most likely in mid- to late-July. However, if the evaluation is positive, we propose to increase the temporal strata and survey other critical times periods in future years. In the case that future surveys are not funded and due to the late start-up data proposed, we will require close-out funds to complete analysis and report-writing in FY03. However, the reporting costs will be significantly reduced from the estimate provided for FY03.

As part of the evaluation, we will fuse the data from the various instruments, add ship-board data from GLOBEC (monitoring and process studies), and perform an ecological interpretation of the biological structure spatial structure (e.g. size and interrelationships of features such as zoo-plankton patches and fish schools, proximity to fronts, short term scale of predator-prey events or frontal structures). We will also evaluate how the data suite (instrument data only or combination instrument/ship/buoy) addresses the complex research hypotheses and questions posed in preliminary drafts of GEM. A publication will be produced concerning the evaluation and interpretation. Earlier this year, we solicited various researchers working in the spill-impacted region for interest in the types of data we could provide to their respective studies. We received several replies including

1) Arthur Kettle/Dave Roseneau, USFWS, seabirds at the Barren Island; would like to know more about the distribution of forage fish, primary and secondary production, and physics of the seabird foraging region;

2) Kathy Kuletz, USFWS, murrelets in PWS; would like us to perform overflights in her nearshore survey areas and provide information on available prey

3) Dave Irons, USFWS, kittiwakes and other seabirds in PWS and NGOA; would like better information on availability and ecology of prey species for seabirds

3) Bruce Wright and Lee Hulbert, NMFS, sharks in PWS and N GOA; would like improved information about the distribution and ecology of salmon and sleeper sharks

There may be others. We will try to overfly areas of interest to these researchers to aid in the determination of the usefulness of the data to them. However, we may be able to coordinate with a small number in 2001 due to the limited flight hour allocation. As with the aerial survey program conducted for APEX, we will produce binned, interpreted data in an archive that will be available to cooperating researchers to use for their own purposes.

NEED FOR THE PROJECT

A. Statement of Problem

There is a need to identify cost-effective research tools for monitoring marine ecology in the EVOS spill region as a part of the GEM program. The data required to address the complex

ecological questions posed by GEM are diverse. The settlement monies are finite and the GEM effort should include tools that are efficient, have adequate spatial coverage, and provide information for multiple research questions and objectives. Distributions and ecological relationships of several of the injured species will likely be captured by the instruments including common murres, marbled and Kittlitz's murrelets, Pacific herring, pink salmon (high seas juveniles), sea otters, sockeye salmon (high seas juveniles), harbor seals, killer whales, and human activities in the areas surveyed.

B. Rationale/Link to Restoration

Prior to the formal initiation of the GEM plan, a full evaluation of potential monitoring tools would facilitate informed decision-making and planning. This proof of concept project enhances readiness to implement GEM by providing an evaluation of a potential suite of tools. Given the list of potential cooperating researchers and diversity of data delivered, there are likely several links to other restoration efforts that have not been identified at this point.

C. Location

For this evaluation, we propose to work in Prince William Sound and the adjacent northern Gulf of Alaska, with transect extensions to the west along the Outer Kenai Peninsula. As we will operate out of Anchorage, we may transect lower Cook Inlet to the Barren Islands, on the way to transects further east for logistical reasons.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

There will likely be very little physical or direct interaction with spill community residents because we will most likely operate out of Anchorage (to keep field costs down). However, we are interested in posting interpreted visualizations on a web site easily accessed by residents. We are interested in providing the information to local schools for educational purposes and can provide simplified verbal interpretations with the visualizations. As our program (airborne remote sensing instrumentation and marine ecological research) is expanding (from other funding), we would like to encourage potential graduate students from the spill region to participate in proposed studies on both Masters and PhD levels. We will be offering opportunities to obtain multi-disciplinary degrees in a combination of 2 or 3 of the following disciplines: engineering, computer science, physics (optics), marine ecology, oceanography, wildlife biology, and fisheries. We feel that participation by local students is an optimal vehicle for information transfer to rural areas.

PROJECT DESIGN

A. Objectives

The objectives for this project are:

1. Determine the types of information that can be collected from remote sensing instrumentation and the limitations of the collection.
2. Interpret the information collected in an ecological sense;

a. Describe general distribution patterns of plankton, fish, and predators
b. Determine the spatial relationships of the biological features to one another
c. Describe ocean structure in terms of chlorophyll, SST-SSS, and ocean fronts.
d. Determine how the biological structure is related to the ocean structure

3 Evaluate the extent of data collected and cost-effectiveness per unit area
4 Evaluate the limitations and usefulness of the interpretation in relation to GEM questions.

B. Methods

The hypothesis for this project is:

Data from airborne remote sensing instrumentation can be used to define spatial and temporal variability of zooplankton, fish, and predator distributions, interrelationships between the three, ocean structure, and relationships between biological distribution and ocean structure.

The instrument package consists of 1) a lidar using pulsed green laser light to map subsurface biological features day to a maximum of 50 m, 2) an infrared radiometer to map SST day (similar to AVHRR satellite data), 3) a 3-chip digital color video set up to map ocean color (chlorophyll), 4) a digital color video set up to capture ocean fronts, near-surface fish schools, and seabird or mammal aggregations, 5) a telescoping video set up to acquire high resolution (6 cm) images of non-white seabirds and mammals for species identification, and 6) an infrared digital video to map birds and mammals at night.

The instrument package and settings vary from day to night. The daytime configuration consists of the lidar, infrared radiometer, and all three digital videos. The nighttime configuration consists of the lidar, radiometer and infrared camera. Due to the cost of processing, we may not operate all videos continuously, instead collecting data only in areas of interest.

Table 1. NOAA-ETL FLOE System Specifications

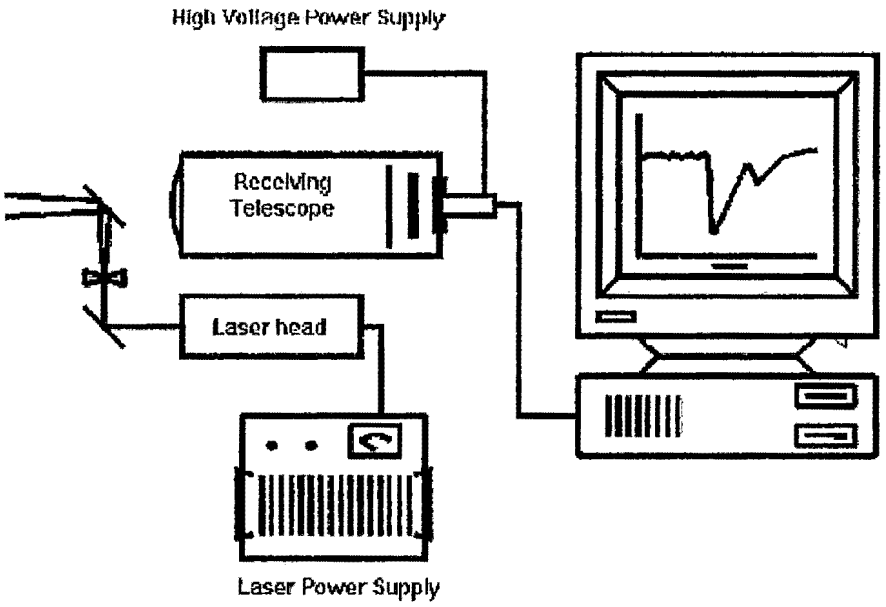
TRANSMITTER		RECEIVER	
Wavelength	532 nm	Aperture diameter	17 cm
Pulse length	15 nsec	Field of view	63 mrad
Pulse energy	100 mJ	Optical bandwidth	10 nm
Pulse repetition rate	30 Hz	Electronic bandwidth	100 MHz
Beam divergence	62 mrad	Sample rate	1 GHz

We will use the NOAA FLOE system (Table 1) for this project in 2002. The FLOE system is simple without scanning or imaging capabilities (Figure 8). The laser is a frequency-doubled, Q-switched YAG laser, linearly polarized parallel to the plane of incidence. A negative lens in front of the laser increases the beam divergence. The laser is mounted next to the receiver telescope and the diverged beam is directed by one mirror to a second mirror mounted to the back of the telescope secondary. The laser beam is directed toward the water coaxial with the telescope. The lidar receiver is a simple refractor that uses a condensing lens to focus the returned signal onto a

photomultiplier tube (PMT) detector. An interference filter reduces the contamination of the lidar signal by background light. A rotating polarizer is used to make measurements of the parallel- and cross-polarized returns. The PMT output is passed through a logarithmic amplifier to reduce the dynamic range of the signal. This signal is routed to an analog-to-digital converter (ADC) in a personal computer where it is digitized and saved to the computer hard disk. In other cases, two ADC boards with different gains are used to increase the dynamic range of the receiver. The maximum range and sensitivity of the lidar system is highly dependent on the clarity of the water, but fish can be detected to depths of 30-50 m below the sea surface in clear waters. We have proposed to build a beta version of FLOE; MEL (Marine Ecological Laser) will be modular, smaller, and have greater penetration capabilities. Beyond 2002, we would likely deploy MEL replacing FLOE. Lidar data processing is discussed below.

We will also use the NOAA ETL infrared radiometer. Radiometers are passive instruments that receive energy signals that are naturally emitted from objects within the instrument's viewing angle. A radiometer antenna pointed downward and receives infrared emissions from the ocean surface the beam. It monitors thermal emissions near the wavelength of 11 microns and the IR brightness temperature is approximately equal to the physical temperature of the ocean surface. The IR brightness temperature is calibrated in the laboratory prior to and following field data collection.

Ocean color and chlorophyll concentration will be estimated using a commercial 3-chip color video, also provided by NOAA. The first step is to synthesize the wavelength bands used by one of the satellite ocean color instruments, such as SeaWIFS or MODIS. Because we are synthesizing these bands from combinations of the wider bands in the video, either or both can be obtained from the same data set. Once we have the bands, we filter the digitized video images through each of the bands in the computer. This produces an estimate of what the satellite instrument would have seen, except, of course, for the distortions introduced by the atmosphere in the satellite images. At this point, we can use the algorithms developed for the satellite instruments for ocean color, chlorophyll concentration, and suspended sediment load. These values can be compared directly with the satellite products, although the spatial scale of the aircraft images is much smaller.



Block Diagram Fish Lidar System

Figure 8.Block diagram for the lidar system

The other color digital cameras are high resolution and can be fitted with tunable, multi-spectral filters and telescoping lens. The real power of this data is the software used to process the images. Within the custom software (developed by private industry partner), the image data is binned (flexible size), geocoded at the center, and normalized color pixel values are assigned to each bin (to detect ocean structure). Manual and shape recognition algorithms are used to extract counts of animals in each bin. Based on similar pixel values, fish school perimeters, surface areas and color density (potentially related to fish density) are extracted for each bin.

As in the NPMR pilot study (see Introduction), we will mount the instruments side by side to either look through a hole in the belly of the aircraft or through a window. Although the swath widths differ between instruments, we will insure they overlap via setting viewing angles for the instruments.

We will base our flight plan around the GLOBEC research vessel schedule and transecting plan as well as other coordinating projects. We will fly a total of approximately 25 hrs; flying at approximately 140 knots, we will cover approximately 6500 km of ocean transects. The day-to-day schedule is relatively flexible due to weather, altered ship courses (due to weather), and other logistical concerns. Our goal will be to maximize synoptic observations with ground survey programs. We will overfly at least one continuously recording oceanographic buoy for each flight. The ship survey or buoy provides 1) a temperature array used to compare temperature profile to surface temperature, 2) light attenuation from PAR or Photosynthetically Active Radiation used to check background correction estimated for lidar data, and 3) chlorophyll concentrations from a fluormeter (for ocean color calibration measurements). We will also derive biological validation measurements from the ground programs from interpreted acoustic data, zooplankton tows, net captures of fish, and visual sightings of birds and mammals. Finally, we

will use ship-board data to obtain sub-surface oceanographic structure (especially salinity, pycnoclines, location/size of fronts, and information of stratification) used to frame our spatial observations ecologically.

The majority of personnel time allocated within this project is for signal processing and analysis. The ratio, summed over all the instruments data produced, is well over 3:1 processing to collection time (a standard for acoustic data). However, processing algorithms are well established for the radiometer and ocean color video. The imaging video and lidar data is significantly more time-intensive.

Processing steps are illustrated from data collected during the pilot study. The laser fires 30 times per second and new files are produced every 66 seconds to limit size. Each file is a 2000 (no. of shots) by 1,000 (0.109 m depth intervals) array and represents approximately 5 km of lineal space. The data in Figure 9 represents the echo from one laser pulse on the afternoon of August 22 in Prince William Sound. Figure 9a shows the raw detector echo with distance form the plane. Clearly, the strongest echo was from the surface of the sea. The lidar signal decays exponentially with depth in the water. Signals were visible down to 30 m below the sea surface. Figure 9b shows the signal in terms of the linear detector current. In Figure 9b, the vertical axis of the plot has been shifted to highlight the signal from just below the sea surface. Figure 9c shows the background signal for the data set of individual laser pulses. This profile represents the median of the 2000 profiles. Figure 9d shows the perturbations in an individual profile (number 400 of the 2000) relative to the background plotted in Figure 9c. In the context of the other measurements made that day it is possible to interpret the echoes in Figure 9d. The echoes centering at 10 m below the sea surface (range 5-15 m) appeared commonly over distances of several km in the lidar and were spotted with spikes of increased signal return. The locations and depths matched plankton and juvenile high seas salmon catches from the ship data. The echoes at 20 m below the surface were much patchier. Net catches of capelin (form large schools) matched these echo locations and depths. The relative target signal (Figure 9d) used to detect targets is a radiometric measure. Specifically it is calculated as the ratio of the difference between the individual profile (Figure 9b) and the median water signal (Figure 9c) divided by that same median water signal. The median signal is small and sensitive to noise at depths of 30 m and over (for this file) and thus the detection of targets near the maximum range is not very robust. This is of particular concern for studies in the Gulf of Alaska where the water in some areas can be considerably more turbid than in the coastal waters of California. However, in Alaskan waters, most of the primary and secondary production along with predatory activity takes place in the upper 20m during the summer when the water column is stratified. Thus, the lidar measurements provide the potential to yield real-time high-resolution snapshots of biological distribution in the upper level of the ocean.

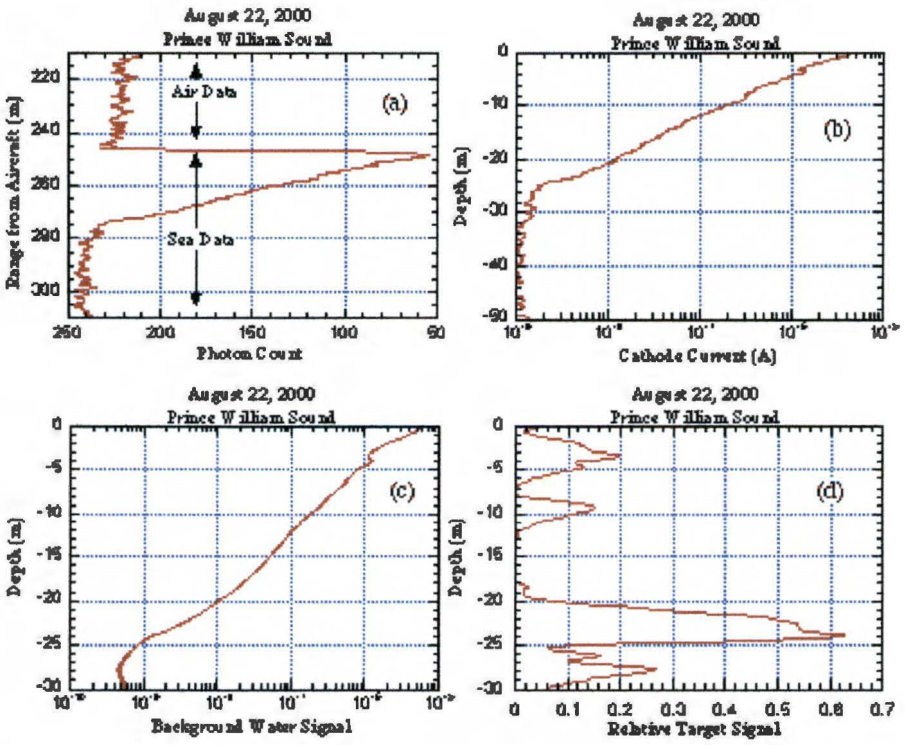


Figure 9. Fish lidar data from 22 August 2000. See text for details.

As part of the pilot study, we made improvements to the existing software (originally written in IDL) in the step-wise signal processing algorithms including:

1) automating the calculation of background signal which tends to change as different bodies of water are transected,
2) automating the identification and downloading of arrays containing potential targets to be linked to validation and target strength information,
3) automating the identification of potential problematic arrays, especially those containing targets near the attenuation depth with amplified noise, and

The two-stage program is written in Visual Basic. The first stage follows the processing steps outlined above summarizing files as 1-D meta-file data for easy viewing and interpretation (see Figure 10). Sequences of files can thus be selected according to "feature grouping" for more detailed analysis. The second stage program allows you to select the file sequences and process the raw data files according to specified bins sizes with appropriate threshold levels and attenuation depths. The data used for analysis is thereby greatly reduced. The output from the programs can be dumped via the dynamic links to Visual Basic, available in most MS Windows software for further processing, visualization and analysis. We will likely use ArcView to overlay validation data in order to identify lidar signal; we will use acoustic density information where available to scale lidar backscatter values to biomass, however, overlap may not be 100%. In the case of non-overlap, we will infer identification and density if from the closest validated sighting and represent the uncertainty in the reporting. Output files can also be created in a commonly used format for viewing on acoustic processing software in a form familiar to many

oceanographers and fishery biologists. This was done to assess the utility of building on existing acoustic software versus creating entirely custom software for the lidar system.

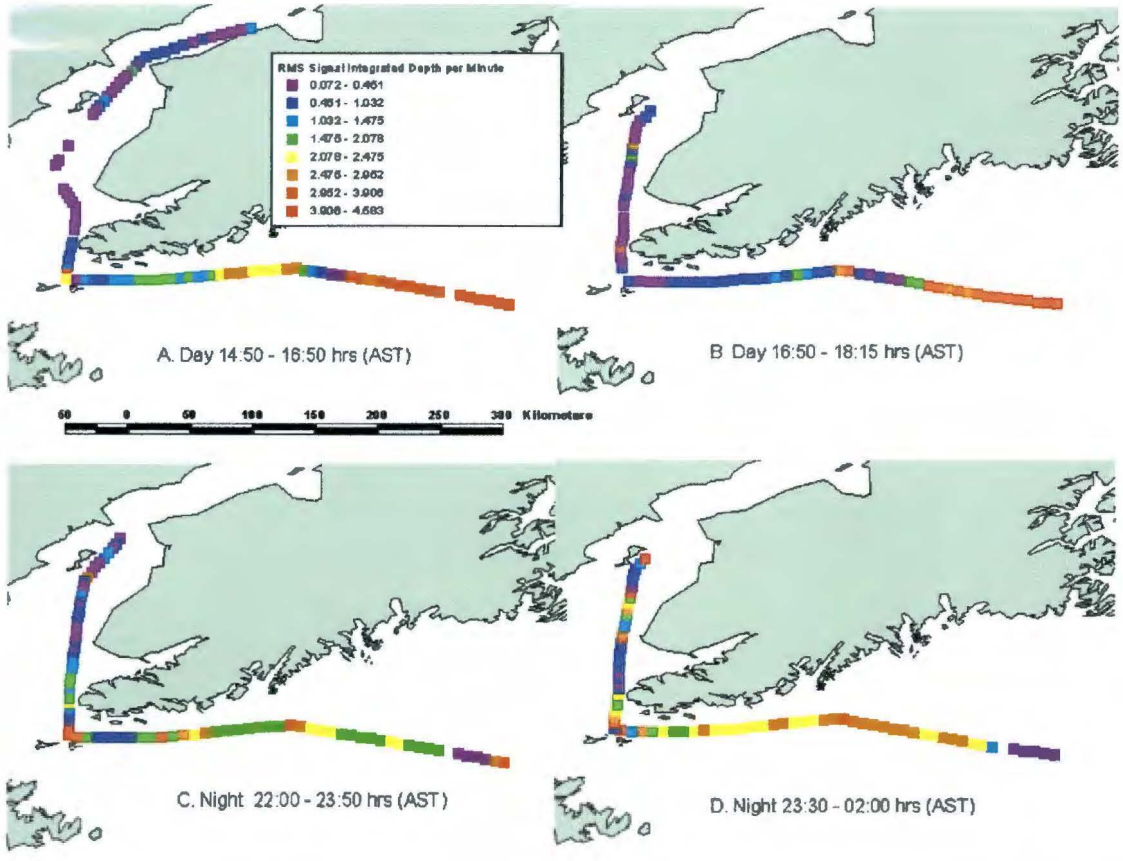


Figure 10. A view of the meta data or file summary along a single survey near the lower Cook Inlet and Outer Kenai coast. Each square is a single file representing about 4.5 km and the Root Mean Square signal integrated over all depths and shots is show as 10^{-4} volts. The left and right hand figures show short term variability collected on the trip out (left) and return (right). The top and bottom figures contrast day and night.

A general treatment of remote sensed and other aerial data is provided in Hunter and Churnside (1995). However detailed statistical modeling of lidar results was explored by Lo et al. (2000), in relation to aerial census of anchovy off the coast of California. They provided methods 1) to estimate the number of transects needed to minimize abundance estimates, 2) to determine the effects of signal to noise ration (SNR) with attenuation (or depth) on the probability of detection, 3) to estimate the maximum detection depth (z_{max}) based on threshold to noise ratio (TNR) and SNR, 4) to predict the probability of detection based on water mass characteristics, and 5) comparisons of estimates to other methods. The maximum detection depth is a function of the size of the organism or aggregation (i.e. school). For organisms residing partly below the maximum detection depth, acoustic data is combined with lidar data to produce a subsurface correction factor. Lo et al. (2000) suggest the application of line transect theory applied in the vertical along transect plane (rather than horizontal) to estimate abundance, estimation and detection error. For organisms above the maximum detection depth, we can assume 100% detection along the survey track. Finally, Lo et al. recommend the further development of signal

processing algorithms to automate the SNR, TNR, z_{max}. Several of these algorithms have been developed under the NPMR pilot study and will be applied to this study. We will use the models developed by Lo et al. to interpret the data collect for this project.

Once we have identified and quantified (normalized signal strength; Figure 9d), we will rely mainly on spatial statistics to describe distributions and interrelational parameters. Potential stochastic descriptions of the data include comparison of spatial variability via variograms, indices of spatial association between distributions (e.g. Moran's or Geary's index; Cliff and Ord 1981; Geary 1954), kridging to smooth and expand estimated distribution patterns, and nearest neighbor or distance statistics to quantify interrelationships. This statistical interpretation will be included in the publication produced as part of this project.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The project is a cooperative effort between the UAF and NOAA. Currently, the NOAA Environmental Technology Laboratory possesses the only publicly accessible lidar system, as well as a suite of other instruments. The lab is populated by physicists, engineers, and highly trained technicians who have designed and built a host of remote sensing instruments used for atmospheric and oceanic research. They have also designed software to process signals. Therefore, the role of the NOAA co-PI, Dr. James. Churnside, will be to provide the lidar, radiometer, and ocean color video. Personnel from his lab will also mount the instruments in the plane, perform maintenance and repairs, and handle the raw data. The role of UAF is to provide the biological expertise needed for survey design, links to external data (from ships and buoys), signal interpretation, and spatial analysis. Data processing tasks and the evaluation/reporting will be a joint effort.

SCHEDULE

A. Measurable Project Tasks for FY02

January 14-23:	Attend EVOS workshop and present pilot study results if desired
March 15-17:	Develop survey design and flight plan; attend scientific planning meeting (project members and coordinating researchers)
July 1:	Instrumentation preparation and calibration completed
July 15 - August 15:	Complete field data collection
September 1:	Validation data collation initiated
October 1:	Signal processing completed

B. Project Milestones and Endpoints

FY02

October 1:	Objective 1; preliminary identification of features capture

FY03

December 15:	Objective 1; identity of capture features validated/limitations of data determined
April 15:	Objective 2; spatial analysis completed

April 30:	Objective 3; evaluation of cost-effectiveness of information Objective 4; evaluate usefulness and limitation for GEM
May 31:	Manuscript draft submitted; final report completed
August 31:	Manuscript revised and finalized

C. Completion Date

August 31, 2003, FY03, is the estimated completion data for this project.

PUBLICATIONS AND REPORTS

No publications are planned for FY02. The project has a late start-up data with data collection proposed near the end of FY02. Therefore, all reporting and publication production will occur in FY03.

PROFESSIONAL CONFERENCES

Other than the EVOS workshop and scientific planning meeting, we have no plans to present the results formally in FY02.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We have other proposal submitted that address instrumentation development, software development, surveys in other locations in Alaska (Kodiak, SE Alaska, Aleutian Chain, Bering Sea), links to satellite data, and target strength work. These proposals include additional co-investigators from agencies, academic organizations and private industry. Sources of funding for these proposals include NSF (Major Research Instrumentation Program, Biocomplexity Program, Small Business Innovative Research Program), CIFAR (UAF-NMFS cooperative program), NMFS, NESDIS, and the Sea Life Center. Surveys under several of these programs (CIFAR and NMFS) are complimentary to the work proposed for GEM and data collection methods are identical.

We will coordinate with the GLOBEC monitoring research program (TomWeingarter, chief scientist; Ken Coyle, acoustician/zooplankton, Russ Hopcroft, zooplankton, Lew Haldorson, fisheries data, and Bob Day from ABL for bird and mammal data) during the late summer cruise. We will also coordinate with GLOBEC process studies occurring at the same time in 2002, specifically with NMFS ABL focusing on juvenile high seas salmon (Jack Helle, Ed Farley) and the zooplankton research (Russ Hopcroft, UAF). We coordinated with them during the pilot study in 2000 and will continue that relationship. In 2000 the NMFS group was operating under the Ocean Carrying Capacity Research program managed by Jack Helle. The other potential coordinating researchers are (repeated from introduction):

1) Arthur Kettle/Dave Roseneau, USFWS, seabirds at the Barren Island; would like to know more about the distribution of forage fish, primary and secondary production, and physics of the seabird foraging region;

2) Kathy Kuletz, USFWS, murrelets in PWS; would like us to perform overflights in her nearshore survey areas and provide information on available prey

3) Dave Irons, USFWS, kittiwakes and other seabirds in PWS and NGOA; would like better information on availability and ecology of prey species for seabirds

3) Bruce Wright and Lee Hulbert, NMFS, sharks in PWS and N GOA; would like improved information about the distribution and ecology of salmon and sleeper sharks

PROPOSED PRINCIPAL INVESTIGATORS

Evelyn D. Brown
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Fairbanks, AK
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Responsibility: Oversee the UAF signal processing tasks, signal validation, biological interpretation, statistical analysis and report writing

James H. Churnside
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325 Broadway
Boulder, CO 80303
phone: (303)497-6744
fax: (303)497-3577
email: jchurnside@etl.noaa.gov

Responsibility: Provide instruments for the study, oversee the NOAA signal processing tasks, instrument calibration, assist in interpretation or processing algorithm improvements, and assist with signal analysis and report writing.

PRINCIPAL INVESTIGATORS

James H. Churnside

Education

Ph.D.	Department of Applied Physics and Electronic Science Oregon Graduate Center (now Oregon Graduate Institute), Beaverton, Oregon 1978
B.S.	Physics, Mathematics and Computer Science Whitworth College, Spokane, Washington 1974

Experience

1991 to present	Chief, Ocean Remote Sensing Division NOAA Environmental Technology Lab., Boulder, Colorado
1985 to 1991	Physicist NOAA Wave Propagation Lab., Boulder, Colorado
1979 to	Member of the Technical Staff

1985 The Aerospace Corporation, Los Angeles, California

Most Recent Journal Publications (of 54)

E. R. Westwater, Y. Han, J. B. Snider, J. H. Churnside, J. A. Shaw, M. J. Falls, C. N. Long, T. P. Ackerman, K. S. Gage, E. Ecklund, and A. Riddle, "Ground-Based Remote Sensor Observations during PROBE in the Tropical Western Pacific," Bull. Am. Meteor. Soc. 80, 257-270 (1999).

C. M. R. Platt, S. A. Young, P. J. Manson, G. R. Patterson, S. C. Marsden, R. T. Austin, and J. H. Churnside, "The Optical Properties of Equatorial Cirrus from Observations in the ARM Pilot Radiation Observation Experiment," J. Atmos. Sci. 55, 1977-1996 (1998).

J.H. Churnside, V.V. Tatarskii, and J.J. Wilson, Oceanographic Lidar Attenuation Coefficients and Signal Fluctuations Measured from a Ship in the Southern California Bight,@ Appl. Opt. 37, 3105-3112 (1998).

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J.A. Shaw and J.H. Churnside, Scanning-Laser Glint Measurements of Sea-Surface Slope Statistics,@ Appl. Opt. 36, 4202-4213 (1997).

J.A. Shaw and J.H. Churnside, Fractal Laser Glints from the Ocean Surface,@ J. Opt. Soc. Am. A 14, 1144-1150 (1997).

Evelyn D. Brown

Education:

B.S.	Zoology and Chemistry, University of Utah, Salt Lake City, 1977
M.S.	Fisheries Biology and Aquacultural Engineering, Oregon State University, Corvallis, OR, 1980
Current	PhD candidate in Fisheries at University of Alaska, Fairbanks (completion expected in the spring of 2001)

Experience:

Research Associate, University of Alaska, Fairbanks, 1995 to the present;

Herring and Fisheries Research Biologist, Alaska Department of Fish and Game, Cordova, Alaska from 1985 to 1995;

Principal Investigator, Injury to Prince William Sound Herring from the *Exxon Valdez* Oil Spill, NRDA FS 11, 1989-1992.

Fisheries Biologist, Florida Department of Natural Resources, St. Petersberg, Florida, 1987-1988; hydroacoustics.

Field Experience:

Aerial surveys; P.I. and primary surveyor, single and twin engine aircraft; 1988-present; techniques include lidar (laser sensing), digital imager (color video and Compact Airborne Spectrographic Imager or CASI), and visual surveys

Shipboard surveys; skiffs, commercial fishing and research vessels (30-110 ft); P.I. on 2, participated in over 12; last decade

Research SCUBA dive master; PI for several studies of nearshore fish spawning and egg survival projects

Operational experience scientific and shipboard downlooking acoustics, side-scan sonars, net sonars, GPS, and computerized navigation

Selected Publications:

Brown, E.D. In prep. A conceptual model of Pacific herring, *Clupea pallasi*: ecology and factors affecting year-class survival in Prince William Sound, Alaska. PhD Dissertation, University of Alaska Fairbanks, Fairbanks, Alaska. (Final Report to the *Exxon Valdez* Oil Spill Trustee Council and submitted to Fisheries Research).

Brown, E.D. In prep. Effect of herring egg distribution and ecology on year-class strength and adult distribution. . PhD Dissertation, University of Alaska Fairbanks, Fairbanks, Alaska. (Final Report to the *Exxon Valdez* Oil Spill Trustee Council and submitted to Fisheries Research).

Brown, E. D., G.A. Borstad, and B.L. Norcross. In final revision. Estimating forage fish and seabird distribution and abundance using aerial surveys: survey design and uncertainty. (Fisheries Research).

Brown, E.D. and B.L. Norcross. In press. Effect of herring egg distribution and ecology on year-class strength and adult distribution: preliminary results, Page 00 in International Symposium on Herring, 2000, University of Alaska Sea Grant AK-SG-01-00.

Brown, E.D. and B.L. Norcross. In press. Effect of herring egg distribution and ecology on year-class strength and adult distribution: preliminary results *in* International Symposium on Herring, 2000, University of Alaska Sea Grant, Report 00:00.

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Brown, E.D., S. Vaughan, and B.L. Norcross. 1999. Annual and seasonal spatial variability of herring, other forage fish, and seabirds in relation to oceanographic regimes in Prince William Sound, Alaska *in* Ecosystem Approaches for Fisheries Management, University of Alaska Sea Grant, AK-SG-99-01, Fairbanks, Alaska.

OTHER KEY PERSONNEL

Kevin Abnett is a software engineer at the Geophysical Institute at UAF. Kevin will be responsible for software/programming adjustments needed to signal processing algorithms and for providing the processed data in coordination with an unnamed engineering/programming technician.

Tim Veenstra, Airborne Technologies Inc., will be contracted to provide the aircraft and video imaging equipment. He will complete all image processing tasks, quantification of targets or pixel valuation, and delivery of binned, geocoded image data to the PIs.

LITERATURE CITED

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

National Marine Fisheries Service
Alaska Fisheries Science Center
Auke Bay Laboratory
11305 Glacier Highway
Juneau, Alaska 99801-8626
Fax (907) 789-6094
(907)789-6038

March 19, 2001

To Whom it May Concern:

We have assisted Dr. Evelyn Brown of the University of Alaska Fairbanks in her research with evaluating LIDAR for fishery uses. We have given her our coastal trawl catch data in 2000 in areas where she flew over our vessel with the LIDAR equipment as we were fishing. This cooperation should allow her to "ground truth" her information with actual catches in the same areas at the same time. These comparisons were primarily in the Gulf of Alaska.

In 2001 we plan on doing surface trawl surveys for juvenile salmon and associated marine species in the Gulf of Alaska and in the eastern Bering Sea. We look forward to cooperating in any way we can to help Dr. Brown ground truth her LIDAR data. We are hopeful that LIDAR will be a very useful tool in locating and monitoring schools of juvenile salmon along the continental shelf as well as schools of returning adult salmon.

Sincerely,

John H. (Jack) Helle, Ph.D.
Program Manager
Ocean Carrying Capacity Research

X-Sender: coyle@jarvis.ims.uaf.edu
X-Mailer: QUALCOMM Windows Eudora Light Version 3.0.6 (32)
Date: Tue, 20 Feb 2001 15:05:41 -0900
To: ebrown@ims.uaf.edu
From: Ken Coyle <coyle@ims.uaf.edu>
Subject: Data validation

To: Evelyn Brown:

From: Kenneth O. Coyle

Date: February 2, 2001

Subject: GLOBEC acoustic MOCNESS data.

The following is to confirm that we will make available to you any acoustic or MOCNESS data collected on the GLOBEC project so that you can use the data for validation of your LIDAR measurements.

Date: Fri, 23 Feb 2001 16:24:38 -0900
From: "Bruce Wright" <Bruce.Wright@noaa.gov>
X-Mailer: Mozilla 4.7 [en] (WinNT; U)
X-Accept-Language: en
To: Evelyn Brown <ebrown@ims.uaf.edu>
Subject: enumerating sharks

Dear Evelyn,

During the early summer to early fall densities of salmon sharks in some bays can exceed 300 sharks per km2, and that's just what we can count at the surface. Alaska Department of Fish and Game biologists have expressed concern these high numbers of predators may be impacting local salmon runs. Shark population estimates and trends may be useful to aiding ADFG biologists in managing salmon and sharks. Aerial surveys appear to be the best technique for enumerating shark numbers, especially with equipment that would penetrate into the water column.

I believe some of the tools you will be using on board your aerial surveys including a lidar (laser-penetration up to 50m-maps 3D biological structure in upper ocean), and video cameras, would provide useful information about sharks in the northeast Pacific. Salmon sharks are warm, so the FIR (forward looking infrared) may be useful for detecting sharks at night.

I think you could validate the lidar with the video camera data. Several surveys in Gulf of Alaska bays during the salmon season would be most productive.

Thanks,
Bruce

Subject: Re: letter of support
To: Evelyn Brown <ebrown@ims.uaf.edu>
X-Mailer: Lotus Notes Release 5.0.3 March 21, 2000
From: David_Irons@fws.gov
Date: Fri, 23 Feb 2001 15:58:33 -0900
X-MIMETrack: Serialize by Router on FW0HUB1/FWS/DOI(Release 5.0.5 |September 22, 2000) at 02/23/2001 06:15:23 PM

Evelyn,

Sorry this is so late, I hope you get what you want.

david

MEMORANDUM FOR: Evelyn Brown

FROM: David Irons, Seabird Coordinator, US Fish and Wildlife Service, Region 7

SUBJECT: Monitoring Forage Fish

As the seabird coordinator for the US Fish and Wildlife Service in Region 7 I am pleased to hear that you are working with the FLOE lidar system. I very much support the use of lidar for monitoring forage fish in relation to seabird distributions and any improvements to water penetrating radar systems. I can see where it would be extremely cost efficient to use these systems to monitor large areas of the north Pacific water where monitoring of the seabird forage base is of interest to the USFWS and the Gulf Ecosystem Monitoring Program.

If you have any questions please contact me at 907/786-3376 or e-mail david_irons@fws.gov.

Subject: remote sensing aerial surveys
To: ebrown@ims.alaska.edu
X-Mailer: Lotus Notes Release 5.0.2b December 16, 1999
From: Kathy_Kuletz@fws.gov
Date: Tue, 6 Mar 2001 09:50:51 -0900
X-MIMETrack: Serialize by Router on FW0HUB1/FWS/DOI(Release 5.0.5 |September 22, 2000) at 03/06/2001 12:09:38 PM

Hi Evelyn,

I'm finally going through some of the emails more carefully, so this is in response to one you sent 2/23/01, regarding the remote sensing for EVOS. That all sounds amazing - I hope its not too late to put in my 2cents.

I will have a small project in PWS on Kittlitz's murrelets this summer. Its part 'disturbance study', and part survey of where/how many Kimu are in PWS (and other areas of AK). As you may already know - Kimu appear to be in significant decline, but our general surveys for PWS can't provide accurate population estimates because of the way Kimu are distributed. Kimu are rare, and tend to be clustered near tidewater glaciers or where there is significant glacial runoff. In the 2000 summer survey, (at least for where our transects fell), they appeared to only be in a few of the northwestern fjords, whereas in previous years, they were more spread throughout the Sound, and in all glacially-fed fjords. We will be conducting boat surveys of areas where we know they do now, or have existed, or where habitat suggests they should be. I haven't worked on the details yet in terms of how much/which areas we will survey (depends on total funds available). We will hit at least ~ 10 fjords though, mostly in the north mainland, but also down near Icy Bay and Drier Bay on Knight Is. It would be great to have the type of habitat /sea conditions / eddies etc that you will be getting. I'm especially interested in the flow/water conditions near glaciers - Kimu appear to feed in the really murky, silty glacial waters, perhaps where it interfaces with salty/clear water.

Your time line wasn't clear - is any of this happening in 2001? Even if it doesn't happen until next year, it might be good info as background. Also, as we expect to get petitioned to list the Kimu, there may be more studies down the line. Let me know if this is something that can be integrated into your study, and how I can plan for that, if its possible.

Regards,

Kathy Kuletz
U.S. Fish and Wildlife Service
Migratory Bird Management
1011 E. Tudor Rd.
Anchorage, Alaska 99503 U.S.A.
kathy_kuletz@fws.gov
Phone: 907-786-3453 Fax: 907-786-3641

Airborne Technologies Inc.

April 6, 2001

EVOS Trustee Council
645 G Street Suite 401
Anchorage, AK 99501

Subject: Letter of intent

To Whom It May Concern:

This letter serves to indicate our intent to collaborate with Evelyn Brown, Institute of Marine Science, School of Fisheries and Ocean Science, University of Alaska Fairbanks and Dr. James Churnside from NOAA's Environmental Technology Laboratory Boulder, CO in their EVOS proposal titled, **Evaluation of Airborne Remote Sensing Tools for GEM Monitoring**. Airborne Technologies Inc. (ATI) will provided:

- Twin-engine aircraft with camera ports and room for pilot plus three
- Multispectral imager and mapping system that works in conjunction with the fish lidar unit
- Thermal imager or 3CCD digital video imager
- Technician for image acquisition during survey flights
- Post process work to include ArcView coverage of survey flight tracks, image analysis of significant data (bird, sea mammal, water color, tidal fronts, fish schools) geo-coded to correlate with the FLOE Lidar data

We understand this project to be a "proof of concept" proposal for long term monitoring and is designed to work in conjunction with an existing ship research program to be flown sometime during July or August 2001. The total additional flight time for the proof of concept flight will be a maximum of 25 hours. The total cost for Airborne Technologies Inc. involvement will be $45,000.

Airborne Technologies Inc. has worked with both Evelyn Brown and Jim Churnside on other remote sensing projects over the past three years. As a private sector company, our desire is to maintain a continuing relationship with both the University and NOAA's Environmental Technology Laboratory in the development of a lidar/imaging system for both research and resource management.

Sincerely,

Tim Veenstra
President - Airborne Technologies Inc.

PO Box 879050 Wasilla, AK 99687
Phone: (907) 357-1500 Fax: (907) 357-1501

FY 02 *EXXON VALDEZ* TRUS COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	PROPOSED FY 2002 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$103.4				$15.0
Personnel	$0.0	$10.5						
Travel	$0.0	$2.8						
Contractual	$0.0	$96.6						
Commodities	$0.0	$0.1						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$110.0	Estimated					
General Administration	$0.0	$8.4	FY 2003					
Project Total	$0.0	$118.4	$240.0					
Full-time Equivalents (FTE)	0.0	1.1						
			Dollar amounts are shown in thousands of dollars.					
Other Resources	$0.0	$0.0	$0.0					

Comments:

(Caution. Use this blank form carefully. It is designed with ADFG only as contractor with UAF only and with NOAA as Co-PI.)

FY02

Prepared: April 2001

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Lead Agency: ADF&G

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	[redacted]
Personnel		$0.0	
Travel		$0.0	
Contractual		$96.6	
Commodities		$0.0	
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS
Subtotal	$0.0	$96.6	Estimated FY 2003
General Administration		$6.8	
Project Total	$0.0	$103.4	$200.0
Full-time Equivalents (FTE)		1.0	[redacted]
			Dollar amounts are shown in thousands of dollars.
Other Resources			

Comments:
Summary sheet for contractual (RSA) with UAF
FTE and Estimated FY 2003 is for UAF

FY02

Prepared: April 2001

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRUS: :OUNCIL PROJECT BUDGET
October 1, 2001 . tember 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel		$10.5						
Travel		$2.8						
Contractual		$0.0						
Commodities		$0.1						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$13.4	Estimated					
General Administration		$1.6	FY 2003					
Project Total	$0.0	$15.0	$40.0					
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
The lidar equipment and other remote sensing instruments, potentially including an infrared radiometer and digital 3-chip color video (set up to collect ocean color), are being provided at no cost to the project. This represents a substantial savings over having to rent or purchase this equipment. Personnel time involved with processing costs is also being provided in-kind. This represents an approximate 50% match of the total personnel time.

FY02

Prepared: April 2001

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRUST OUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
James Churnside	Supervisory Physicist	ZP 5	0.3	20.0		6.0
James Wilson	Electronics Engineer	ZP 4	0.3	15.0		4.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.6	35.0	0.0	
					Personnel Total	$10.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
RT Denver to Anchorage - Field Data Collection	1.8	1	5	0.2	2.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$2.8

FY02

Prepared: April 2001

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

FORM 3B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUST COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
	$0.0

Commodities Costs:	Proposed FY 2002
Description	
misc. (water filter for laser, dry nitrogen for laser, data recording media, etc.	0.1
Commodities Total	$0.1

Project Number: 02584

FORM 3B

FY02

Monitoring

Commodities DETAIL

Prepared: April 2001

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
NOAA Fish Lidar	1	NOAA

FY02

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

FORM 3B
Equipment
DETAIL

Prepared: April 2001

FY 02 *EXXON VALDEZ* TRUS COUNCIL PROJECT BUDGET
October 1, 2001 tember 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	[redacted]
Personnel		$25.8	
Travel		$5.9	
Contractual		$47.9	
Commodities		$1.0	
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS
Subtotal	$0.0	$80.6	Estimated FY 2003
Indirect		$16.0	
Project Total	$0.0	$96.6	$200.0
			[redacted]
Full-time Equivalents (FTE)		1.0	
	Dollar amounts are shown in thousands of dollars.		
Other Resources			

Comments:
Summary for UAF portion of this budget; carried forward as contractual from ADF&G

The indirect rate is 25% TDC, as negotiated by the Exxon Valdez Oil Spill Trustee Council with the University of Alaska.

(Use this statement if there is a graduate student tuition and use proper resident or non-resident amount)
Student personnel costs include non-resident tuition of $6,048 per year.

FY02

Prepared: April 2001

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

FY 02 *EXXON VALDEZ* TRUST COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2002
	Evelyn Brown	Research Associate	1.5	6.6		9.9
	Engineer/Programmer	Engineer/Programmer	1.5	6.4		9.6
	Graduate Student	Graduate Student	9.0	0.7	0.0	6.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	12.0	13.7	0.0	
					Personnel Total	$25.8

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2002
	Field testing R/T Fairbanks-Anchorage (Brown)	0.3	2	8	0.3	3.0
						0.0
	EVOS workshop and research planning (Fairbanks-Anchorage) (Brown)	0.3	1	4	0.2	1.1
						0.0
	Scientific Meeting (GLOBEC/PICES) (Brown)	0.8	1	5	0.2	1.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$5.9

FY02

Prepared: April 2001

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUS' :OUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed
Description	FY 2002
communications	0.2
Aerial Survey Contract (aircraft and imaging services)	45.0
Recharge- Kevin Abnett, GI (Data Processing/Programming)	2.5
(42 hrs. @ $60.00 p/hour)	
Copy/Reproduction	0.2
Contractual Total	$47.9

Commodities Costs:	Proposed
Description	FY 2002
Software Upgrades--ESRI-ArcView/Info, Splus, Data storage	0.3
Electronic supplies and tools	0.4
Hardware/Printer Supplies/Repair	0.3
Commodities Total	$1.0

FY02

Prepared: April 2001

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: University of Alaska Fairbanks

FORM 4B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRUST COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2002
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

FY02

Project Number: 02584
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

PWSRCAC - EVOS Long Term Environmental Monitoring Program, Submitted Under the BAA No. 52ABNF100031

Project Number:	02589-BAA
Restoration Category:	Monitoring
Proposer:	Prince William Sound Regional Citizens' Advisory Council
Lead Trustee Agency:	not applicable
Cooperating Agencies:	
Alaska SeaLife Center:	no
Duration:	on going long term
Cost FY 02:	$218.0
Cost FY 03:	
Geographic Area:	Prince William Sound, Kodiak, Kenai Peninsula, Alaska Peninsula
Injured Resource/Service:	

ABSTRACT:

The Prince William Sound Regional Citizens' Advisory Council/Exxon Valdez Oil Spill Trustee Council Long Term Environmental Monitoring Program provides essential long term baseline measurements of hydrocarbon levels and sources at program sites within areas of the Prince William Sound, Kenai Peninsula, Kodiak, and Gulf of Alaska. The program objective is to provide a more comprehensive program for the collection of baseline data in subtidal sediments and mussel tissue that can be used to determine impacts of oil sources on the ecosystem. This program will provide an improved link to recovery status and greater efficiency in hydrocarbon sampling and analysis that has been on going since 1993 under the auspices of PWSRCAC.

INTRODUCTION:

The Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) seeks partnership with the Exxon Valdez Oil Spill Trustee Council (EVOSTC) to carry out long term baseline measurements of hydrocarbon levels at program sites in the geographic area impacted by the T/V *Exxon Valdez* oil spill of 1989. Although PWSRCAC's Long Term Environmental Monitoring Program (LTEMP) has conducted hydrocarbon testing since 1993, the agency's purview is contained within the geographic area defined by oil tanker traffic lanes to and from the Alyeska Marine Terminal in the Prince William Sound.

The PWSRCAC/EVOSTC partnership will enable the expansion of the gathering of baseline data throughout the T/V *Exxon Valdez* oil spill impacted areas to testing sites in the Kenai Peninsula, the Alaska Peninsula, and Kodiak as well as the Prince William Sound. The scope of sampling will be enhanced to contribute a substantial amount of data to the baseline information that has been collected since 1993.

This program will aid researchers, subsistence communities, and trustees in the determinations of recovery status within the broader zone of the Prince William Sound, Kenai Peninsula, Kodiak and Alaska Peninsula.

The program will provide long term baseline measurements of hydrocarbon levels and sources in subtidal sediments and indigenous blue mussels. Subtidal sediment and intertidal indigenous (native) blue mussel tissue samples will be collected from fourteen stations for the analysis of polycyclic aromatic hydrocarbons (PAH), aliphatic hydrocarbons (AHC) which includes the unresolved complex mixture (UCM), total organic carbon (TOC), and particle grain size (PGS). Intertidal mussel samples will be collected for the analysis of PAH and lipid content with additional mussels collected for the measurement of gonadal index.

NEED FOR THE PROJECT:

A. Statement of Problem

Long term data sets having to do with hydrocarbon levels throughout the T/V *Exxon Valdez* oil spill impacted area are not available. The LTEMP data collection stemming from 1993 excludes much of the geographic scope of the T/V *Exxon Valdez* oil spill impacted coastline in the north Gulf of Alaska, including the oiled coastline along the Kenai and Alaska Peninsulas, Kodiak and Prince William Sound. PWSRCAC funding may only be applied to projects relating to the Alyeska Marine Terminal and associated tanker trade.

Long term environmental monitoring needs to be implemented in order to identify the physical and biological changes taking place in the north Gulf of Alaska ecosystem. It is essential to distinguish between natural trends and human caused changes in the environment. Establishing a baseline is needed in order to identify and assess trends over time.

The growth in commercial and recreational use of the north Gulf of Alaska creates further complexity in the problem of having adequate baseline data. These sensitive coastal marine environments are experiencing increased pressures on already intense use. This is evidenced by the growth in numbers of large and small passenger cruise ship traffic, the extension of the

longevity of the Trans Alaska Pipeline and its shipping activity, the new Whittier road access which is expected to create exponential growth in numbers of visitors, State oil and gas lease sales, new ports, increases in recreational uses, and demands for new access to fishing sites.

Baseline date is needed for the accurate assessment of recovery and to extend recovery determinations to the broader zone of the Prince William Sound, Kenai Peninsula, Kodiak and Alaska Peninsula. Essential tools will be of use to researchers, subsistence communities and trustees. Measurements are needed regarding the seasonal cycles of availability of hydrocarbons in zone affected by the T/V *Exxon Valdez* oil spill of 1989.

While the PWSRCAC investment in long term monitoring has been made independently since 1993, competing interests for funding have resulted in some decline in the LTEMP scope, in particular the exclusion of sediment sampling. While the monies to fund the majority of the sediment sampling were cut, there is strong sentiment for the need for continuance of such. While the PWSRCAC funding source for LTEMP is Alyeska Pipeline Service Company, there may be project outcomes indicating sources of pollution other than that produced by Alyeska. Cooperative sources of project funding for hydrocarbon sampling and testing may be appropriate.

B. Rationale/Link to Restoration

A PWSRCAC/EVOSTC partnership will enable enhanced long term environmental monitoring in the T/V *Exxon Valdez* oil spill impacted areas in the north Gulf of Alaska along the Kenai and Alaska Peninsulas and Kodiak, as well as the Prince William Sound. The program will provide long term baseline measurements of hydrocarbon levels and sources in subtidal sediments and indigenous blue mussels.

Timely implementation of a program to extend of hydrocarbon testing to these areas will provide current and long term data sets that may prove extremely valuable in understanding ongoing natural and human caused changes. Results will allow researchers, subsistence users, and trustees to expand recovery determination to a greater portion of the zone impacted by the T/V *Exxon Valdez* oil spill.

Long term data sets can provide the baseline for the tracking of trends in the ecosystem and assistance in the identification of threats to important coastal resources. An early warning system can alert to the need for more specific research as changes occur such as leaps in hydrocarbon levels, as observed in Aialik Bay in 1998 (ref. LTEMP 1997-98 Annual Report). Environmental management can be enhanced with an improved information supply that is also independent of that provided by industry users. The program will provide tracking of lingering oil pollution from the T/V *Exxon Valdez oil spill* of 1989.

The collection of long term baseline data is important because of the large variability inherent in studying natural populations. Because of the physical and biological variability in nature, a large amount of baseline data reflecting existing conditions is required before man-made changes to the environment can be identified or assessed. Collection of reliable data over time helps in the understanding of how natural and man made forces interact within a complex ecosystem.

The Long Term Environmental Monitoring Program can identify and track the multitude of origins of hydrocarbons in the marine environment. Hydrocarbons in the marine environment,

particularly in the T/V *Exxon Valdez* oil spill area, can have a multitude of origins, including both natural and anthropogenic sources. These include the release of oil through man's activities such as the T/V *Exxon Valdez* oil spill in 1989, operations at the Alyeska Marine Terminal, or other oil transportation activities, combustion sources such as stack exhaust or forest fires, boating and ship activities, natural oil seepage, biological processes from bacteria or other organisms, and atmospheric fallout. Natural events such as earthquakes can also result in the release of hydrocarbons as can the seasonal change in physical water mass properties and environmental energy. All of these may contribute hydrocarbons to sediments and resident biota in Prince William Sound and the Gulf of Alaska

The PWSRCAC/EVOSTC partnership can leverage funding to implement essential long term environmental monitoring of the EVOS impacted coastal area. At this time the PWSRCAC board is prioritizing a wide area of responsibilities having to do with the environmentally safe transportation of oil. PWSRCAC and EVOSTC seem best suited to enter into such a funding partnership as long term funding commitments are possible, at least more so than with the annual governmental funding cycle. LTEMP data is of use and interest to many stakeholders outside the PWSRCAC. A participative investment in the program will help insure long term funding for long term monitoring. LTEMP has proven successful and cost effective. Testing standards are high and have been maintained consistently since 1993.

C. Location

Established sites include:

Aialik Bay
Alyeska Marine Terminal
Disk Island
Gold Creek
Knowles Head
Sheep Bay
Shuyak Harbor
Sleepy Bay
Windy Bay, and
Zaikof Bay

*Four sites to be added may include:

Kachemak Bay
Kodiak Island, and
Alaska Peninsula (Katmai National Park)
Kenai Fjords National Park

*NOTE: THE EXACT LOCATIONS OF THE NEW TESTING SITES WILL BE DETERMINED AFTER RECONNAISSANCE OF THE AREAS AND STUDY AND COORDINATION BETWEEN PWSRCAC AND EVOSTC .

See Figure 1.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

PWSRCAC operates a standard practice making annual presentations and mailing a quarterly PWSRCAC Newsletter to most post office boxes in the affected communities. Presentations and articles are offered in lay terms and technical information is offered upon request. PWSRCAC

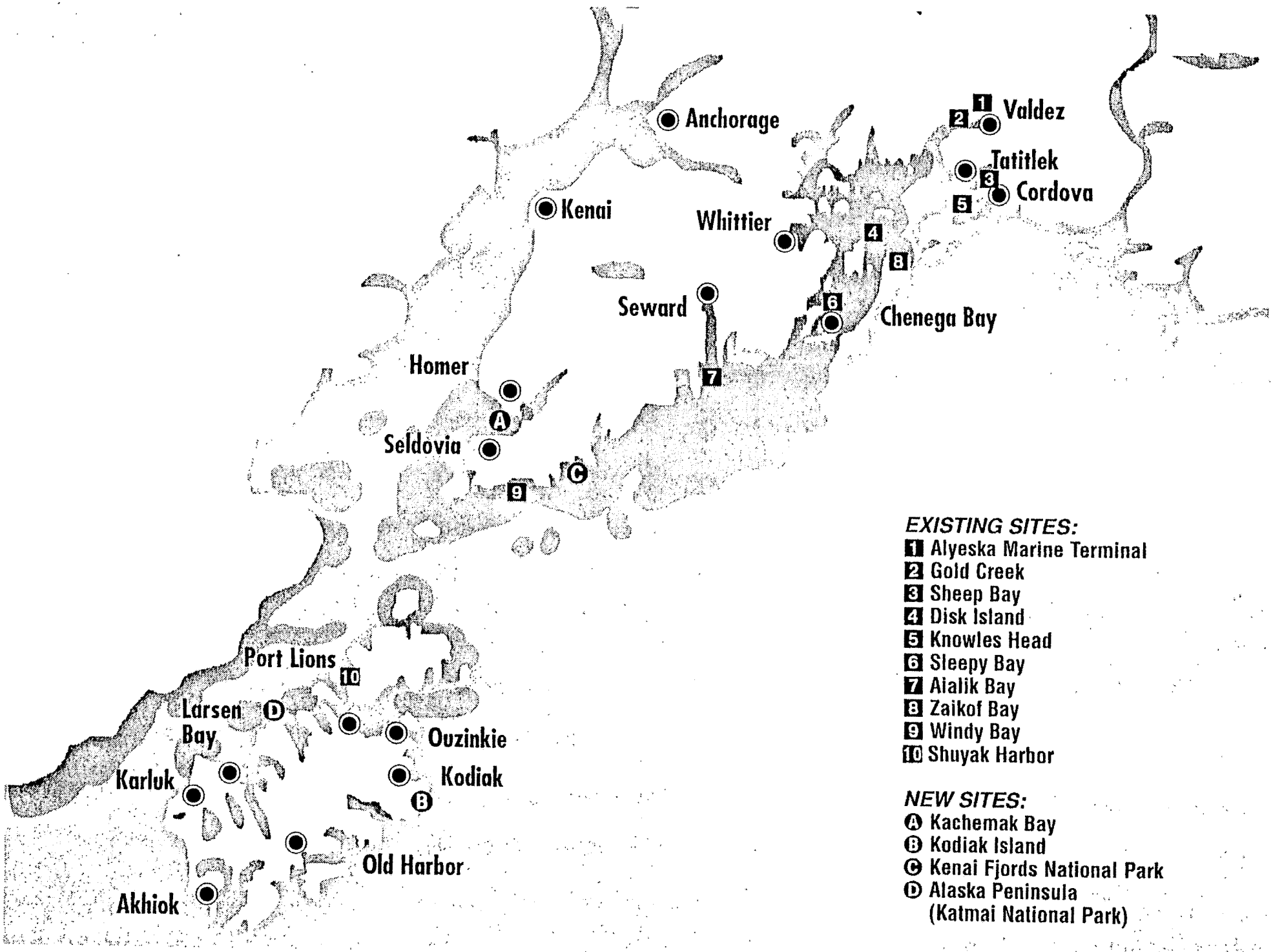
Anchorage
Kenai
Whittier
Seward
Homer
Seldovia
Valdez
Tatitlek
Cordova
Chenega Bay
Port Lions
Larsen Bay
Ouzinkie
Kodiak
Karluk
Old Harbor
Akhiok
EXISTING SITES:
1 Alyeska Marine Terminal
2 Gold Creek
3 Sheep Bay
4 Disk Island
5 Knowles Head
6 Sleepy Bay
7 Alalik Bay
8 Zaikof Bay
9 Windy Bay
10 Shuyak Harbor
NEW SITES:
A Kachemak Bay
B Kodiak Island
C Kenai Fjords National Park
D Alaska Peninsula
(Katmai National Park)

Figure 1

managers make a practice of going out into the communities to dispense project information, including LTEMP, to the general population.

In order to encourage greater community participation, technicians from local communities will be recruited and hired to accompany scientists during the collection of samples. The openings will be rotated between communities to broaden the reach of participation and understanding about the long term monitoring project.

PWSRCAC works closely with other federal, state, Native, and local government agencies, conservation organizations, businesses, and private landowners. Community involvement is inherent in PWSRCAC's nineteen member Board of Directors, and committee memberships, which includes the following community representatives:

Executive Committee:

Stan Stephens, President	AK Wilderness Recreation & Tourism Ass.
John Allen, Vice President	Tatitlek Corp., Tatitlek Village IRA Council
Marilynn Heddell, Secretary	Whittier
William M. Walker, Treasurer	Valdez
Stephen Lewis, Member at Large	Seldovia
Dennis Lodge, Member at Large	Seward
Paul McCollum, Member at Large	Homer

Other Directors:

Margy Johnson	Cordova
Patience Andersen-Faulkner	Cordova District Fishermen United
JoAnn McDowell, Ph.D.	Valdez
Jim Nestic	Kodiak Village Mayors Assoc.
Wayne Coleman	Kodiak
Cheryll Heinze	Alaska State Chamber of Commerce
Blake Johnson	Kenai Peninsula Borough
Bill Lindow	Prince William Sound Aquaculture Corp.
Tom Copeland	Oil Spill Region Environmental Coalition
Pete Kompkoff	Chenega Bay Corp., Chenega IRA Council
Jane Eisemann	Kodiak
Sheri Buretta	Chugach Alaska Corporation

Scientific Advisory Committee (This committee oversees LTEMP):

Richard Tremaine, Chair	Anchorage
Dr. Peter Armato,	Seward
Gig Currier,	King Salmon
Gary Lawley, Ph.D.	Anchorage
Michelle Hahn O'Leary,	Cordova
AJ Paul, Ph.D.	Seward
Charles K. Weaverling,	Cordova
John Williams	Cordova

PROJECT DESIGN

A. Objectives

The purpose of the Long Term Environmental Monitoring Program is to provide long term baseline measurements of hydrocarbon levels and sources in subtidal sediments and indigenous blue mussels at program sites within areas of Prince William Sound, Kenai Peninsula, Kodiak, and the Gulf of Alaska, an area represented by the EVOSTC and in part by PWSRCAC. The objectives of the program are to fully document the field and laboratory data collected and to maintain data integrity. This expanded data collection will expand monitoring efficiency and may then be used in determinations by researchers, subsistance users, and trustees by providing a link to the recovery status of species of concern.

B. Methods

The basic sampling approach for this program is consistent with the National Oceanographic and Atmospheric Administration's (NOAA) National Mussel Watch Project where native populations of sedentary organisms are utilized as bioindicators of chemical contamination, and nearby sediments are used to evaluate trends in contamination in the marine environment.

Bivalves such as the blue mussel filter large volumes of water, and numerous studies have indicated that they can accumulate hydrocarbons to a level several orders of magnitude above the water column concentrations. Long term studies of mussel tissue at selected sites can provide information concerning the trends of hydrocarbon contamination at those sites. Bioaccumulation of hydrocarbons in mussels is a dynamic process as mussels eliminate the contaminants from their body tissues both in response to cleaner conditions and through the release of gametes during spawning. For this reason, repeated sampling is helpful in determining trends in contamination, as each sampling event provides information on contamination levels that exist at that point in time

Sediment analyses are intended to provide information concerning the potential accumulation of hydrocarbons in the subtidal environment. Sediment transport from beaches potentially contaminated with petroleum or deposition of hydrocarbons adsorbed on particulate matter are the primary processes contributing to hydrocarbon concentrations in subtidal sediments. For this program, recently-deposited sediments (top 2 centimeters [cm]) are examined to determine hydrocarbon content.

Analytical approach includes the use of compound-specific measurements for organic parameters such as PAH and AHC (including UCM). These parameters are used to assess hydrocarbon concentrations in both tissue (PAH and AHC) and sediment (PAH and AHC). Additional parameters analyzed for tissues included percent lipids and gonadal index. These measurements are important because the gonads in these organisms are largely composed of lipid material which is the primary storage vehicle for hydrocarbons (National Research Council, 1985). When the lipid-rich gametes are released during spawning, hydrocarbons are also discharged. Measurement of the gonadal state and percent lipids is therefore necessary to provide information concerning apparent differences in tissue concentrations which may be an artifact of spawning condition at the time of mussel collection rather than real temporal differences. Mussels in temperate areas generally spawn in the cooler months. Primary spawning (and release of lipid-rich gametes that may contain accumulated hydrocarbons) occurs from mid-April to

early June. Sampling in late spring (March) allows collection of mussels in varying stages of gametogenesis, but prior to major spawning activity. Sample collection in the summer occurs in the late- or post-spawning period when mussel gonads are returning to a resting state.

Analytical strategy is summarized in Table 1.

Analytical methods include tissue sample collection in the intertidal area which is analyzed for PAH, AHC, and lipid content. Mussel samples designated for hydrocarbon analysis are collected by hand from the mid-intertidal zone of each station using a stratified random sampling design. Three replicates of 30 individuals each are collected from three randomly-selected points along a 30-m transect. Replicate mussel samples are analyzed for PAH, AHC, and percent lipids.

In addition to the tissue samples designated for chemical analysis, twenty additional mussels are collected at each station for assessment of gonadal state. Samples for gonadal index determination are also collected. A single composite sample of 20 individual mussels are collected at each intertidal station (approximately 7 individual mussels from each replicate area). These mussels are bagged and returned to the survey vessel without freezing. These live mussel samples are chilled in the refrigerator or a cooler with ice packs until processing.

Subtidal sediment samples are analyzed for the following parameters: PAH, AHC, PGS, and TOC. A modified Van Veen grab was used to collect each replicate. Shallow subtidal sediment is collected using divers at a limited number of sites. Field and equipment rinsate blanks are analyzed for PAH and AHC.

With the exception of gonadal index which is determined in the field or at Kinnetic Laboratories Inc. (KLI), Anchorage, all samples are analyzed at the Geochemical and Environmental Research Group (GERG) at Texas A&M University..

Navigation and station location include the use of nautical and topographic charts, radar, and a global positioning system (GPS). A locally chartered vessel is used for all field surveys. In addition, during March surveys, Gulf of Alaska stations are sampled from a chartered float plane out of Anchorage. Beach sampling is accomplished using a Zodiac® outfitted with an outboard motor.

The project includes a comprehensive quality assurance, quality control (QA/QC) program that encompasses all aspects of the project, from initial sample collection through laboratory analysis and data analysis to reporting.

The early stages of the LTEMP program included an investigation of the statistical power of the study design which indicated that the triple replication in the existing study design was sufficient to address program objectives (KLI, 1993a).

Table 1. LTEMP Analytical Strategy.

Parameter	Description	Matrix	Relevance
Polycyclic aromatic hydrocarbons (PAH)	2 to 6-ring polycyclic aromatic hydrocarbon compounds; includes homologous series of aromatic hydrocarbons consisting of unsubstituted (parent) compounds, such as naphthalene, and substituted compounds, which are similar structures with alkyl side chains that replace hydrogen ions, such as C_1-naphthalene	Mussel tissue, sediment, and water (blanks)	Useful for determining hydrocarbon contamination and the relative contribution of petrogenic, pyrogenic, and diagenic sources; useful in source identification and determination of weathering rates
Aliphatic hydrocarbons (AHC)	Fully saturated normal alkanes (paraffins) and branched alkanes, n-C_{10} to n-C_{34}; includes the isoprenoid compounds pristane (C_{19}) and phytane (C_{20}) that are often the most abundant isoprenoids in petroleum hydrocarbons	Mussel tissue, sediment and water (blanks)	Useful for determining hydrocarbon contamination and the relative contribution of petrogenic and biogenic sources; useful in determination of weathering rates and rates of oil degradation
Unresolved complex mixture (UCM)	A mixture of hydrocarbons of undefined structure that are not separated by gas chromatographic techniques; represented by the total resolved plus unresolved area minus the total area of all peaks that have been integrated; a characteristic of some fresh oils and most weathered oils	Mussel tissue, sediment and water (blanks)	Useful for determining hydrocarbon contamination and the relative contribution of petrogenic, pyrogenic, and diagenic sources; useful in source identification and determination of weathering rates
Percent Lipid	Lipid material in mussel tissue is primary storage area for hydrocarbons; gametes are mostly comprised of lipids	Mussel tissue	Useful in determining spawning state of mussels; hydrocarbon body burdens decrease when lipid-rich gametes are released during spawning
Gonadal Index	Measure of shell length, shell volume, volume and weight of gonadal tissue, volume and weight of non-gonadal tissue	Mussel tissue and shell	Useful in determining spawning state of mussels; hydrocarbon body burdens decrease when lipid-rich gametes are released during spawning
Particle Grain Size (PGS)	Percent sand, silt, and clay	Sediment	Assessment of particle size distribution in sediments; potentially used to standardize organic parameters such as PAH and AHC
Total Organic Carbon (TOC)	Organic carbon	Sediment	Assessment of organic carbon load in sediment; potentially used to standardize organic parameters (PAH and AHC)
Total Resolved Aliphatic Hydrocarbon (TRAHC)	A mixture of hydrocarbons defined and undefined by gas chromatographic techniques that represents the total resolved and unresolved area of the GC run. Includes the AHC analyte list, UCM, and other compounds (e.g., plant waxes and lipids)	Mussel tissue	Provides additional information concerning biogenic (biologically sourced) component of the hydrocarbons that may be present in the mussel tissue

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Prince William Sound Regional Citizens' Advisory Council cooperates with several agencies and groups throughout the region and state. Participation from Native Alaskan communities in particular is encouraged in order to garner local knowledge and gain feedback regarding the PWSRCAC's work.

PWSRCAC has contracted for sampling, laboratory work and reporting to Kinnetic Laboratories, Inc. (KLI) with an office in Anchorage, Alaska. Project personnel are Alaska based. Laboratory analysis is performed at GERG, Geochemical and Environmental Research Group at Texas A&M University. KLI has won each public bid since the program was initiated in 1993. Currently KLI is under a three year contract with PWSRCAC ending June 30, 2002. KLI's work has proven satisfactory to the PWSRCAC board, management and Scientific Advisory Committee. An independent scientific peer review of the contractor's draft product is performed periodically. An in depth data analysis was performed in 1998 (J.R. Payne Environmental, 1998). Resumes of key personnel at Kinnetic Laboratories are attached (Attachment A).

The National Oceanic and Atmospheric Administration (NOAA)'s Mussel Watch Project samples five sites in Alaska, two of which are in the Prince William Sound at Siwash Bay and Mineral Creek. Sampling frequency is once every two years. NOAA and PWSRCAC coordinate with shared samples. In the spring 2000 testing NOAA shared samples for background testing.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 – September 30, 2002)

October, 2001	Notice to Proceed
March, 2002	Field Sampling
April, 2002	Field Survey Report
April-May, 2002	Laboratory Analysis
April-May, 2002	Laboratory QA/QC
May, 2002	Laboratory Reporting
April-September, 2002	Data Validation and Management
July, 2002	Field Sampling
July, 2002	Field Survey Report
July-August, 2002	Laboratory Analysis
July-September, 2002	Laboratory QA/QC
September, 2002	Laboratory Reporting
August-September, 2002	Data Analysis

B. Project Milestones and Endpoints

See Figure 2.

B. Completion Date

The completion date for work to be performed in FY02 is December 15, 2001 with the submittal of the final LTEMP Annual Report.

PROJECT TIMELINE

PRINCE WILLIAM SOUND REGIONAL CITIZENS ADVISORY COUNCIL

PWS RCAC/EVOS LONG TERM ENVIRONMENTAL MONITORING PROGRAM, 2001-2002

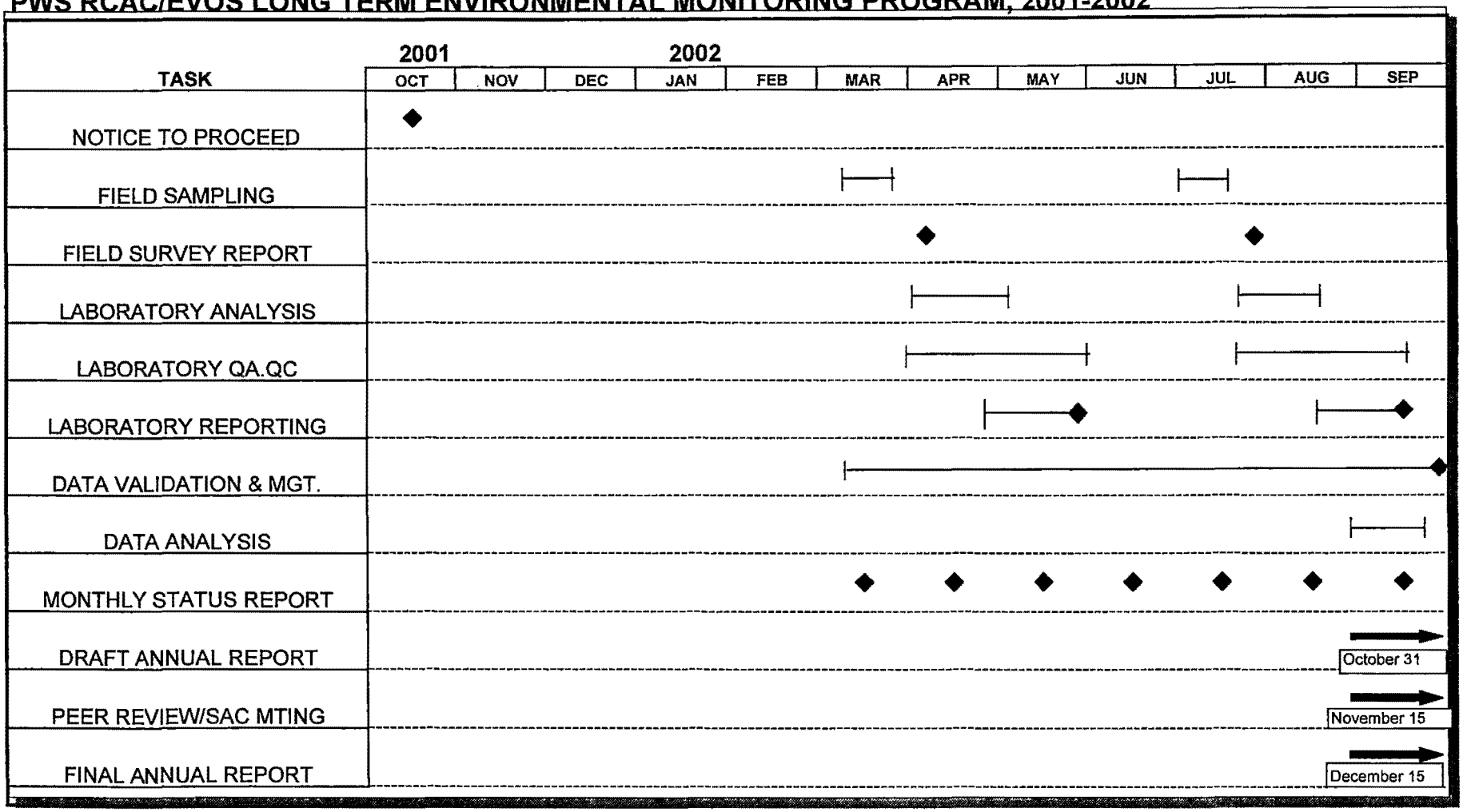

Figure 2. PWSRCAC/EVOS Long Term Environmental Monitoring Program Project Timeline

PUBLICATIONS AND REPORTS

1. March-September, 2002 Monthly Status Report
2. October 31, 2002 Draft Annual Report
3. November 15, 2002 Peer Review/Scientific Advisory Committee Meeting
4. December 15, 2002 Final Annual Report

PROFESSIONAL CONFERENCES

No travel funds for professional conferences are being requested. PWSRCAC is prepared to pay conference costs associated with presenting LTEMP. PWSRCAC managers frequently deliver papers at professional conferences and are willing to present project results when applicable

NORMAL AGENCY MANAGEMENT

Proposer is not a government agency.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

LTEMP data is provided to Native Alaskan corporations and representatives on an annual basis. The data is shared specifically with NOAA where particular coordination efforts take place. Reports and data will be available on the PWSRCAC web site www.pwsrcac.org.

On a two year cycle, letters are written to agencies and private companies performing similar work in the Prince William Sound, north Gulf of Alaska area to provide an update regarding LTEMP, make certain project results are being disseminated, and to insure no duplication of effort is taking place. Copies of several written responses are attached *(Attachment A)*.

PRINCIPAL INVESTIGATOR:

Name: John S. Devens, Ph.D.
Affiliation: Executive Director, Prince William Sound Regional Citizens' Advisory Council
Mailing address: P.O. Box 3089, Valdez, AK 99686
Phone number: (907) 835-5957
Fax number: (907) 835-5926
E-mail address: rcac@valdez.pwsrcac.org

See resume Attachment B

PWSRCAC is an independent non-profit organization formed after the T/V *Exxon Valdez* oil spill of 1989 to promote environmentally safe operation of the crude oil terminal in Valdez and the tankers it serves. Under a contract with Alyeska Pipeline Service Company, PWSRCAC monitors and advises Alyeska on terminal operations, spill prevention, response planning, and other environmental issues. The federal Oil Pollution Act of 1990 requires an industry funded citizens' advisory group for Prince William Sound. Our 19 member board includes communities affected by the Exxon Valdez oil spill and interest groups with a stake in the affected region.

The Scientific Advisory Committee sponsors PWSRCAC LTEMP. The committee oversees and performs periodic peer reviews of the work.

OTHER KEY PERSONNEL:

See resumes of Kinnetic Laboratories personnel (Attachment C).

PWSRCAC LTEMP Project Manager: Lisa Ka'aihue

LITERATURE CITED:

1993 LTEMP Annual Monitoring Report & Appendices
1994 LTEMP Annual Monitoring Report & Appendices
1995 LTEMP Annual Monitoring Report & Appendices
1996-97 LTEMP Annual Monitoring Report & Appendices
1997-98 LTEMP Annual Monitoring Report & Appendices
1998-99 LTEMP Annual Monitoring Report & Appendices
1999-2000 LTEMP Annual Monitoring Report & Appendices
Long Term Data Analysis of Hydrocarbons in Intertidal Mussel and Marine Sediments, 1993-1996, J.R. Payne Environmental

All reports indicated above available upon request.

FY 02 *EXXON VALDEZ* TRU : COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel		$160.0						
Travel		$35.2						
Contractual		$9.8						
Commodities		$83.4						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$288.4	Estimated FY 2003					
Indirect								
EVOSTC Total		**$218.0**						
PWSRCAC Total*	$0.0	$93.5						
Project Total		$311.5						
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
*RCAC will provide 30% of the project's funding to reduce the EVOS participation to 70% of project funding. In-kind funding provided by PWSRCAC includes manager time of approximately 300 hours, Scientific Advisory Committee volunteer time of approximately 200 hours, and miscellaneous office expenses for faxing, copying, telephone calls and such. These in-kind expenses are estimated at greater than $30,000.00

FY02

Prepared: 4/2/01

Project Number: 02589-BAA
Project Title: PWSRCAC/EVOSTC Long Term Environmental Monitoring
Name: Lisa Ka'aihue

FORM 4A
Non-Trustee
SUMMARY

FY 02 *EXXON VALDEZ* TRU E COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2002
	Kinnetic Laboratories	Scientist V	0.4	19281.0		7,712.4
		Scientist IV	6.3	16960.0		106,848.0
		Computer Analyst IV	0.1	18210.0		1,821.0
		Scientist III	0.2	12854.0		2,570.8
		Computer Analyst III	0.5	12140.0		6,070.0
		Scientist III	2.3	9997.0		22,993.1
		Scientist I	0.3	7319.0		2,195.7
		Editor/Drafting	0.3	7855.0		2,356.5
	Community Hires	Technician/Trainees	1.5	4333.0		6,499.5
						0.0
						0.0
						0.0
		Subtotal	11.9	108949.0	0.0	
					Personnel Total	$159,067.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2002
	Airfare R/T (ANC-VDZ)	170.0	4	36	125.0	5,180.0
	Truck rental/day			12	50.0	600.0
	Mileage charge/mile -- 1800 miles/.25 cents			1800	0.25	450.0
	Sampling vessel PWS w/crew per day			16	950.0	15,200.0
	Sampling vessel GOA w/crew per day			8	1200.0	9,600.0
	Float plane - Cesna 206/hr			14	300.0	4,200.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$35,230.0

FY02

Prepared: 4/2/01

Project Number:
Project Title: PWSRCAC/EVOSTC Long Term Environmental Monitoring
Name: Lisa Ka'aihue

FORM 4B
Personnel
& Travel
DETAIL

Contractual Costs:			Proposed
Description	Unit	Rate	FY 2002
KLI Zodiak Mark III/day	23	75	1,725.0
SCUBA Gear (2)/day	21	200	4,200.0
Poseidon compressor/day	21	50	1,050.0
Benthic grab/day	17	25	425.0
Field computer/day	23	15	345.0
Navigatoin/Survey Eqpt./day	23	25	575.0
Fed-X sample shipping/cooler	9	75	675.0
Freight costs	620	1	620.0
Communication	150	1	150.0
		Contractual Total	$9,765.0

Commodities Costs:			Proposed
Description	Unit	Rate	FY 2002
Photocopies/page	15000	0.05	750.0
Facsimile/page	150	0.50	75.0
Shackles/Line/Hardware	150	1	150.0
Chemistry sample containers 250 ml/case	12	40	480.0
Chemistry sample containers 1000 ml/case	1	50	50.0
Acetone/case 4 X 4L	1	145	145.0
Hexane/case 4 X 4L	1	150	150.0
HPLC Water/case 4 X 4L	1	100	100.0
Lab supplies (gloves, pipettes, etc.)	150	1	150.0
Tissue PAH/AHC analysis/sample	84	450	37,800.0
Sediment PAH & AHC analysis/sample	100	375	37,500.0
Sediment Particle Size & TOC analysis/sample	100	60	6,000.0
		Commodities Total	$83,350.0

FY02

Prepared: 4/2/01

Project Number:
Project Title: PWSRCAC/EVOSTC Long Term Environmental Monitoring
Name: Lisa Ka'aihue

FORM 4B
Contractual &
Commodities
DETAIL

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	
Description	of Units	

FY02

Prepared: 4/2/01

Project Number:
Project Title: PWSRCAC/EVOSTC Long Term Environmental Monitoring
Name: Lisa Ka'aihue

FORM 4B
Equipment
DETAIL

Attachment A
Letters

Status: U
Date: Tue, 20 Mar 2001 14:50:12 -0500
From: "Gunnar Lauenstein" <Gunnar.Lauenstein@noaa.gov>
Organization: NOAA/NOS/NCCOS/CCMA
X-Accept-Language: en,pdf
To: kaaihue@anch.pwsrcac.org
Subject: NOAA Mussel Watch Project sampling

Re: Your March 15, 2001 letter

Dear Lisa Ka'aihue

The NOAA Mussel Watch Project current samples all of its core sites biennially. Currently we regularly sample five sites in Alaska. These sites will be sampled shortly and then not again until 2003. The list of those core sites is provide below.

Gunnar

KTMP Ketchikan Mountain Point 55° 17.63' 131° 32.88
NBES Nahku Bay East Side 59° 27.20' 135° 20.19'
PVMC Port Valdez Mineral Creek Flats 61° 07.97' 146° 27.66'
UISB Unakwit Inlet Siwash Bay 60° 57.65' 147° 38.76'
CIHS Cook Inlet Homer Spit 59° 36.87' 151° 26.65'

--
****
Gunnar G. Lauenstein, Ph.D.
National Ocean Service
National Oceanic and Atmospheric Administration
1305 East West Highway, #10130
Silver Spring, MD 20910
Ph (301) 713-3028 ext. 152
Fax (301) 713-4388
Email Gunnar.Lauenstein@noaa.gov
****

Status: U
Date: Thu, 22 Mar 2001 09:03:55 -0800
Subject: Monitoring work
To: kaaihue@anch.pwsrcac.org
Cc: John_Whitney_AKSSC@hazmat.noaa.gov
From: Gary_Shigenaka@hazmat.noaa.gov (Gary Shigenaka)

Dear Ms. Ka'aihue,

Dr. John Whitney forwarded your request for information on planned environmental monitoring activities in Prince William Sound. As you may or may not know, I have been managing NOAA/HAZMAT's long-term monitoring program in the Sound for over ten years. Between 1989 and 2000, we visited the Sound and a series of fixed sites to study trends in impact and recovery from the spill and cleanup. In 2001, we are finally approaching the end of our available funding and thus have considerably scaled back our activities. Although we are still finalizing plans, we currently have developed and targeted the following projects for this year:

Allegedly funded
1. Revisit of Fucus recovery study site in Kasitsna Bay. This manipulative experiment was implemented in 1999 and 2000 and is designed to test hypotheses on long-term effects of severe disturbance in the rocky intertidal, particularly with respect to trends in Fucus.

2. Resampling of hydraulic washing study site in Lower Herring Bay, Knight Island. This is another manipulative experiment launched in 2000 to test hypothesis on the physical and biological effects of aggressive beach cleaning.

Funding not yet in place pending clarification on budget status
3. Long-term chemistry wrap-up/synthesis. We have contacted Jim Payne and Bill Driskell and may invite them to perform a final interpretation of our sediment and tissue chemistry results.

Proposed, no funding in sight
4. Continuation of pilot studies to investigate the use of molecular biomarkers as a monitoring tool. In 2000, I made collections of mussels and clams in Prince William Sound that were analyzed by a biotechnology startup for a suite of molecular biomarkers. We did this to evaluate the approach as a cost-effective way to quantify impact and recovery, and to link chemistry with biology. Preliminary results are promising and increased levels of oxidative stress at oiled site. As a further refinement of these pilot studies, I would like to collect and analyze mussels at the four major PWS boat harbors (Cordova, Valdez, Whittier, Seward) for tissue chemistry and molecular biomarkers and compare the results to reference locations. Another refinement of biomarker studies would involve reciprocal bivalve transplants between an oiled and an unoiled site to evaluate physiological accommodation and adaptation in the organisms.

I do not foresee us returning to the multiple site survey apporach that was our "bread and butter" in the first 12 years of our monitoring, for two reasons. First, it is an expensive program. Second, I feel as though we have answered many of the original questions that provided the impetus for the work. The research phase we have now entered is based upon the testing of hypotheses generated from the larger monitoring results and will rely on small, focused experiments as described above.

I hope this provides some sense of where we are headed with our work. If I can clarify any of this or can answer any questions, please contact me

via email or at (206)-526-6402.

Cheers,

Gary Shigenaka

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
949 East 36th Avenue, Suite 308
Anchorage, Alaska 99508-4363

JAN 11 1999

Ms. Lisa Ka'aihue
Project Manager
Regional Citizens' Advisory Council
750 W. 2nd Avenue, Suite 100
Anchorage, Alaska 99501-2168

Dear Ms. Ka'aihue:

This letter is in response to your letter of December 31, 1998, to Dr. Richard Prentki soliciting coordination between the Prince William Sound Citizens' Advisory Council's Long-Term Environmental Monitoring Project and environmental monitoring work being done by Minerals Management Service (MMS).

We appreciate being kept informed of your environmental monitoring program and have found your studies useful and of high quality. The MMS does not have any additional contaminant field work scheduled for the Cook Inlet/Shelikof Strait Planning Area at this time. Field sampling for the Shelikof Strait Sediment Quality Study has been completed, with the Final Report due in January, 2000. The MMS will hold another workshop on that study in 1999, when the contractor is ready to report results. Dr. Richard Prentki (907-271-6599) of my staff will provide you with dates, agenda, and reports as they become available.

Because of the relative magnitudes of offshore oil industry activity, the MMS is currently primarily interested in the Beaufort Sea Planning Area, with the Cook Inlet/Shelikof Strait Planning Area being of secondary interest. I am enclosing a copy of the FY 2000-2001 Alaska Annual Studies Plan for your information, which will provide you with a summary of our current and proposed studies. The Annual Studies Plan is developed from external and within-agency needs assessment, with the individual study descriptions then prioritized by MMS. Generally, only a portion of proposed studies are funded in a given year. Thank you for contacting us.

Sincerely,

Cleveland J. Cowles, Ph.D.
Chief, Environmental Studies Section

Enclosure

Exxon Valdez Oil Spill Trustee Council

645 G Street, Suite 401, Anchorage, AK 99501-3451 907/278-8012 fax: 907/276-7178

November 26, 1997

Lisa Ka'aihue
Regional Citizens' Advisory Council
750 W. 2nd Avenue, Suite 100
Anchorage, Alaska 99501

Dear Lisa:

This letter concerns the RCAC staff recommendation to negotiate a contract for the LTEMP Data Analysis project (611), which I understand will be considered by the Board at its December 4 meeting. Although I am not in a position to comment on any competing uses for RCAC funds, I encourage the Board to authorize a contract to carry out the data analysis project. Here are my reasons:

The larger LTEMP project (608) is of fundamental importance to the RCAC mission, and you now have four years' data available for analysis. There sometimes is a tendency for institutions to sponsor the gathering of large volumes of data without a clear vision of how the data will be used, nor adequate provision for analysis. Arranging now for a comprehensive, statistically rigorous review of the LTEMP data is both appropriate and timely. The results, of course, bear directly on the RCAC mission to monitor the environmental impact associated with the terminal facilities and tanker traffic. Moreover, a thorough analysis also will enable the RCAC to better evaluate the scientific worth and cost-effectiveness of the LTEMP data and provide a solid basis for extending or modifying the program over the longer term.

Good, long-term data sets on environmental parameters are rare and extremely valuable, as we learned all to well in the aftermath of the *Exxon Valdez* oil spill. As the RCAC looks to the scope and design of the LTEMP program in the future (FY 1999 and beyond), the most important thing you can do now is to obtain a thorough analysis of the existing data. Since you lack a statistician or hydrocarbon chemist among your scientific advisors, an outside expert is necessary, as you have proposed. I also note that you plan to obtain independent scientific peer review of the contractor's draft product, and this is essential.

Again, I understand the need for project 611 and encourage the RCAC Board to proceed. Please let me know if I can supply any information relative to the *Exxon Valdez* restoration program.

Sincerely,

Stanley E. Senner
Science Coordinator

cc: Molly McCammon
Executive Director

ss/ty

X-From_: Gunnar.Lauenstein@noaa.gov Tue Jan 12 09:06:57 1999
Date: Tue, 12 Jan 99 13:08:22 EST
X-Priority: 3 (Normal)
To: <sac@alaska.net>
From: Gunnar G Lauenstein <Gunnar.Lauenstein@noaa.gov>
Reply-To: <Gunnar=Lauenstein%CMBAD%NORCA@mhc.rdc.noaa.gov>
Subject: Alaska Mussel Watch Project sampling
X-Incognito-SN: 1047
X-Incognito-Version: 4.11.23
MIME-Version: 1.0

Re: Your December 31, 1998 letter

Dear Ms. Ka'aihue:

Our Mussel Watch Project initially established two sites in Alaska, both in Prince William Sound. Those are the sites at Siwash Bay and Mineral Creek with sampling occurring on annual basis. Sampling frequency was reduced to once every two years after 1993. In 1995 we also analyzed samples from some of your sites. All NOAA Mussel Watch Project samples are analyzed for selected PCB congeners, PAHs, chlorinated pesticides and trace elements. The standard list of analytes has been expanded on occasion. Analytes determined in samples are documented in NOAA Technical Memorandum NOS ORCA 130. Also in 1995 three additional sites were added to the list of sites that are part of the core sampling effort: Homer Spit,Mountain Point, and East Side. Our core Alaska samples will be sampled during the 1999 field season and the projection is that these sites will be sampled again in the year 2001.

Detailed site information is available in NOAA Technical Memorandum NOS ORCA 112. This technical memorandum and the methods memorandum are available from this office.

Data resulting from this work are available at our internet site: http://www-orca.nos.noaa.gov/projects/nsandt/nsandt.html.

Site summary information is provided below.

If you would like technical memoranda or more information about our project please let me know.

Sincerely,

Gunnar G. Lauenstein

Mussel Watch Project Sites

Site code	Site name	Site location	Latitude (N)	Longitude (W)
KTMP	Ketchikan	Mountain Point	55° 17.63'	131° 32.88
NBES	Nahku Bay	East Side	59° 27.20'	135° 20.19'
PWSH	Prince William Sound	Sheep Bay	60° 38.44'	145° 59.40'
PWKH	Prince William Sound	Knowles Head	60° 41.28'	146° 35.01'
PVMC	Port Valdez	Mineral Creek Flats	61° 07.97'	146° 27.66'
UISB	Unakwit Inlet	Siwash Bay	60° 57.65'	147° 38.76'
PWDI	Prince William Sound	Disk Island	60° 29.58'	147° 39.35'

GASL Prince William Sound Sleepy Bay 60° 04.04' 147° 49.53'
GAWB Gulf of Alaska Windy Bay 59° 13.12' 151° 31.02'
CIHS Cook Inlet Homer Spit 59° 36.87' 151° 26.65'
GASH Gulf of Alaska Shuyak Harbor 58° 30.06' 152° 37.31'

Mussel Sample Collection Years

Site	Main Location	Specific Location	State	93	94	95	96	97	99	01
KTMP	Ketchikan	Mountain Point	AK		x		x	x	x	
NBES	Nahku Bay	East Side	AK		x	x	x	x		
PWSH	Prince William Snd.	Sheep Bay	AK					x		
PWKH	Prince William Snd.	Knowles Head	AK						x	
PVMC	Port Valdez	Mineral Creek	AK	x	x		x	x	x	
UISB	Unakwit Inlet	Siwash Bay	AK	x	x		x	x	x	
PWDI	Prince William Snd.	Disk Island	AK						x	
GASL	Gulf of Alaska	Sleepy Bay	AK						x	
GAWB	Gulf of Alaska	Windy Bay	AK						x	
CIHS	Cook Inlet	Homer Spit	AK		x		x	x	x	
GASH	Gulf of Alaska	Shuyak Harbor	AK						x	

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Alaska Outer Continental Shelf Region
949 East 36th Avenue, Suite 308
ANCHORAGE, ALASKA 99508-4363

Seventeenth Coast Guard District (mor)
(Docket CGD17-99-13)
P.O. Box 25517
Juneau AK 99802

JAN 12 2000

Dear Sir:

This letter is in support of recertification of the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) as the voluntary advisory group for Prince William Sound, Alaska, under the Oil Terminal and Oil Tanker Environmental Oversight and Monitoring Act of 1990.

The Alaska Outer Continental Shelf Region of the Minerals Management Service (MMS) has worked cooperatively in the last several years, sharing data and reports, and MMS staff have given presentations to PWSRCAC. The MMS, other government agencies, and the public have benefited from PWSRCAC-sponsored or supported workshops.

I would like to commend the PWSRCAC's emphasis on science and dedication in performing their functions under the 1990 Act. In particular, I appreciate the high quality of the science in their environmental monitoring such as the LTEMP monitoring program. Because of the cooperative relationship offered by the PWSRCAC, I have been able to integrate PWSRCAC monitoring results and some of PWSRCAC concerns in designing Minerals Management Service environmental studies related to oil and gas activities in the Gulf of Alaska. This integration has made for both better and more cost-effective science.

Overall, the public and MMS have benefited from the work of PWSRCAC and I recommend recertification of the PWSRCAC as the voluntary group for Prince William Sound.

Sincerely,

Richard T. Prentki, Ph.D.
Oceanographer & COTR

cc: John Devens, Executive Director

Attachment B
Resume John Devens, Ph. D.
Principal Investigator

John S. Devens
PO Box 770
Valdez, Alaska 99686
(907) 835-3340

Highlights

In 1978 I founded Prince William Sound Community College and served as president until March 1992, at which time I resigned to run for the United States House of Representatives. Although I was not successful in my bid for Congress, I did come within 3% of defeating a twenty year incumbent. In August of 1993, I became President of Sterling College, a small, private, Vermont college specializing in environmental studies and resource management. I served as President of Sterling College until 1996 at which time I refused a second three-year contract. In 1997 I accepted the position of Executive Director of the Prince William Sound Regional Citizens' Advisory Council.

During the first three years as President of Sterling College I concentrated on increasing the number and amount of private gifts, diversifying offerings, and on increasing enrollment. During that period of time, Sterling received the largest single gift in its history which more than doubled the income from annual giving, began an off campus program of study in the Western United States, and increased enrollment by 22%.

As President of Prince William Sound Community College my greatest accomplishments were in the areas of fund raising at both the state and local levels, encouraging support from both political and industrial areas, long range planning, and in program development. PWSCC received accreditation while I was president.

My experience includes giving many speeches to national and international audiences and authoring numerous professional articles, papers and media presentations. I have held academic rank at five colleges and universities, hold the Certificate of Clinical Competence in both Audiology and Speech- Language Pathology, was president of two colleges, served as Mayor of Valdez, Alaska during the Exxon oil spill, led five trade missions to Asia, administered budgets, developed long range plans and have had more than twenty years of administrative experience.

Education

Wichita State University — Wichita, Kansas
Ph.D. in Communication Science — 1975

Emory University — Atlanta, Georgia
M.Ed. in Audiology and Speech Pathology — 1966

Belmont College — Nashville, Tennessee
B.S. in Elementary Education — 1964

Experience

Regional Citizens' Advisory Council — Anchorage, Alaska
Executive Director — 1997 to present

- The Regional Citizens' Advisory Council receives its authority from the Oil Pollution Act of 1990 and is funded through a contract with the Alyeska Pipeline Service Company. The annual budget of slightly more than $3,000,000 funds a number of studies and research projects designed to provide information regarding the safe transportation of petroleum products in Alaskan waters. There is a staff of 16 people located in two offices. The Executive Director reports to a 19 person Board of Directors.

Cross Country Healthcare — Boca Raton, Florida 33432
Clinical Consultant — 1996 to 1997

- I provided clinical speech pathology and audiology services in hospital and skilled nursing homes. The assignment includes working with Radiology Departments in providing video florographic studies.

Sterling College — Craftsbury Common, Vermont
President — 1993 to 1996

- Greatest accomplishments were in the areas of fund raising, long range planning, increasing enrollment, diversifying the offerings, and in budgeting and the fiscal management of a budget of approximately $2,000,000. Sterling College is a small, private, liberal arts college specializing in environmental studies and resource management.

Prince William Sound Community College — Valdez, Alaska
President — 1978 to 1992

- My accomplishments in this position include very good relations with both local and state government, fund raising, budget management, long range planning, and developing good community support. Programs were developed in areas such as developmental disabilities, secretarial sciences, fisheries, electronics, broadcasting, and many others. Of the $3,000,000 budget, approximately $1,000,000 came from fund raising efforts.

City of Valdez — Valdez, Alaska
Mayor — 1984 to 1989

- Represented Valdez, coordinated City Council meetings, initiated long range planning, initiated budget planning for a $32,000,000 budget, led five trade missions to Asia, and represented the City during the Exxon oil spill.

Valdez Hearing and Speech Center — Valdez, Alaska
Owner and Manager — 1977 to 1992

- I provided hearing and hearing aid evaluations for the local community including the state center for the developmentally disabled and the public school system. I also did

some speech and language evaluations for the residents at the center for developmental disabilities.

University of Alaska Learning Center — Valdez, Alaska
Director — 1977 to 1978
- Coordinated the center and made plans to create a community college. The Learning Center became Prince William Sound Community College.

University of Houston Victoria Campus — Victoria, Texas
Assistant Professor of Special Education — 1975 to 1977
- Taught upper division and graduate courses in special education and in speech pathology and audiology. Directed the Speech Pathology program.

Victoria Hearing and Speech Center — Victoria, Texas
Owner and Operator — 1975 to 1977
- I provided hearing and hearing aid evaluations for the community.

Wichita State University — Wichita, Kansas
Assistant Professor Educational Psychology — 1974 to 1975
- I taught graduate courses in educational research, research design, and curriculum.

Alaska Department of Health and Social Services — Fairbanks, Alaska
Regional Audiology Supervisor — 1971 to 1973
- Responsible for a hearing conservation program in Northern Alaska, including budget preparation, project proposals, and supervision and training of staff. This position also included the evaluation and use of the ATS-1 communications satellite as a means of providing health and educational information to remote communities. Hearing and hearing aid evaluations were provided to a very diverse population. I originated the first hearing aid clinics in the state.

University of Alaska — Fairbanks, Alaska
Lecturer — 1971 to 1973
- I taught upper division courses in speech and hearing sciences.

Alaska Crippled Children and Adults Center — Fairbanks, Alaska
Director — 1971 to 1973
- I administered a community speech and hearing center and served as the audiologist for the center.

Institute of Logopedics — Wichita, Kansas
Director of Audiology — 1970 to 1971
- I administered a clinical audiology program with a staff of five.

Columbia College — Columbia, South Carolina
Director Speech and Hearing Program — 1967 to 1970

- I directed an undergraduate program in speech correction and hearing rehabilitation.

Emory University School of Medicine Atlanta, Georgia
Instructor in Surgery and Physical Medicine 1966 to 1967
- I lectured physicians and nurses in techniques used in speech pathology and audiology and provided clinical services at two hospitals.

Publications

Oil Spill A Community Perspective
Proceedings of the First International Conference on Offshore Drilling and Fisheries, Bergan, Norway (1990)

A Decade of Progress in Prince William Sound
Panel member "Valdez Over the Last Decade" and "A Decade of Progress, A Vision of the Future" at the Partners in Prevention Symposium, Valdez, Alaska (1999)

Oil Spill Response and Prevention: What Still Needs to be Done
Panel member at Legacy of an Oil Spill, EVOS Symposium, Anchorage, Alaska (1999)

Team Building
Session Chair at the International Oil Spill Conference, Seattle, Washington (1999)

Citizens Making Oil Transportation Safer in Alaska
Speech given at the International Association of Public Participation in Phoenix, Arizona (1998)

A Citizens Advisory Program in Alaska
Speech given at the International Forum for Oil-Polluted Sea Areas, Ploudalmezeau, France (1998)

Voyage on the ARCO Juneau
Published in MariTimes (1997)

Oil Spill Preparedness: A Call for Action
Paper published in The Municipal Advisor (1989)

The Exxon Valdez Oil Spill
Proceedings of the International Conference of 'Oiled Mayors', Valdez, Alaska (1989)

Acoustic Barriers: A Seminar on Public Law 94-142
Proceedings of NOISEXPO 78, Chicago, Illinois (1978)

Development of Educational Programs for Hearing Conservation
Proceedings of NOISEXPO 77, Chicago, Illinois (1977)

Effects of Noise Upon Student Performance in Public School Classrooms
Proceedings of NOISEXPO 77, Chicago, Illinois (1977)

Dynamic Auditory Localization by Normal and Learning Disabled Children
The Journal of the American Audiological Society, (1977)

"Hearing Loss After Ten Years of Exposure to Power Equipment Noise in Remote Northern Alaskan Villages
Proceedings of NOISEXPO 76, (1976)

"Technical Note: An Apparatus for Exploring Dynamic Auditory Localization
The Journal of the American Audiological Society, (1976)

"Acoustic Characteristics of the Public School Classrooms Constructed Between 1890 and 1960
Proceedings of NOISEXPO 75, Chicago, Illinois (1975)

How We Hear
Media Kit, Alaska State Operated Schools, Anchorage, Alaska, (1972)

Protect Your Hearing
Media Kit, Alaskan State Operated Schools, Anchorage, Alaska (1972)

My Child
Film, South Carolina Education Television System, Columbia, South Carolina (1970)

You Are Not Alone
Film, South Carolina Education Television System, Columbia, South Carolina (1970)

Parents Must Help Part 1
Film, South Carolina Education System, Columbia, South Carolina (1970)

Parents Must Help Part 2
Film, South Carolina Education Television System, Columbia, South Carolina (1970)

Future Sound
Film, South Carolina Education Television System, Columbia, South Carolina (1970)

Alaska's Economic Future
Speech given at Loussac Library for teachers, Anchorage, Alaska (1992)

Oil Spill and the Environment
Speech given at Belmont University, Nashville, Tennessee (1991)

Legislative Issues in the 102nd Congress

Speech given at the American Speech, Language and Hearing Association, Atlanta, Georgia (1991)

Trade Relations Between Alaska and the USSR
Speech given to business group, Petropavlovsk, Kamchatka, USSR (1991)

Oil Spill, A Community Perspective
Speech given to the Tiger Bay Club, Ocala, Florida (1990)

The Exxon Valdez Oil Spill
Series of speeches given at Portland Rotary, Portland, Oregon, Tacoma Chamber of Commerce, Tacoma, Washington, Seattle Chamber of Commerce, Seattle Washington and the Seattle Propeller Club, Seattle, Washington (1990)

Oil Spills and the Environment
Speech given at Peninsula College (1990)

Oil Spill, the International Problem
Series of speeches given in France (1989)

Oil Spill, a Community Perspective
Paper delivered at the First International Conference of Off Shore Drilling and Fisheries, Bergan, Norway (1989)

Good Environment is Good Business
Speech given to the Alaska Resource Development Council, Anchorage, Alaska (1989)

Foreign Trade Zone 108
Speech given at the Foreign Trade Zone Conference, Orlando, Florida (1988)

The Alaska Gas Line
Speech given at the International Trade Conference, Seoul, Korea (1988)

Economic Development
Speech given at the National League of Cities Convention, Seattle, Washington (1985)

Building for the Future
Speech given at the Resource Development Council Conference, Anchorage, Alaska (1985)

Maritime Education in Alaska
Speech given at the Pacific Rim Maritime Conference, Honolulu, Hawaii (1981)

Dynamic Auditory Localization of Learning Disabled Children
Scientific Exhibit, American Speech and Hearing Association Convention, San

Francisco, California (1978)

Hearing Conservation - An Educational Approach in Alaskan Villages
Paper delivered at the American Speech and Hearing Convention, Chicago, Illinois (1977)

Development of Education Programs for Hearing Conservation
Paper delivered at NOISEXPO '77, Chicago, Illinois (1977)

Effects of Noise Upon Student Performance in Public School Classrooms
Paper delivered at NOISEXPO '77, Chicago, Illinois (1977)

The Noise Level and How it Affects the Learning Disabled Child
Paper delivered to the Texas Association for Children with Learning Disabilities, Houston, Texas (1976)

Communicative Disorders in the Public Schools
Speech given at the Spring Meeting of La Bahia Guidance Association, Victoria, Texas (1976)

Hearing Loss After Ten Years of Exposure to Power Equipment Noise in Remote Northern Alaskan Villages
Paper presented at NOISEXPO '76, New York, New York (1976)

Auditory Tracking Abilities in Learning Disabled Children
Paper presented at the Coastal Bend Chapter of the Council for Exceptional Children Conference, Victoria, Texas (1975)

Acoustic Characteristics of Public School Classrooms Constructed between 1890 and 1960
Paper presented at NOISEXPO '75, Atlanta, Georgia (1975)

Hearing Conservation North of the Arctic Circle via ATS-1 Satellite
Paper presented at the American Speech and Hearing Convention, Las Vegas, Nevada (1974)

A Survey of Sound Pressure Levels and Reverberation Times in Public School Classrooms
Paper presented at the American Speech and Hearing Convention, Las Vegas, Nevada (1974)

Rehabilitative and Identification Audiometery North of the Arctic Circle
Paper presented at the Kansas Speech and Hearing Convention (1974)

Sensori-Neural Hearing Problems in Alaskan Natives: A New Problem

Workshop presented at the Alaskan Speech and Hearing Association Convention, Fairbanks, Alaska (1972)

Communication Disorders in a Mentally Retarded Population
Three day workshop presented at the Pineland State School for the Retarded, Columbia, South Carolina (1970)

Hearing Conservation in a Preschool Population
Paper presented at the South Carolina Speech and Hearing Association Convention, Columbia, South Carolina (1969)

Issues Concerning the Use of Hypnosis in Speech Correction
Paper presented to the Charleston Speech and Hearing Association, Charelston, South Carolina (1968)

Accomplishments

American Speech, Language, and Hearing Association
1967-present, certified in both Audiology and Speech, Language Pathology

Association of Vermont Independent Colleges
1993-1996, member of Executive Committee

Vermont Higher Education Council
1994-1996, member accreditation committee

Association of Vermont Independent Colleges
1994-1996, Secretary/Treasurer

Who's Who in America
1997-Selected for inclusion in the 51st edition.

The National Distinguished Service Registry
1990- for distinguished service in the profession of Speech, Language, and Hearing.

Who's Who Among Human Services Professionals
1988-1989-listed for work in the Speech, Language, and Hearing profession.

Who's Who in Education
1995-1996 - listed for work done in college administration.

Who's Who in the East
1995-1996 - my listing in Who's Who in the West was changed when I moved to Vermont.

Who's Who in the World
1997- listed for accomplishments in education, government service, and the speech and hearing field.

Certificate of Appreciation
1978 - in recognition of a significant contribution to the American Speech and Hearing Association and to the profession of speech pathology and audiology.

Human Acoustics Seminar
1973 - successful completion of a seminar in human acoustics given by B&K Instruments.

The Propeller Club of the United States
1984 - charter member of the Port of Valdez, Alaska chapter of The Propeller Club of the United States.

Alaska Municipal League
1983-1988, Board of Directors

National League of Cities
1983-1988, member Small Cities Advisory Council and Community and Economic Development Policy Committee

Trade Missions to Asia
1984-1989, I led five trade missions to Asia to encourage reverse investments and promote the all Alaskan Gas Line

Alaska Resource Development Council
1988-1991, member Board of Directors

Alaska District Export Council
1988-1993, Appointed by the US Secretary of Commerce to the Board of Directors

Alaska-Korea Business Council
1988-1992, member Board of Directors

International Oiled Mayors Association
1989, organizer and member

Alaska Visitors Association
1980, President of Valdez Chapter

Valdez Chamber of Commerce
1987-Citizen of the Year

Valdez Convention & Visitors Bureau
1987-"No Matter What it Takes" award for services to the visitor industry.

KCHU Public Radio
1987-"Silver Reel" award for support of Public Radio.

Governor's Council for the Handicapped and Gifted
1980-1982, Advocate for the Gifted and Chairman of the Finance Committee

Horsemanship for the Handicapped
1973-1978, National Chairman of the Advisory Committee

International Oticongress
1973 - participation in the 3rd International Oticongress in Copenhagen, Denmark.

Explorers Club
Member

Public Office
1980-1989, City Council, Valdez, Alaska
1981-1983, Mayor Pro-temp, City of Valdez
1984-1989, Mayor, City of Valdez
1990&1992, Candidate for US Congress

Attachment C
Resumes of Kinnetic Laboratories Personnel involved with LTEMP

5.1 Key Personnel

Janet Kennedy, A.S., KLI's Alaska Regional Manager, will continue to serve as the Project Manager, a Principal Investigator, and the primary Point of Contact for the project. She will oversee all aspects of the project and will lead the database and reporting tasks. Ms. Kennedy holds a degree in marine biology and oceanography. She has 16 years of experience in monitoring and assessment projects pertaining to the oil industry and their effects on the marine environment, 10 years of which have been in Alaska. Her experience includes monitoring programs on the U.S. Atlantic and Pacific coasts as well as the Gulf of Alaska, PWS, Cook Inlet, and the Beaufort Sea. She has participated in field sampling efforts for all types of projects ranging from intertidal beach sampling to deep water (2000 meter) sampling of the benthos. She currently serves as the Program Manager for the PWS RCAC LTEMP as well as Assistant Program Manager for the Municipality of Anchorage's Point Woronzof monitoring program. She was also the Assistant Project Manager for the programs performed by KLI for the Cook Inlet RCAC.

Mark A. Savoie, M.S., will perform as Assistant Program Manager and will continue to lead the laboratory coordination and quality assurance task. He will oversee the data analysis and interpretation and be heavily involved in report writing. Mr. Savoie is an expert in water and sediment quality issues. He has worked extensively throughout Alaska for 18 years, including involvement on a large number of projects in the Cook Inlet and Kodiak Island region and on a variety of EVOS hydrocarbon studies. He has served as the Principal Investigator on a large number of NPDES discharge monitoring programs, including those for Anchorage's Point Woronzof and the Drift River Ballast Water Treatment Plant (BWTP) discharges into Cook Inlet. He has been heavily involved in LTEMP since it began. Mr. Savoie has also served as Program Manager for the programs KLI has recently performed for the Cook Inlet RCAC as well as the program KLI performed for the Alaska Council of Trout Unlimited.

Technical oversight for the project will continue to be provided by **Patrick Kinney, Ph.D.,** who will act as a Principal Investigator on the project. Dr. Kinney has been involved in the LTEMP since the initial design phase. He is the founding principal of KLI who has nearly 30 years of experience in environmental studies. He has actively

participated in more than 50 large applied programs designed to quantitatively assess impacts on the marine environment. His experience includes numerous programs in Alaska and ranges from program design and implementation to interpretation and presentation of results.

Gary Lawley will take the lead for the field logistics for the project. Mr. Lawley has extensive experience in sampling and logistics and has worked extensively in Alaska, including the PWS, Cook Inlet, Kodiak Archipelago, Alaska Peninsula, Beaufort Sea, and Gulf of Alaska areas. Mr. Lawley has held a technical support position at KLI for the last three years. He has participated in LTEMP sampling since March 1996 and is well versed in the requirements of the project. His prior experience is extensive and ranges from laboratory work to sampling fish in the Beaufort Sea to EPA Superfund cleanup and remediation work. Mr. Lawley will be joined in the field by senior KLI scientists such as Janet Kennedy, Mark Savoie, or **Dawn Reeder, B.S.** Ms. Reeder has a decade of experience working with environmental science projects in Alaska. She has served as field leader and a KLI research diver for the LTEMP in the past and has been involved with the LTEMP sampling since 1994.

The analytical aspects of the project will be administered by task-specific, doctorate-level Principal Investigators who have been involved with the LTEMP since its inception. **Guy Denoux, Ph.D.**, will continue to serve as internal project manager at GERG; he will lead the hydrocarbon analysis and fingerprinting tasks. He serves as the laboratory and data manager for the geochemical and environmental groups and as the systems manager for the analytic computer group. Dr. Denoux has many years of experience in environmental analyses and 10 years of experience with GERG at the assistant research scientist level. He will be assisted by **Terry Wade, Ph.D.**, the Deputy Director of Environmental Sciences at GERG. Dr. Wade, who has also been involved since the early days of the LTEMP, will provide additional technical or interpretive support as needed for the project. Dr. Wade has authored over 100 publications and brings expertise in the areas of environmental chemistry, marine organic geochemistry, chemical oceanography, and methods development to the project. **Ms. Grace Ekman, M.S.**, the quality assurance/quality control (QA/QC) manager, will continue to oversee the analytical work at GERG from a QA standpoint, as she has done since 1994. Her role at the laboratory is to ensure that all laboratory operations are consistent with good

laboratory practices, GERG's QA procedures and policies, and any applicable regulatory requirements. Ms. Ekman has 18 years of experience in analytical chemistry, the majority of which has pertained to QA.

While Database Management will be led by Janet Kennedy, additional support for this task and for any statistical analyses will be provided by **Peter Wilde, B.A.**, and **Gary Gillingham, B.A.**, both of KLI Santa Cruz. Mr. Wilde is a senior programmer and computer analyst capable of providing database and computer programming support to programs with a variety of data management needs. He has provided technical support for the LTEMP in the past, including providing report-writing expertise in Microsoft Access® when the database was transferred from Visual FoxPro®. Mr. Gillingham also has a history of providing support for the LTEMP, particularly in the area of statistical testing, interpretation, and report writing. He is a biologist specializing in marine intertidal and subtidal ecology with extensive experience in Alaska and California. His has considerable expertise in the area of statistical handling of biological and chemical data.

Additional support for all aspects of the project will be provided as needed by **Brenda Gumminger, B.S.** Ms. Gumminger has 13 years of experience in marine studies and computer science. She has worked for KLI in Anchorage for the last five years and has provided database, technical, and field support for a number of programs, including the LTEMP. Her familiarity with the LTEMP is extensive and covers field and documentation practices, data entry requirements and management, quality control, and report production.

5.2 Resumes of Key Personnel

Brief resumes are provided on the following pages for key personnel for the proposed project. More extensive resumes are available upon request.

JANET M. KENNEDY
Alaska Regional Manager
Senior Environmental Scientist

KINNETIC LABORATORIES INCORPORATED

EXPERTISE

Water and Sediment Quality Evaluations
Environmental Issues Related to Oil and Gas Development and Oil Spills
NPDES Permitting and Discharge Evaluations
Benthic Community Analysis
Database Management

EXPERIENCE WITH FIRM

Ms. Kennedy is currently Regional Manager of Kinnetic Laboratories' office in Anchorage, Alaska. She is an environmental scientist holding a degree in Marine Biology and Oceanography with 16 years of experience in marine studies, primarily revolving around monitoring and assessment projects pertaining to the oil industry. She has participated in numerous multi-disciplinary long-term monitoring programs as well as impact assessment programs pertaining to oil and gas development. Ms. Kennedy has participated in numerous research surveys in the U.S. Atlantic and Pacific Oceans and areas of Alaska including Prince William Sound, the Gulf of Alaska, the Beaufort Sea, Cook Inlet, and Shelikof Strait. She has been with KLI for the last eight years.

Selected Project Experience

- Program manager (1995-1999) and assistant program manager (1993-1994) for the Prince William Sound Regional Citizens' Advisory Council's Long-Term Environ-mental Monitoring Program. This program is designed to monitor the potential impacts of petroleum hydrocarbons on biota and sediments in Prince William Sound and the Gulf of Alaska. Mussels are used as bioindicators of hydrocarbon accumulation in the intertidal environments, while subtidal sediments, collected by both grab and divers, are analyzed to provide information on long-term inputs to the marine environment. The program has also included emergency sampling in response to spill events at the Alyeska Marine Terminal.

- Assistant program manager for the Cook Inlet Regional Citizens' Advisory Council's 1995 Environmental Monitoring Program, 1996 Shelikof Strait Program, 1997 Cook Inlet Sediment Characterization and Toxicity Study, and 1997 Kenai River and Estuary Investigation Project. These programs focused on the potential environmental effects of oil industry activities in Cook Inlet. Program designs have included monitoring subtidal sediment chemistry and toxicity, bioaccumulation in fish and mussels, benthic investigations, and use of bio-surrogates to monitor hydrocarbons in the water column.

- Assisted in the preparation of the Northstar Development draft and final EIS. Authored affected environment and impacts sections for the benthic infauna and sediment quality components of this large EIS prepared for offshore oil drilling on the North Slope of Alaska.

- Assistant program manager for the Municipality of Anchorage's NPDES 301(h) secondary treatment waiver monitoring program. Components of this study have included: water and sediment quality, evaluation of discharge criteria, ocean currents and dispersion, benthic invertebrates, and permit and regulatory compliance determinations. Another important part of this project was participation in the initial EIS and subsequent special studies and evaluations that

have been conducted in support of the Permit reapplication. Additional monitoring has also been performed for the Municipality of Anchorage in conjunction with the Eagle River Wastewater Treatment Facility.

- Participated in Prudhoe Bay Seawater Treatment Plant NPDES Monitoring for ARCO Alaska, Inc. This program included sampling and analysis of water and sediments from Prudhoe Bay during winter (through the ice) and summer (open water conditions).

- Assistant program manager for the 1991-92 Kuparuk Seawater Treatment Plant and Kuparuk Wastewater Treatment Plant NPDES monitoring programs. These programs involved effluent and receiving water monitoring of toxicity and water quality parameters.

- Assistant science manager/field leader for a large number of studies performed for EXXON in response to the T/V *EXXON VALDEZ* oil spill. The programs included water and sediment quality assessments, fate and effects studies, and clean-up and treatment efficacy studies. She held the position of chief scientist for the 1990 Bioremediation Monitoring Program, a five-month study jointly funded by EPA, ADEC, and EXXON. Ms. Kennedy was also heavily involved in the report writing and database management efforts for these programs.

- Support personnel for a number of programs involving Natural Resource Damage Assessment and oil spill environmental response planning. Ms. Kennedy authored a variety of sampling protocols for scientific response to potential oil releases in Prince William Sound and on the North Slope.

- Laboratory supervisor, data manager, and a field leader involved in a large MMS-funded five-year California OCS monitoring program involving soft- and hard-bottom community assessment along with chemical assessment and oceanography.

- Task coordinator for the MMS-sponsored U.S. North, Mid-, and South Atlantic Slope and Rise Studies and the Georges Bank Monitoring Program. These programs involved intensive study of deep water benthic communities and the potential impacts of oil development on these communities.

- Senior taxonomist for an NPDES monitoring program conducted in the coastal waters of Massachusetts offshore from a nuclear power plant discharging thermal effluent.

EDUCATION

A.S., Marine Biology and Oceanography, Southern Maine Vocational Technical Institute, 1982

PROFESSIONAL AFFILIATIONS AND CERTIFICATIONS

Member of the American Society of Testing and Materials (ASTM)

MARK A. SAVOIE
Vice-President
Senior Environmental Scientist

KINNETIC LABORATORIES INCORPORATED

EXPERTISE

Oceanography / Ocean Circulation
NPDES Discharge Evaluations
Coastal and Nearshore Sediment Processes
Water and Sediment Quality Impact Assessment
Oil Spill and NRDA Environmental Studies

EXPERIENCE WITH FIRM

Mr. Savoie is a senior physical oceanographer/coastal engineer and serves as the Vice President for Kinnetic Laboratories, Inc. (KLI). He has an extensive background in physical oceanography and coastal processes and is responsible for conducting and managing oceanographic, NPDES, water/sediment quality, and nearshore sediment dynamic studies.

Selected Project Experience

- Project manager and co-principal investigator for the Municipality of Anchorage's NPDES 301(h) secondary treatment waiver monitoring program, a project now in its fourteenth year. Components of this study have included: water and sediment quality, evaluation of discharge criteria, ocean currents and dispersion, invertebrates, and permit and regulatory compliance determinations. Another important part of this project was participation in the initial EIS and subsequent special studies and evaluations that have been conducted in support of the Permit reapplication.

- Member of the team preparing the Northstar Development EIS for offshore oil drilling on the North Slope of Alaska. Authored affected environment and impacts sections for the oceanography and sediment and water quality components of the EIS. Also performed NPDES Ocean Discharge Evaluation Criteria and plume modeling to assist with EIS preparation and design modifications for this project.

- Program manager for the Cook Inlet Regional Citizens' Advisory Council's (RCAC) 1997 Cook Inlet Sediment Characterization and Toxicity Study and 1997 Kenai River and Estuary Investigation Project. These programs focus on the potential environmental effects of oil industry activities in Cook Inlet. Program designs have included monitoring subtidal sediment chemistry and toxicity as well as benthic investigations. Heavy involvement with other Cook Inlet RCAC programs performed prior to 1997 by KLI, which included bioaccumulation in fish and mussels, sediment quality, and the use of bio-surrogates to assess hydrocarbon contaminant levels in the water column..

- Senior scientist on the Prince William Sound RCAC Long-Term Environmental Monitoring Program which was designed to monitor the potential impacts of petroleum hydrocarbons on biota and sediments in Prince William Sound and the Gulf of Alaska. This program has been performed by KLI since 1993.

- Principal investigator and project manager for the Prudhoe Bay Waterflood Physical Processes Monitoring Program from 1982-85. This study was conducted to verify EIS predictions and determine the environmental impact of the West Dock Causeway and Waterflood Extension. The study evaluated the effects of the causeway on water circulation, temperature, and salinity patterns and their effects on biological resources. The study also included littoral transport studies to determine the effect of the causeway on shoreline and nearshore accretion and erosion patterns.

- Project manager and principal investigator for the 1991-92 Kuparuk Seawater Treatment Plant and Kuparuk Wastewater Treatment Plant NPDES monitoring programs. These programs involved effluent and receiving water monitoring of toxicity and water quality parameters.

- Principal investigator for the oceanographic and sedimentation components of the Proposed Lisburne Development EIS. This study involved determining the environmental impact of a proposed causeway and alternatives in Prudhoe Bay. Wind and wave hindcasting was performed to determine the effects of waves and currents on the proposed structure. Littoral transport of sediments was examined through use of Corps of Engineers littoral transport and sedimentation models.

- Project manager during 1987 and assistant project manager during 1985-86 for the Kuparuk Waterflood NPDES monitoring program. This study included water and sediment quality, benthic invertebrate and fish monitoring components, and a discharge dye dispersion sampling program.

- Senior scientist and assistant project manager in charge of marine studies for the design of the new City of San Diego wastewater outfall off Mission Bay and task manager for both the oceanography and water quality tasks. He was also the physical oceanography task manager for the marine EIR/EIS NEPA documentation for the City of San Diego Clean Water Program 20-year and 40-year infrastructure planning for water reclamation and disposal facilities, which included three major outfalls.

- Principal investigator for the physical oceanographic components of a large, MMS-funded five-year California OCS monitoring program offshore of Point Conception.

- Project manager during 1988-90 for the Endicott NPDES Monitoring Program. This study included water and sediment quality, benthic invertebrates, and dye dilution and dispersion studies including computer modeling of the effluent discharge.

- Senior scientist for the physical oceanographic and water quality components of the EIS for Cities Service's proposed San Miguel project in the Santa Maria Basin.

- Senior scientist involved in two wind and wave hindcasting studies: one for Saint Paul Island, Alaska, which examined a failed breakwater, and the other which examined the failure of a bulkhead on Kodiak Island, Alaska.

- Co-principal investigator for the Beaufort Sea Mesoscale Circulation Design Study that was conducted for the National Oceanic and Atmospheric Administration (NOAA) and the Minerals Management Service (MMS).

- Physical oceanographic and sediment processes task leader for the Peard Bay NOAA/OCSEAP ecosystem study along the Chukchi sea coast.

- Contributed his expertise in the areas of field work, analysis, and data interpretation as a participant of the EXXON U.S.A. physical oceanographic program in the Point Thomson offshore lease areas of the Beaufort Sea.

- From Spring 1989 through 1991, Mr. Savoie managed a large segment of the scientific studies being carried out on the T/V *EXXON VALDEZ* oil spill for EXXON. In addition to scientific interpretation and input, Mr. Savoie was involved in field operations and database management associated with these extensive studies.

- Co-principal investigator on the oceanographic and sediment processes sections of the Comprehensive Marine Report for the West Dock Causeway and Waterflood Extension. This report was prepared for the U.S. Corps of Engineers and emphasized impacts of the causeway and comparisons with EIS predictions.

EDUCATION

M.S., Ocean Engineering; Rosenstiel School of Marine and Atmospheric Science, University of Miami; 1981
B.S., Atmospheric and Oceanic Science; College of Engineering, University of Michigan; 1979

PATRICK J. KINNEY
Principal

KINNETIC LABORATORIES INCORPORATED

EXPERTISE

Senior Environmental Scientist
Senior Project Management
Program Design and Implementation

EXPERIENCE WITH FIRM

Dr. Kinney is a founding principal of Kinnetic Laboratories and a principal of an affiliated analytical and toxicity testing laboratory firm, ToxScan, Inc. In addition to administrative duties, Dr. Kinney remains an active scientist, participating heavily in project design, data interpretation, and report preparation. Dr. Kinney received his Ph.D. in Chemical Engineering and his post-doctorate in Oceanography. He has 35 years of professional experience focused on environmental issues such as water quality, sediment quality, and oceanographic studies.

Selected Project Experience

- Designed and/or served as principal investigator on over 75 NPDES monitoring studies involving effects of point source discharges, as well as other studies involving nonpoint discharges of spills and hazardous materials, such as the T/V *Exxon Valdez* oil spill (EVOS). During the EVOS scientific response, designed and/or provided doctorate-level support for a variety of programs involving water and sediment quality, fate and effects, and clean-up and treatment efficacy studies.

- Program manager and principal investigator on the initial Long-Term Environmental Monitoring Program (LTEMP) performed by KLI for the Prince William Sound Regional Citizens' Advisory Council. Helped design the initial LTEMP (1993) and has served as principal investigator for the six years that KLI has performed this program.

- Project manager responsible for preparing the crucial oceanographic and biological sections of the Municipality of Anchorage 301(h) waiver application, including supporting studies in Cook Inlet. He assisted in subsequent special studies during the application review, and after the NPDES permit was granted, he initiated the initial 5-year NPDES monitoring program. In more recent years, has provided additional support for this program by working on special problems such as metals water quality criteria and plant BOD performance.

- Principal investigator for the University of Alaska for the early oceanographic studies of Cook Inlet; also led the major fate and effect pollution studies in Alaska associated with petroleum industry developments. These programs included extensive oceanographic studies performed for six years in the deep Arctic Ocean and the first baseline marine ecosystem studies sponsored by EPA and SeaGrant covering the area from Barrow to Prudhoe Bay.

- Principal investigator for KLI on additional Alaskan arctic projects for NOAA, including the physical oceanographic studies carried out along the Beaufort coast; the Peard Bay ecosystem studies on the Chukchi Sea arctic coast; and the offshore physical oceanographic mooring program on the open Chukchi Sea coast (NOAA). Performed the MMS/NOAA-sponsored ecosystem characterization and synthesis project for the North Aleutian Shelf area. Performed large coastal physical and coastal engineering studies carried out in the Point Thomson area just east of the

Endicott study area for EXXON, U.S.A. Managed a geochemical sediment sampling study carried out for several oil companies in the Beaufort Sea, from Barrow to the Canadian border.

- Participated in NPDES monitoring work for the ARCO Kuparuk, ARCO Prudhoe, and BP Endicott developments, as well as assisting in a review report for Alyeska of their NPDES monitoring results for submittal to EPA.

- Managed a physical oceanographic study associated with discharges from production platforms offshore Santa Barbara. Designed and performed multi-year studies carried out on the California OCS on the effect of drilling fluids and produced water discharged from exploratory and production platforms.

- Instrumental in developing the basic study designs and techniques now used in large urban runoff studies in San Francisco Bay, including the first large programs for Santa Clara and Alameda Counties. Include development of special automatic sampling stations which integrate hydrologic information to achieve flow-proportioned sampling, instrumentation of sub-basins by land use categories, synthesis of total pollutant loading by modeling, and parallel instrumentation checks of large downstream drainage channels and streams.

- Project manager or chief scientist on a number of other stormwater studies, including Monterey Bay area studies, and stormwater management plan studies with Woodward Clyde Consultants for Naval Facilities in Southern California

- Key participant in the toxicological study of agricultural drain water for the San Luis Drain project, involving a large number of Delta and San Francisco Bay species

- Project manager for an 18-month study involving instrumentation of the Sacramento River Delta for currents, suspended load, salinity, and other parameters associated with salinity intrusion control studies. Project manager for instrumentation of the stormwater monitoring program for the Sacramento regional study.

- Project manager for the City and County of San Diego stormwater monitoring project, which includes multi-year sampling from 15 automatic monitoring stations distributed according to location, land use, and receiving water categories, along with modeling interpretations

- Project manager and chief author of the team responsible for the marine impact EIR/EIS documentation for the City of San Diego metropolitan area infrastructure planning study which involved 20- and 30-year water reclamation and disposal facilities.

EDUCATION

Post-doctorate, Scripps Institution of Oceanography, University of California, San Diego; 1966
Ph.D., Engineering; Iowa State University; 1963
B.S., Engineering, South Dakota School of Mines, 1957

GARY G. LAWLEY
Research Technician
Alaska Field Operations

KINNETIC LABORATORIES INCORPORATED

EXPERTISE Field Operations/Logistics
Environmental Assessment and Monitoring Programs

EXPERIENCE WITH FIRM Mr Lawley currently serves as a field technician for the Kinnetic Laboratories, Inc. (KLI) office in Anchorage, Alaska. As a technician on the KLI staff since 1995, he works closely with project managers to ensure field operations follow study specifications and are performed in the most efficient and effective manner. He has extensive experience in the implementation of a wide range of environmental studies. His duties include logistics, conducting shipboard operations, and assuring that the chain of custody and sample handling procedures are carried out according to appropriate standards. He has thirteen years of field experience in Alaska and has worked in areas including Prince William Sound, the Gulf of Alaska, Cook Inlet, the Chukchi Sea, and the Beaufort Sea.

Selected Project Experience

- Field technician for the Prince William Sound Regional Citizens' Advisory Council's Long-Term Environmental Monitoring Program. This on-going program is designed to monitor the potential impacts of petroleum hydrocarbons on biota and sediments in Prince William Sound and the Gulf of Alaska. Mussels are used as bioindicators of hydrocarbon accumulation in the intertidal environments, while subtidal sediments, collected by both grab and divers, are analyzed to provide information on long-term inputs to the marine environment.

- Field technician for the Cook Inlet Regional Citizens' Advisory Council's 1996 Shelikof Strait Program, 1997 Cook Inlet Sediment Characterization and Toxicity Study, and 1997 Kenai River and Estuary Investigation Project. These programs focused on the potential environmental effects of oil industry activities in Cook Inlet. Program designs included monitoring mussels for bio-accumulation of hydrocarbons in 1996 and examining subtidal sediment chemistry and toxicity in 1997.

- Dive tender on several NPDES monitoring programs for various Log Transfer Facilities in Prince William Sound, the Gulf of Alaska, and the Kodiak Archipelago. These subtidal bark accumulation programs are performed by divers who record bark accumulation levels and biota encountered at fixed points along multiple transects. Also entailed deployment and maintenance of under-water video, underwater single-side band communication, and specialized dive gear.

- Field technician for the Municipality of Anchorage's NPDES 301(h) secondary treatment waiver monitoring program, a project now in its thirteenth year. Components of this study have included: water and sediment quality, evaluation of discharge criteria, ocean currents and dispersion, invertebrates, and permit and regulatory compliance determinations. Subsequent special studies and evaluations have been conducted in support of the Permit reapplication.

- Field technician for the Alaska Council of Trout Unlimited's Kenai River Estuary Sediment and Water Quality Investigations. This program employed a sediment

quality triad approach examining chemical, toxicological, and biological parameters to help evaluate the levels and potential effects of contaminant discharges on the Kenai River Estuary and its biota.

- Field technician supporting a bathymetric survey of a possible Log Transfer Facility to be sited at Cape Yakataga. Mobilized and expedited equipment and crew to a remote location. Formulated site-specific safety/contingency plan; employed small skiff and hand-held sonar to aquire GPS-located and tidally-adjusted water depths for a highly dynamic Gulf of Alaska beach site.

- Field technician performing a sediment survey of a private subtidal lease in Ketchikan, Alaska. This program included confidential analysis of grab sampled sediment for metals, hydrocarbons, and dioxins.

- Field technician for the Municipality of Anchorage's Eagle River Waste Water Treatment Plant's NPDES permit. In support of the permit's renewal, a four-season analysis of Eagle River's ambient metal load was calculated upstream from the treatment plant and compared to downstream loads. Flow-based composite samples of plant effluent were also analyzed for chronic and acute toxicity.

- Field technician five seasons for a study of anadromous fish in the nearshore environment of the Beaufort Sea. Study parameters included recruitment, genetic distribution, fecundity and migration habits of five target species correlated with marine/esturine temperature and salinity gradients. Responsible for the siting, installation, and maintence of Fyke nets, identification and tagging of fish, collection of water quality data, collection of genetic samples, and the operation and maintenance of support skiffs. A variety of tagging methods were used to identify Fyke net captured and recaptured fish.

- Laboratory technician for the University of Alaska at Anchorage. Responsible for the maintenance of the student microbiology labs. Included isolation, identification, and culture of 20 to30 reference cultures of bacteria; growth media production; purchasing lab supplies; maintaining microscopes; basic instruction; and proctoring of exams.

- Field technician on an industry-funded cleanup and site remediation of an oil processing facility at Nikiski, Alaska. Confined space supplied air work cleaning and dismantling small cracking chambers, millon gallon oil storage tanks, and sludge ponds. Level B and C personal protective equipment required daily.

- Field technician on an EPA Superfund cleanup site along Ship Creek in Anchorage, Alaska. This RCRA-mandated remediation of a uncontrolled hazardous waste and hazardous materials site necessitated levels B and C personal protective equipment and methods. Program designed to control and dispose of site hazards including PCB's, dioxins, dibenzofurans, heavy metals, and hydrocarbons.

CERTIFICATIONS

U.S.C.G. Western Rivers. Sixpack. License to operate charter vessels.
CPR, First Aid, and Confined Space Entry Certified
HAZWOPER 40 hr. Training in accordance with 29 CFR
PADI Diver Certification, Open Water

DAWN R. REEDER
Environmental Scientist

KINNETIC LABORATORIES INCORPORATED

EXPERTISE

Water and Sediment Quality Evaluations
Marine and Terrestrial Ecosystem Surveys
Site Assessment Studies
Bioremediation; Soil and Groundwater Remedial Systems
Hazardous Waste and Underground Storage Tank Removals

EXPERIENCE WITH FIRM

Ms. Reeder is an environmental scientist holding a degree in Biological Sciences with 10 years of experience in environmental studies. She has worked for KLI since 1989 on a variety of projects. Her responsibilities include field sampling, data analysis, report preparation, and technical editing. Ms. Reeder is an active research diver for KLI. She has worked extensively in Alaska in areas including Prince William Sound, the Gulf of Alaska, the Pribilof Islands, the Beaufort Sea, Cook Inlet, and Shelikof Strait.

Selected Project Experience

- Field scientist and/or research diver for the Prince William Sound Regional Citizens' Advisory Council's Long-Term Environ-mental Monitoring Program. This program is designed to monitor the potential impacts of petroleum hydrocarbons on biota and sediments in Prince William Sound and the Gulf of Alaska. Mussels are used as bioindicators of hydrocarbon accumulation in the intertidal environments, while subtidal sediments, collected by both grab and divers, are analyzed to provide information on long-term inputs to the marine environment. The program has also included emergency sampling in response to spill events at the Alyeska Marine Terminal.

- Field scientist for the Cook Inlet Regional Citizens' Advisory Council's 1995 Environmental Monitoring Program and the 1996 Shelikof Strait Program. These programs focused on the potential environmental effects of oil industry activities in Cook Inlet. Program design included monitoring subtidal sediment chemistry and toxicity, bioaccumulation in fish and mussels, benthic investigations, and use of bio-surrogates to monitor hydrocarbons in the water column.

- Research diver and lead scientist on numerous NPDES monitoring programs for various Log Transfer Facilities in Prince William Sound, the Gulf of Alaska, and the Kodiak Archipelago. Divers record bark accumulation levels and biota encountered at fixed points along multiple transects.

- Research diver and lead scientist performing a bathymetric survey of a possible Log Transfer Facility to be sited at Cape Yakataga. This near-shore survey was performed in a highly dynamic area of the Gulf of Alaska in near-marginal conditions.

- Scientist performing field sampling and other support for the Municipality of Anchorage's NPDES 301(h) secondary treatment waiver monitoring program. Components of this study have included water and sediment quality, evaluation of discharge criteria, ocean currents and dispersion, benthic invertebrates, and permit and regulatory compliance determinations.

- Participated in Prudhoe Bay Seawater Treatment Plant NPDES Monitoring for ARCO Alaska, Inc. In particular, provided field support for collection of benthic sediments from Prudhoe Bay during winter (through the ice).

- Field scientist for a number of studies performed for EXXON in response to the T/V *EXXON VALDEZ* oil spill. Her responsibilities included sampling sediments, water, and benthic infauna for fate and assessment and cleanup efficacy studies. During shoreline treatment monitoring studies, Ms. Reeder filmed underwater video to document plume dispersion and sample collection.

- Participated in Remedial Investigation/Feasibility Studies (RI/FS) throughout Alaska as a part of the U.S. Department of Defense (DOD) Installation Restoration Program. Prepared RI/FS study plans and reports, participated in all phases of ongoing field investigations (site reconnaissance and installation and sampling of soil borings and groundwater monitoring wells), and performed Risk Assessments prioritization of 23 RI/FS hazardous waste sites using the DOD Automated Defense Priority Model.

- Supervised subcontractor field crews and served as site Health and Safety Officer during the first phase of a cleanup effort of several abandoned drum dump sites on the Pribilof Islands. Duties included field characterization and laboratory sampling of drum contents and supervision of the consolidation and staging of wastes for future transport.

- Performed numerous site investigations logging soil borings and collecting soil samples for chemical and geotechnical analyses. Installed, developed, and sampled groundwater monitoring wells to evaluate the extent of subsurface soil and groundwater contamination resulting from fuel releases.

- Environmental scientist performing various site assessments. Duties included records searches, interviews, site reconnaissance, and soil field screening to evaluate past activities and potential presence of hazardous materials.

EDUCATION

B.S. Biological Sciences, Stanford University, Palo Alto, California, 1990

CERTIFICATIONS

NAUI Diver Certifications: Openwater I Certification, 1986
American Red Cross Adult CPR and First Aid
40 Hour Hazardous Materials Health and Safety Training
8 Hour Supervisory Hazardous Materials Health and Safety Training
8 Hour Entry to Confined Spaces Training

PETER M. WILDE
Data Systems Manager

KINNETIC LABORATORIES INCORPORATED

EXPERTISE

Statistical Analysis
Database Management
Computer System Management
System and Software Design

EXPERIENCE

Mr. Wilde has served as a computer analyst and physicist at Kinnetic Laboratories since 1979. As computer analyst, he has been responsible for data processing, programming, and statistical analysis for a variety of environmental studies. He is skilled in working with a wide range of computer hardware, from micro- and mini-computers to large mainframe systems. Using his expertise in analyzing sophisticated data sets, he designs the software required to address and simplify complex physical, biological, and environmental problems. His responsibilities include computer system and data management, data processing, sensor interfacing, statistical analyses, time-series analyses, and interpretation of results.

Selected Project Experience

- Provides data and statistical analysis support for fate and effects and EPA-required studies for a number of industrial and municipal point and nonpoint-source discharge programs, including the Municipality of Anchorage's Point Woronzof NPDES monitoring program. Performs statistical testing and provides data submittals for EPA in the Ocean Data Evaluation System (ODES) format. Has developed software for monitoring storm drain run off in Campbell CR-10 microloggers, including interfacing to various remote flow and depth sensors.

- Provides data and statistical analysis support for a variety of environmental studies including a long-term monitoring program in Alaska to determine effects of petroleum industry operations on sediment and biota. Provided initial database design, statistical design and analysis, and data reporting support for this program which has been performed by KLI since 1993 for the Prince William Sound Regional Citizens' Advisory Council.

- Developed and wrote a majority of the specialized software used in KLI's oceanographic data analyses, data processing, and computer modeling efforts. Participated in physical oceanographic studies along the coasts of Alaska and California. Performed as data system manager and computer analyst in support of production research for a study of EXXON's Point Thompson Unit on the Beaufort Coast of Alaska. Served as data system manager for several ecological and oceanographic studies performed by KLI for NOAA in areas of Alaska including the Beaufort Coast, Chukchi Sea Coast, Resurrection Bay, and Cook Inlet.

- Data systems manager for the physical oceanographic studies performed for ARCO Oil and Gas Company off Coal Oil Point, California. This study involved the use of current meters, hydrographic profiling, and drogues. Other projects in California include a

large physical study of saltwater intrusion into the San Francisco Bay-Delta and an analysis of current meter data being collected to evaluate potential dredge disposal sites (both studies for the San Francisco Corps of Engineers).

- Analyzed offshore wind, wave, and current meter data as part of a 5-year MMS study of offshore development along the California Coast.

- Developed a complete set of data processing programs used for KLI's benthic infaunal analysis studies involving soft-bottom benthic communities. Also responsible for computer data analysis for hard-bottom benthic studies for Carmel and Santa Cruz monitoring studies, the Texaco Jade and Platform Harvest projects, and a long-term California OCS monitoring study.

- Has written extensive software to manage and analyze large multi-year data bases for the MMS rocky intertidal ecological study in central and northern California and the MMS oil seep study in the Santa Barbara Channel.

EDUCATION

B.A., Physics and Information Sciences, University of California, Santa Cruz; 1978.

GARY GILLINGHAM
Senior Marine Biologist/Taxonomist

KINNETIC LABORATORIES INCORPORATED

EXPERTISE

Invertebrate Taxonomy
Benthic Community Analysis
NPDES Permitting and Discharge Evaluations
Water and Sediment Quality Impact Evaluations
Environmental Issues Related to Oil and Gas Development

EXPERIENCE WITH FIRM

Mr. Gillingham is a staff invertebrate taxonomist and biologist with 20 years of experience and expertise on the biology of faunas living in marine soft-substrates. As a senior staff biologist and technical writer for Kinnetic Laboratories since 1981, he has extensive experience in invertebrate taxonomy, field sampling, data analysis, and report production. His activities have also involved him in other areas besides biology, such as associated project tasks that require sampling for sediment and water quality chemistry data.

Selected Project Experience

- Marine biological task leader for NPDES 301(h) applications for North San Mateo, Oceanside, Encina, Escondido/San Elijo, Oxnard, and Watsonville (California). Has performed supporting studies of the marine benthos for the NPDES monitoring program for the Municipality of Anchorage's Point Woronzof discharge as well.

- Assisted in the preparation of the Northstar Development draft and final EIS. Authored affected environment and impacts sections for the benthic infauna components of this large EIS prepared for offshore oil drilling on the North Slope of Alaska.

- Program manager for a baseline survey in Nigeria, Africa for Mobil Producing Nigeria Ultd. Two separate offshore oil field production units, Oso Field and Ubit Field, which were scheduled for expansion, were surveyed for baseline information. Conducted sampling for benthic fauna, fish, and zooplankton as well as water column profiling for major water quality parameters. Collected sediment cores and grabs for sediment trace metal and organic chemistry analyses.

- Has Provided statistical analysis and interpretive support for a variety of environmental studies including a long-term monitoring program in Alaska to determine effects of petroleum industry operations on sediment and biota. Provided initial statistical design support and interpretation of results during the early stages of the program which has been performed by KLI since 1993 for the Prince William Sound Regional Citizens' Advisory Council.

- Biological task leader for an EIS and associated field studies for a proposed desalination plant at Marina, California.

- Field scientist and task leader for invertebrate communities evaluation for the Prudhoe Bay Seawater Treatment Plant NPDES Monitoring for ARCO Alaska, Inc. Program includes sampling and analysis of water and sediments from Prudhoe Bay. Spring sampling involves working through the ice for collection of water quality, benthic

samples, and oceanographic measurements. Summer sampling includes oceanographic measurements and water sample collection.

- Senior taxonomist from 1988 through 1990 for the Endicott NPDES Monitoring Program. This study included water and sediment quality, benthic invertebrates, and dye dilution and dispersion studies including computer modeling of the effluent discharge.

- Participated on over two dozen separate studies in the Monterey and San Francisco Bay regions involving either baseline surveys, NPDES monitoring, 301(h) permit preparation, dredging and wetlands studies, as well as EIS/EIR related field sampling and report preparation.

- Task manager for marine biology for the Ecological Assessment of Naval Air Station, Alameda, a large multi-disciplinary project for PRC Environmental Management, Inc. of San Francisco.

- Benthic invertebrate task leader for the Kuparuk Waterflood NPDES monitoring program from 1985 through 1987. This study included water and sediment quality, benthic invertebrate and fish monitoring components, and a discharge dye dispersion sampling program.

- Involved with the numerous scientific studies associated with the T/V *Exxon Valdez* Oil Spill. His involvement began within the first days of the spill response. Assisted in setting up the water and sediment chemistry sampling operations in Prince William Sound, then served as the principal field investigator on subsequent sediment study cruises through the winter of 1990. Served in the same capacity for the sediment and water chemistry components of a crustacean resource study within the Sound.

- Benthic invertebrate task leader for the Peard Bay NOAA/OCSEAP ecosystem study along the Chukchi sea coast from 1982 through 1984.

- Prior to working with Kinnetic Laboratories, Mr. Gillingham worked as a marine biologist for private and state agencies. He has worked on many community analysis and life-history monitoring studies throughout southern and central California, as well as several areas in Alaska. He served as a staff research assistant and taxonomist at Moss Landing Marine Laboratories for six years and worked also as a part-time independent consultant and taxonomist during that time.

EDUCATION

B.A., Zoology; California State University, Long Beach; 1973
A.A.; Art , Fresno City College, Fresno, California; 1969

SPECIAL TRAINING AND PROFESSIONAL AFFILIATIONS

Southern California Association of Marine Invertebrate Taxonomists (SCAMIT), 1981-present

BRENDA G. GUMMINGER
Environmental Scientist/
Computer Analyst

KINNETIC LABORATORIES INCORPORATED

EXPERTISE

Database Management, Processing, and Analysis
Environmental Issues Related to Oil and Gas Development and Oil Spills
NPDES Permitting and Discharge Evaluations
Technical Editing and Writing

EXPERIENCE WITH FIRM

Since her employment began at KLI in 1994, Ms. Gumminger has participated in several major projects including Prince William Sound Regional Citizen's Advisory Council's Long-Term Environmental Monitoring Program; Cook Inlet Regional Citizen's Advisory Council's environmental monitoring programs; and the EPA-required environmental monitoring for the Municipality of Anchorage's secondary wastewater discharge. Although her primary tasks on these projects involve database management and report writing and editing, she also provides field sampling, quality control, and management support. Ms. Gumminger holds a degree in marine biology and has 13 years of experience in marine studies and computer science. She has participated in research surveys in the U.S. Atlantic Ocean and areas of Alaska including Prince William Sound, the Gulf of Alaska, and Cook Inlet.

Selected Project Experience

- Provided scientific and computer analyst support for the Prince William Sound Regional Citizens' Advisory Council's Long-Term Environmental Monitoring Program. This program is designed to monitor the potential impacts of petroleum hydrocarbons on biota and sediments in Prince William Sound and the Gulf of Alaska. Tasks include field sampling and documentation, data management and processing, quality control, technical reporting and editing, and overall administrative support for the program.

- Provided scientific and database support for the Cook Inlet Regional Citizens' Advisory Council's 1995 Environmental Monitoring Program, 1997 Cook Inlet Sediment Characterization and Toxicity Study, and 1997 Kenai River and Estuary Investigation Project. These programs focused on the potential environmental effects of oil industry activities in Cook Inlet. Tasks have included logistical support, sample documentation, quality control, data management, and reporting.

- Scientist and technical writer/editor for the Municipality of Anchorage's NPDES 301(h) secondary treatment waiver monitoring program. This comprehensive study includes the production of a large-scale annual report providing all in-plant monitoring results as well as those from ambient water monitoring in Cook Inlet. Provided field sampling, data tabulation and synthesis, quality control, and technical writing support.

- Database coordinator for a multidisciplinary database containing environmental damage assessment data collected by a number of scientific teams in response to the T/V *EXXON VALDEZ* oil spill. Responsibilities included database design and development involving interaction with program scientists and other data management personnel to determine the optimum database design; contribution to the design and development of field documentation and sample tracking procedures for integration with existing database; and interaction with

laboratories and principal investigators to ensure database structure compatibility and data submission and revision accuracy. Included all aspects of database management including data tracking, loading, reformatting, manipulation, validation, and report generation. Database tasks were performed in R:BASE and/or ORACLE using SQL. Ms. Gumminger was also responsible for supervising and coordinating the work of other contract team members by providing guidance and reviewing final products; implementing quality control procedures; focusing on the development and modification of new or existing Standard Operating Procedures (SOPs); and field support involving water and sediment sampling both nearshore and onshore.

- Data programmer/analyst responsible for application and database design, development, and management. Included work on a large-scale project to develop an extensive relational database of geochemical data involving the digitizing of sample locations in AutoCAD and transferring this location data to an R:BASE database. Developed a database and application to store library reference information involving development of front end data entry and data editing screens for end users as well as linking several command files to generate reports from the database. Also provided support for Alaska Clean Seas using and developing their spill response GIS/Database.

- Marine technician and data entry technician providing laboratory and field support for both industrial and government-sponsored programs, many of which involved assessing impacts of oil-related development on the marine ecosystem. Her laboratory responsibilities included sediment grain-size analysis (including pipette analysis), preparation of sediment for Carbon, Hydrogen, Nitrogen (CHN) analysis, benthic sorting, identification and biomass data collection of invertebrates and marine algae, quality control, and training and supervising others in the above tasks. Her field experience involved offshore benthic sampling in the U.S. Atlantic Ocean using various equipment. Other responsibilities included data entry, data processing, and statistical analyses.

- Proficiency with computers covering a wide variety of conventional software applications and platforms. Capable of using both Macintosh and IBM-compatible computers and either DOS or Windows operating systems. Experienced in managing databases using R:BASE, FoxPro, and Microsoft Access database management software as well as ORACLE using SQL computer language. Has also managed data using Excel, QuattroPro, and Lotus 123 spreadsheets. Fluent in the use of Microsoft Word and WordPerfect word processing software as well as developing graphics using CorelDraw.

EDUCATION

B.S. Marine Biology, University of Massachusetts-Dartmouth, 1986

CERTIFICATIONS

National Association of Underwater Instructors (NAUI) Openwater I Dive Certification, 1983

Dr. Guy J. Denoux

Laboratory Manager

Specialties: Laboratory Manager
Data Manager-Geochemical and Environmental Data
Systems Manager-Analytical Computer Systems

Education: B.S. (Biological Sciences) University of New Orleans, 1973; M.S. (Zoology and Physiology) Louisiana State University, 1976; Ph.D.(Oceanography), Texas A&M University, 1984.

Professional Experience: Assistant Research Scientist, Geochemical and Environmental Research Group, Texas A&M University, 1989-Present; Research Associate, Dept. of Oceanography, Texas A&M University, 1984-1989; Research Assistant, Dept. of Oceanography, Texas A&M University, 1982-1984, Graduate Teaching Assistant, Dept. of Oceanography, Texas A&M University, 1981; Research Assistant, Dept. of Oceanography, Texas A&M University, 1981; Research Assistant, Dept. of Oceanography, Texas A&M University, 1981; Graduate Teaching Assistant, Dept. of Oceanography, Texas A&M University, 1980; Research Assistant, Systematics Collection, Dept. of Oceanography, Texas A&M University, 1980; Graduate Teaching Assistant, Dept. of Oceanography, Texas A&M University, 1980; Research Assistant, Dept. of Oceanography, Texas A&M University, 1979; Graduate Teaching Assistant, Dept. of Oceanography, Texas A&M University, 1979; Research Assistant, Dept. of Oceanography, Texas A&M University, 1978; Graduate Teaching Assistant, Dept. of Oceanography, Texas A&M University, 1978; Research Assistant, Dept. of Oceanography, Texas A&M University, 1977; Graduate School Fellow, Dept. of Oceanography, Texas A&M University, 1976-1977; Research Fellow, PRECOL, Dept. of Zoology and Physiology, Louisiana State University, 1975-1976; Teaching Assistant, Dept. of Zoology and Physiology, Louisiana State University, 1974-1975; Research Fellow, Petroleum Refineries' Environmental Council of Louisiana (PRECOL), Dept. of Zoology and Physiology, Louisiana State University, 1974.

Selected Publications:

Denoux, G.J., A study of the fine-scale patchiness of selected copepod species in the California Current, Ph.D. Dissertation, Texas A&M University, College Station, TX, 1984.

Kennicutt, M.C., II, J.M. Brooks and G.J. Denoux, Carbon isotope, gas chromatography, and fluorescence techniques applied to the North Slope of Alaska correlation study, In: Alaska North Slope Oil-Rock Correlation Study: Analysis of North Slope Crude (Ed. by L.B. Magoon and G.E. Claypool), pp. 639-650, AAPG Studies in Geology Series #20, 1986.

Kennicutt, M.C., II, G.J. Denoux, J.M. Brooks and W.A. Sandberg, Hydrocarbons in Mississippi Fan and intraslope basin sediments, Geochim. Cosmochim. Acta, 51: 1457-1466, 1987.

Brooks, J.M., M.C. Kennicutt II, R.R. Bidigare, T.L. Wade, E. Powell, G.J. Denoux, R.R. Fay, J.J. Childress, C.R. Fisher, I. Rosman, and G.S. Boland, Chemosynthetic ecosystems, hydrates and oil seepage on the Gulf of Mexico slope: an update, EOS, 68(18): 498-499, 1987.

Kennicutt, M.C. II, J. M. Brooks, and G. J. Denoux, Leakage of deep, reservoired petroleum to near-surface sediments in the Gulf of Mexico continental slope, Marine Chemistry, 24(1): 39-59, 1988.

Kennicutt, M.C. II, J. M. Brooks, R. R. Bidigare and G. J. Denoux, Gulf of Mexico Hydrocarbon Seep Communities: I. Regional Distribution of Hydrocarbon Seepage and Associated Fauna, Deep-Sea Research, 35: 1639-1651, 1988.

Brooks, J.M., M.C. Kennicutt II, T.L. Wade, A.D. Hart, G.J. Denoux and T. J. McDonald, Hydrocarbon distributions around a shallow water multiwell platform, Environmental Science & Technology, 24(7): 1079-1085, 1990.

Wade, T.L., J.M. Brooks, M.C. Kennicutt II, T.J. McD onald, G.J. Denoux, and T.J. Jackson, Oysters as biomonitors of oil in the ocean, In: Proceedings 23rd Annual Offshore Technology Conference, Houston, TX, pp. 275-280, May, 1991.

Kennicutt II, M.C., S.T. Sweet, T.J. McDonald, and G.J. Denoux, Oil spills in polar climates: The Bahia Paraiso accident, In: Proceedings 23rd Annual Offshore Technology Conference, Houston, TX, pp. 493-500, May, 1991.

Dr. Terry L. Wade

Deputy Director, Environmental Sciences

Specialties: Environmental Chemistry
Chemical Oceanography
Methods Development
Atmospheric Deposition
Project Management
Marine Organic Geochemistry

Education: B.A. (Chemistry), Hartwick College, 1971; M.S. 1974, Ph.D. 1978 (Chemical Oceanography), University of Rhode Island.

Professional Experience: Associate Director and Research Scientist, Geochemical and Environmental Research Group, Texas A&M University, 1992-present; Associate Research Scientist, Geochemical and Environmental Research Group, Texas A&M University, 1986-1992; Member, Graduate Faculty, Texas A&M University, 1986-Present; Assistant Research Scientist, Dept. of Oceanography, Texas A&M University, 1984-1986; Adjunct Assistant Professor, Dept. of Oceanography, Old Dominion University, 1984-Present; NASA-ASEE Summer Faculty Fellowship Program, NASA Langley Research, 1982; Joint Appointment, Dept. of Chemical Science, Old Dominion University 1979-1986; Assistant Professor of Oceanography, Dept. of Oceanography, Old Dominion University, 1978-1984; Research Assistant and Graduate Student, Graduate School of Oceanography, University of Rhode Island, 1971-1978; National Science Foundation Summer Research Assistant, Hamilton College, 1970.

Selected Publications (>100 Publications):

Wade, T.L., B. Garcia-Romero, and J. M. Brooks. 1991. Oysters as biomonitors of butyltins in the Gulf of Mexico. Mar. Environ. Res., 32:233-241.

Wilson, E.A., E.N. Powell, T.L. Wade. R.J. Taylor, B.J. Presley, and J.M. Brooks. 1992. Spatial and temporal distributions of contaminant body burden and disease in Gulf of Mexico oyster populations: The role of local and large-scale climatic controls. Helgol.,nder Meeresunters, 46:201-235.

Kennicutt II, M.C., T.L. Wade, B.J. Presley, A.G. Requejo, J.M. Brooks, and G.J. Denoux. 1994. Sediment contamination in Casco Bay, Maine: Inventories, Sources, and Potential for Biological Impact. ES&T 28: 1-15.

Jackson, T.J., T.L. Wade, T.J. McDonald, D.L. Wilkinson, and J.M. Brooks. 1994. Polynuclear Aromatic Hydrocarbon contaminants in oysters from the Gulf of Mexico (1986-1990). Environmental Pollution, 83: 291-298.

Wade, T.L., D.J. Velinsky, E. Reinharz, C.E. Schlekat. 1994. Tidal River Sediments in the Washington, DC Area II. Distribution and sources of organic contaminants. Estuaries 17: 321-333.

Sericano, J.L., S.H. Safe, T.L. Wade, and J.M. Brooks. 1994. Toxicological significance of non-, mono- and diortho-substituted polychlorinated biphenyls in oysters from Galveston and Tampa Bays. Environmental Toxicology and Chemistry 31: 1797-1803.

Frost, K.J., C. Manen, and T.L. Wade. 1994 Petroleum Hydrocarbons in Tissue of Harbor Seals from Prince William Sound and the Gulf of Alaska. In: T.R. Laughlin (ed.) Impacts of the Exxon Valdez Oil Spill on Marine Mammals. Academic Press 331-358.

Salata. G., T.L. Wade, J. Davis, J.L. Sericano, and J.M. Brooks. 1995 Organochlorine contamination of marine mammals in the Gulf of Mexico. Environmental Pollution 88: 167-175.

Sericano, J.L., T.L. Wade, T.J. Jackson, J.M. Brooks, B.W. Tripp, J.W. Farrington, L.D. Mee, J.W. Readman, J.-P. Villeneuve, and E.D. Goldberg. 1995 Trace Organic Contamination in the Americas: An Overview of the U.S. National Status and Trends and the International "Mussel Watch" Programs. Marine Pollution Bulletin 31: 214-225.

Gardinali, P.R., T.L. Wade, L. Chambers, and J.M. Brooks. 1996 A complete method for the quantitative analysis of planar, mono, and diortho PCB's, polychlorinated digenzo dioxins, and furans in environmental samples. Chemosphere 32: 1-11.

Wade, T.L., P.R. Gardinali, T.J. Jackson, J.L. Sericano, and L. Chambers. 1996 NOAA National Status and Trends Program: PCDD/PCDF Concentrations in Bivalves and Sediments. Organohalogen Compounds 29: 1-5.

Summers, J.K., T.L. Wade, V.D. Engle, and Z.A. Malaeb. 1996 Normalization of Elemental Concentrations of Contaminants in Estuarine Sediments of the Gulf of Mexico. Estuaries 19: 581-594.

Grace Ekman

Quality Assurance/Quality Control Manager

Education: B.S., Chemistry, Johnson State College
M.S., Organic Chemistry, University of Vermont
Medical and scientific courses at Alverno College,
MATC, WCTC

Current Position: 1994 to present: Quality Assurance/Quality Control Manager, Geochemical and Environmental Research Group, Texas A&M University, College Station, Texas. As Quality Assurance/Quality Control Manager for the Geochemical and Environmental Research Group at Texas A&M University, Ms. Ekman is responsible for promulgating, enacting, and enforcing QA procedures and policies at GERG. The QA Manager ensures that all GERG activities are operated in a manner that provides confidence that project and QA objectives are met. Ms. Ekman is independent of project management, and is responsible for ensuring applicable QC policies and directives provide products of high quality to both internal and external clients.

Selected Experience: Quality Assurance/Quality Control Manager, Law Environmental National Laboratories, Pensacola, Florida. Responsible for insuring that laboratory operations were consistent with good laboratory practices and in compliance with regulatory requirements. She served as technical and QA/QC liaison to clients and regulatory agencies, responding to questions regarding methodologies, data interpretation and analytical results. Responsible for development and maintenance of analytical and instrumental documentation, SOPs and QA Manuals and project plans. Responsible for QA/QC training, developed inhouse training documentation, completed analyst proficiency requirements, and initiated the use of control charts with associated statistical protocol. Maintained state certifications, in addition to managing various proficiency sample programs and internal/external audit activities.

Client Services Manager, CH2M Hill, Montgomery, Alabama. Responsible for overall implementation of client services and project management functions. Responsible for preparing proposals, reports, and technical papers as well as management of large-scale laboratory projects. Monitored workload capability of the laboratory, supervised client services, data package and sample custody activities, as well as serving as the interface between client and laboratory management. Represented laboratory services to prospective and current clients, provided technical support to the staff, and provided management support to the laboratory director. Involved in preparation of marketing plans for the laboratory.

Regional Quality Assurance Manager, National Environmental Testing, Thorofare, New Jersey. As QA/QC manager for a National Environmental Testing's Atlantic Region, assisted in the definition and implementation of national, regional, and divisional QA goals. Coordinated and supported QC officers at each laboratory and managed the preparation of uniform SOPs and QAPPs in accordance with various regulatory protocols. Assisted in the implementation of the firm's internal QA testing program and the internal/external audits, proficiency samples and associated corrective actions. Was responsible for the implementation of regional safety programs and safety training activities. In addition, was very active in modifications of job descriptions and in documentation of personnel training activities.

Organic Laboratory Manager/QC Supervisor, CHEM-BIOCorporation, Oak Creek, Wisconsin. Responsible for the management of all chemists in the GC/MS, GC, and extraction sections for a full service environmental laboratory. Duties included budgetary responsibility, personnel, and new equipment justification and procurement. Directed the analysis of PCB's, pesticides, herbicides, VOA, Semi-VOA, TPH, drug testing, and industrial hygiene samples in multi-media matrices

As laboratory manager, was responsible for heavy client contact. Answered technical questions; advised field and laboratory protocol, responsible for scheduling samples; and developing new procedures and methodologies. Very knowledgeable of EPA regulations and protocols, drinking water regulations and AIHA procedures.

Responsible for QA/QC for organic, drug testing, inorganic, and industrial hygiene samples analyzed by entire laboratory. Duties included QC data review and technical review and approval of the data packages. Additionally, responsible for QC documentation; use of control charts and statistical methods; adherence to existing methods; method development: SOP generation; internal and external lab audits; regulatory and client proficiency samples; and maintaining various state certifications.

DAVID P. JANKA
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PERSONAL RESUME

- HIGHLIGHTS OF QUALIFICATIONS -

* Organized and resourceful, with a wide range of skills *
* Capable and experienced with a record of reliability *

- RELEVANT SKILLS AND EXPERIENCE -

- Owner and operator of Auklet Charter Services, a Cordova based charter boat business specializing in Prince William Sound scientific research, film crew support and adventure cruises, emphasizing natural history, wildlife viewing, birding, photography, kayak drop-offs and support.

- Over 20 years Alaskan boating experience (see page 2 for details). U.S. Coast Guard licensed operator of uninspected passenger vessels upon inland waters since 1987.

- Involved with a variety of research projects requiring exact record keeping, meticulous observations and odd hours in sometimes difficult conditions. Other duties included vessel operations, computer usage, learning and adapting lab and field techniques, species identification and sampling procedures. Fields of study included glaciology, marine, lake and stream ecology, fisheries, water quality and pollution monitoring, and marine intertidal.

- Served as Executive Director of Prince William Sound Conservation Alliance, a private non-profit public advocacy and environmental education organization. Responsibilities included fund-raising, membership, office management, newsletter publication, grant writing, interaction with regulatory agencies, contact with the media, elected officials, and other environmental organizations. Other duties included responding to governmental and industry activities, representation at public hearings, conferences and meetings, building public awareness and assimilating the wide range of environmental issues affecting the Prince William Sound area.

- Coordinated the fall 1990 and participated in the summer 1990 and spring 1991 Valdez Local Response Program (a State funded program for local response to the Exxon Valdez oil spill). Duties included the hiring, training and outfitting of a crew for manual clean-up of oiled salmon stream sites in Prince William Sound. Worked with state, federal and industry personnel. Supervised and/or participated in field, vessel and office operations, shoreline surveys, and documentation.

- Helped build, coordinate and manage a remote camp and food facility at Growler Island, in Prince William Sound, 30 miles SW of Valdez. Was responsible for overnight guests, daily visitors, care of small boats, equipment and facilities. Supplied interpretative information and took overnight guests on day charters and hikes. Responsible for spring set-up, fall break-down and winter caretaking.

- Worked in most aspects of a production salmon hatchery.

- Camping, hiking, cross-country skiing, ocean kayaking and photography experience.

- Designed, engineered, and built a two-story 28' x 34' houseboat (1984-1986) in which my wife, Annette, and daughters, Holly and Brenna, and I live.

- RELEVANT SKILLS AND EXPERIENCE CONTINUED -

- Operated and/or crewed on a variety of vessels in Alaska including:

58' "*Auklet*". Extended trips supporting research, agency and filming projects in Prince William Sound, the southern Kenai peninsula, Kenai Fjords National Park and Shelikof Strait. Organizations worked with; Prince William Sound Science Center; Kinnetic Labs; National Biological Service; Hymet; PWS Regional Citizens Advisory Council; NMFS; USFS; NOAA; Bristol Environmental; Marine Research Specialists; USGS; ADEC; Universities of AK, CA, WA; ADF&G; U.S. Fish and Wildlife Service; North Gulf Oceanic; KTOO TV; Graphic Films; Tokai TV; and ABR.

40' "Growler". U. S. Geological Survey research vessel undertaking glacier research in Glacier Bay and Kenai Fjords National Parks, Prince William Sound, and SE Alaska. Work included the charting of newly formed fjords and documenting the advance and retreat of tidewater glaciers.

34' "Sea view", 36' "Coho II", 32' "Seaquel", and 30' "Greystone". Vessels working in Prince William Sound in response to the Exxon Valdez oil spill.

80' "Glacier Spirit". October-December 1987 Valdez-Cordova, four trips/week "ferry" run. 1986 Valdez-Anchorage run and shuttle of personnel and visitors from aircraft carrier anchored in Cook Inlet to the Port of Anchorage. Valdez-Columbia Glacier tours.

Research work, tourist cruises, supply runs, pleasure trips and fishing charters in Prince William Sound aboard the motor vessels; "Kyle David", "Doreen", "Tempest", "Denali", "Discovery", "Mary Helen", "Vince Peede", "Arctic Tramp", "Peggy's J", "Raider", "Kingfisher", "Seaquin" and "Suzy Q"; sailing vessels, "Arctic Tern II", "Arctic Tern III", and "Arctic Falcon", landing crafts; "Silver Eagle" and "Pacman" as well as many skiffs and kayaks.

In 1991 supplied local knowledge, interpretive information and guiding for David Rockefeller Jr's. 4-44' sailing vessel flotilla trip through Prince William Sound and on to Seward and Greenpeace's 140' motor/sailor "Rainbow Warrior's" trip from Anchorage to Valdez.

- EMPLOYMENT HISTORY -

March 1995-present	Owner/operator, Auklet Charter Services, P. O. Box 498 Cordova, Alaska 99574.
1992-1995	Operator of the motor/vessel "*Auklet*" for Dean Rand of Discovery Voyages, P. O. Box 1500 Cordova, Alaska 99574.
1991-1992	Executive Director, Prince William Sound Conservation Alliance, P. O. Box 1697 Valdez, Alaska 99686.
1990-1991	Project Coordinator and Field Technician for the Valdez Local Response Program through Prince William Sound Conservation Alliance, Valdez.
1989-1990	Relief skipper on vessels working Exxon's Prince William Sound operations.
1986-1990	Camp manager and charter boat operator for Stan Stephen's Cruises, P. O. Box 1297, Valdez, Alaska 99686.

- EMPLOYMENT HISTORY CONTINUED -

1985-1993	Owner/Photographer of Coastal Images, Valdez.
1986-1987	Cab and local tour bus driver for Valdez Yellow Cab, Valdez.
1979-1986	Non-credit instructor (banjo and photography) and theater set construction for Prince William Sound Community College, Valdez.
1980-1985	Fisheries Technician/Biologist for Valdez Fisheries Development Association, Solomon Gulch Hatchery, Valdez.
1976-1983	Research Assistant in Prince William Sound for National Marine Fisheries Service, Auke Bay, Alaska.
1979-1980	Research Assistant in Valdez for Rockwell International, Canoga Park, CA.
1978-1979	Research Assistant in Alaska for U.S. Geological Survey, Tacoma, WA.
1970-1978	Earlier Alaska, Wisconsin and Illinois Employment: Photography, Recreation, Restaurant/Bar, Inventory Control, Parts, Purchasing, Shipping and Receiving.

- EDUCATION AND TRAINING -

Prince William Sound Community College:

1997/1998	"24 Hour & 8 Hour Refresher HAZWOPER Technician"
1995	"Survival Equipment, Procedures and Onboard Drills"
1992	"Grant writing"
1990/1992	"CPR and First Aid"
1983	"Astronomy"
1981	"Sailing And Seamanship for Prince William Sound"
1980	"Marine Environment of Prince William Sound"

Cordova Fire Department:

1993, '94 , '96, '98	CPR and First Aid Training.

Alaska Department of Environmental Conservation and/or Exxon:

1990/1991 HAZWOPER Training.

Valdez Fire Department:

1987-1992	CPR and First Aid Training.

Benet Academy High School, Lisle, Illinois

1972	Graduate.