01573

CHENEGA BAY STREAM ENHANCEMENT PROJECT PROPOSAL (revised)

To: The Chenega Bay IRA Council
By: Andy McLaughlin -BS: Wildlife Management (Purdue University)

Summary

Currently several stream habitat constraints exist within the local airport stream watershed (O'Brian Creek). Improvements to these limiting factors would benefit the numerous fish species that utilize the habitat as well as the entire local ecosystem. Many species of salmon and trout populations occur in the stream. These species include, but are not limited to, Pink salmon (*Onchorynchus gorbuscha*), Chum salmon (*O. keta*), Coho salmon (*O. mykis*), Sockeye salmon (*O. nerka*), Dolly Varden trout (*Salvelinus fontinalis*), and cutthroat trout (*Salmo clarki*). Not only would all of the fish populations benefit from enhancement to the stream habitat but the remainder of the ecosystem would also benefit. The Native village of Chenega Bay would also gain an enormous potential for the expansion of socioeconomic factors. A self-sustaining and limited subsistence use fishery would be priceless for the community, as well as adding potential for promoting tourism. By applying certain prescribed habitat improvements the potential for improved salmonid reproductive successes could be promoted. All of the salmonid species would benefit from such improvements, and numerous other wildlife would also gain from the benefits of such restoration. This proposal is designed to improve numerous habitat conditions by enhancement of the current stream regime.

ISSUES:
Permitting/ Environmental Impact Statements/ Inventory
Legal Issues
Labor/ Equipment/ Surveying
Specific Projects/ Habitat Improvements
Funding
Subsistence Use/ Fishing Restrictions
Tourism

I.) SPAWNING HABITAT IMPROVEMENTS

Presently the salmonid species of O'Brian creek spawn in what can be considered marginal habitat. Some easily identifiable factors that can be improved are; water depth , spawning substrate enhancement, stream topography & structural diversity, and sedimentation control. All of these constraints can be easily improved upon both economically and physically. Such modifications will actively contribute to future natural salmon runs and increased productions will result.

A.) Water Depth

The current stream water depth is too shallow for successful spawning and rearing of the larger salmonid species. In the main branch of the stream channel a series of wing dams and short height fish ladders could easily supplement the natural habitat and provide adequate spawning and travel depth for the returning adult salmon. The resulting increases in water depth will also provide more efficient rearing and outmigration environments for the newly hatched salmon fry in the early stages of their life cycle. A substantial increase in spawning area will also result. Spawning habitat that has previously had limited use (due to inadequate depth and lack of water) could be utilized by more fish in the upper stretches of the watershed. This series of dams and short height fish ladders is a vital constituent of the stream enhancement proposal in order to expand the range of habitat currently utilized by the spawning fish.

In the small branch of stream that originates from the air strip watershed, and constitutes the fork that has confluence with the main stream channel just downstream

(Water Depth - continued)

from the bridge, a small dam can be positioned within a narrow portion of the pre-existing ravine that surrounds the stream bed. This area supports the greatest potential for providing a substantially adequate deep water brood pond. The pond could be ~ 20 feet deep, and approximately 4 acres in area. If such a reservoir were constructed, and fitted with a tall height fish ladder, a drastic improvement in potential rearing environment would result. Certain salmonid species (Kings, Reds, and Silvers) that "require" a one year holdover in a freshwater rearing environment could have the potential to complete that part of their life cycle there. This reservoir could also house resident populations of both Cutthroat and Dolly Varden trout.

This proposed reservoir could also provide opportunities for the community that have never previously existed. Not only would such a body of water provide a newly acquired niche for fish habitat, but it also could provide numerous local recreational opportunities (ice skating, swimming, pick-nicking, fishing, hunting, etc.). The specifically proposed area of this branch of watershed has previously had very limited use by both salmon and village residents. With the strategic placement of a small dam creating a small reservoir in this drainage, it could provide undiscovered resource opportunities for both fish and community members that were not previously available.

B.) Spawning Substrate

Presently the stream floor consists of bedrock, gravel, and limited silt. By eliminating the areas of poor substrate (silt and large cobble rock) and increasing the amount of available spawning gravel on the stream floor the survivability of the naturally hatched salmon fry will improve. Enhancement of the stream floor substrate can be provided by the addition of imported pea gravel. Suspected areas in the stream bed can be evaluated for compatibility with egg hatch success and zones of marginal habitat can be identified. Areas of high siltation do not provide ample percolation rates so that enough oxygen can be supplied to the developing embryos. Areas with predominantly too large of rock substrate and bedrock substrate do not provide adequate spawning material for salmonids to create their spawning "nests" or redds. Removal of inadequate substrate and replacement with a more successful substrate (pea gravel) will dramatically effect the hatching success and fish survivability. These areas can simply be dug out with a back hoe and supplemented with imported pea gravel. Such an improvement to egg environment will increase hatching success and provide higher outmigration numbers which in turn will increase the marine survival. Increase in marine survival will cause larger numbers of adult salmon to return for spawning and the cycle can repeat itself indefinitely. Introduction of a more suitable spawning substrate for a more sustainable fishery is another feasible alternative for improving the quality of the present zones of marginal spawning habitat.

C. Stream Structure, Topographic Diversity, Sedimentation Control/Restoration

It will be imperative to maintain as much diversity within the stream structure as possible. Introduction of rip rap on embankments with areas in need of erosion control, strategically placed vegetation, brush, logs, and root clumps for maintaining changes in stream channel direction, are crucial ingredients for proper enhancement of the stream. Maintaining a diversity of these factors is necessary for a healthy stream. In allowing a natural meander of the stream channel within the flood plain, a diversity of depths and substrates can be maintained. Such diversity is needed to meet the requirements for the life cycles of invertebrate species. These aquatic insects and other organisms are food for fish, birds, and other wildlife. It is vital to keep a "dynamic equilibrium" in place within the entire watershed system.

The introduction of short height fish ladders not only will provide avenue for the adult salmon to return upstream, but it will also allow for the dual purpose of providing sufficient oxygenation of the water at times of low dissolved oxygen saturation (when temperatures reach critical highs).

Areas of the main stream channel's watershed (particularly the upstream area that was deforested for the airstrip) could use some form of erosion control to eliminate potential problems from excessive siltation due to run off in the future. Zones that prove to be the source of extreme sedimentation can be revegetated to help control erosion. These headwaters are the "lifeblood" of O'Brian Creek. Presently the forested zone of watershed (between the bridge and the clearcut) is acting as a buffer from severe sedimentation, but further upstream investigation is necessary within the clearcut to minimize organic material deposits that are caused by runoff. Controls of erosion can be provided in the future as the need arises.

II. Permitting

A.) Environmental Impact Statements (EIS) and Environmental Assessments (EA)

These necessary requirements can be met by a contracted environmental consulting firm. Though I have been informed that these requirements would only be necessary if federal funds are used for the project. This information was provided by the U.S. Forest Service.

B.) Inventory/Monitoring/Maintenance

These processes can be provided by a local village resident work force. It is possible that uncontrolled and excessive sedimentation in the future could eventually require physical removal of silt from the stream bed.

C.) Legal Issues

Undoubtedly certain land use permission must be obtained from Chenega Corporation. It might be necessary to obtain a "conservation easement" in order to obtain the rights to provide this local stream enhancement project.

The State of Alaska (due to proximity of the airstrip to the watershed) might have to be involved and the Department of Transportation & FAA will also have to be consulted.

Inquiry into the Alaska State Fish & Game Department will also be prudent in order to comply with any pending state regulations. I have been informed that an Alaska Fish & Game title 16 permit and a LOE 404 permit would be necessary for the project.

Other permits might be necessary in order to obtain the required fill and materials that can be provided from local sources.

All permitting issues could be provided by a contracted environmental consulting firm, if needed.

III.) WORK FORCE

A.) Labor

The general laborers can be provided from "in house", and local residents can provide the majority of the jobs (other than what will be required by outside contractors).

B.) Equipment/ Materials

Several pieces of large heavy machinery already exist in the village and could be utilized for all of the needed support. Permission might need to be obtained from the sources of the local machinery before they can be legally utilized.

Several tons of pea gravel /spawning substrate can readily be imported by landing craft from outside sources. The substrate materials needed for building the desired dams can be supplied locally.

Aluminum fish ladder deneils can be manufactured by an outside contractor to meet our specific requirements.

C.) Surveying

Limited surveying will be required to evaluate the adequate placement of desired dam structures. Each small wire gabion dam can be filled with preexisting rocks from the same proximity of the local stream bed. The location of the first dam should be placed at the high tide level in elevation where adult salmon travel depths first become inadequate. The proper placement of these water retainment structures will optimize stream spawning habitats by adopting prescribed water depths that are adequate for the needs of the fish. Each subsequent dam position should be determined by the next increase in increment of 2 feet while traveling up the stream channel.

IV. SPECIFIC PROJECTS

The entire stream enhancement and rehabilitation project consists of numerous smaller scale modifications to the existing stream habitat. Details on the areas in need of improvement will eventually be more specifically defined and mapped.

The potential for state of the art salmon stream habitat enhancement to take place in Chenega Bay, Alaska is at hand. If we are the first ones to do it in Prince William Sound others will surely follow suit, and our project can be used as an example. Hundreds of similar projects have already taken place elsewhere and could easily be consulted for direction if the need would arise.

Fish populations can eventually be supplemented to the newly reformed habitat. If desired, hatcheries could eventually be utilized to supplement the naturally spawning salmon runs, or to stock a local trout population. Gametes from locally caught adult salmon and trout could be used in a hatchery program to provide the same genetic make-up as the wild stocks that presently occur. Or locally placed in stream incubation devices along with a locally performed egg take could be used to improve the existing hatch success, if desired. Alaska Fish and Game permits would be necessary in order to do so.

A series of 4 or 5 rock gabion dams constructed of nylon coated aluminum wire mesh basket material and welded aluminum fish ladders would be prudent for the lower stretches of the watershed that meets the tidal zone. This zone is also the area most easily accessible by heavy machinery and it contains the largest areas of unused gravel substrate within the flood plain. Dams strategically positioned there would increase the water depth resulting in a vast increase in spawning area that previously could not be utilized by the salmon. It would be more feasible to build a series of smaller dams within the upper stretches of the watershed (in the forested region) with natural materials that already exist in the proximity of where the dams are needed. These "less permanent" dams could easily be constructed by a local work crew.

V. FUNDING

Aide for grant writing proposals can be provided by the local Environmental Specialist and Assistant if needed. An adequate source for funding of this specific project can easily be sought out.

Shared funding for the building of the brood pond dam could possibly be provided by Ducks Unlimited as the resulting wetlands habitat will stand to benefit multiple waterfowl species.

Trout Unlimited might also prove to be a funding source for the stream restoration and enhancement as benefit to the fish habitat is bound to result.

The Exxon Valdez Oil Spill Trustee Council will be very beneficial as a potential funding source. They have an interest in benefiting intertidal communities , subtidal communities, sockeye salmon, pink salmon, Cutthroat trout, Dolly Varden trout, and numerous other parts of the ecosystem that would stand to benefit from such a project.

Other funding sources interested in benefiting human services such as recreation, tourism, and subsistence could also be sought out.

VI. SUBSISTENCE USE and FISHING RESTRICTIONS

A sustainable subsistence harvest of returning adult salmon will be the largest benefit for community residents. If a multi-species salmonid escapement is allowed to increase on a naturally regeneratable basis, the benefits it would provide to the community would be immeasurable. These proposed stream habitat improvements can also provide potential for resident populations of trout which can also supply a sustainable subsistence food resource. The resulting increase in spawning area and brood pond will provide a newly available wetlands habitat niche that can be utilized by a diversity of waterfowl and wildlife species.

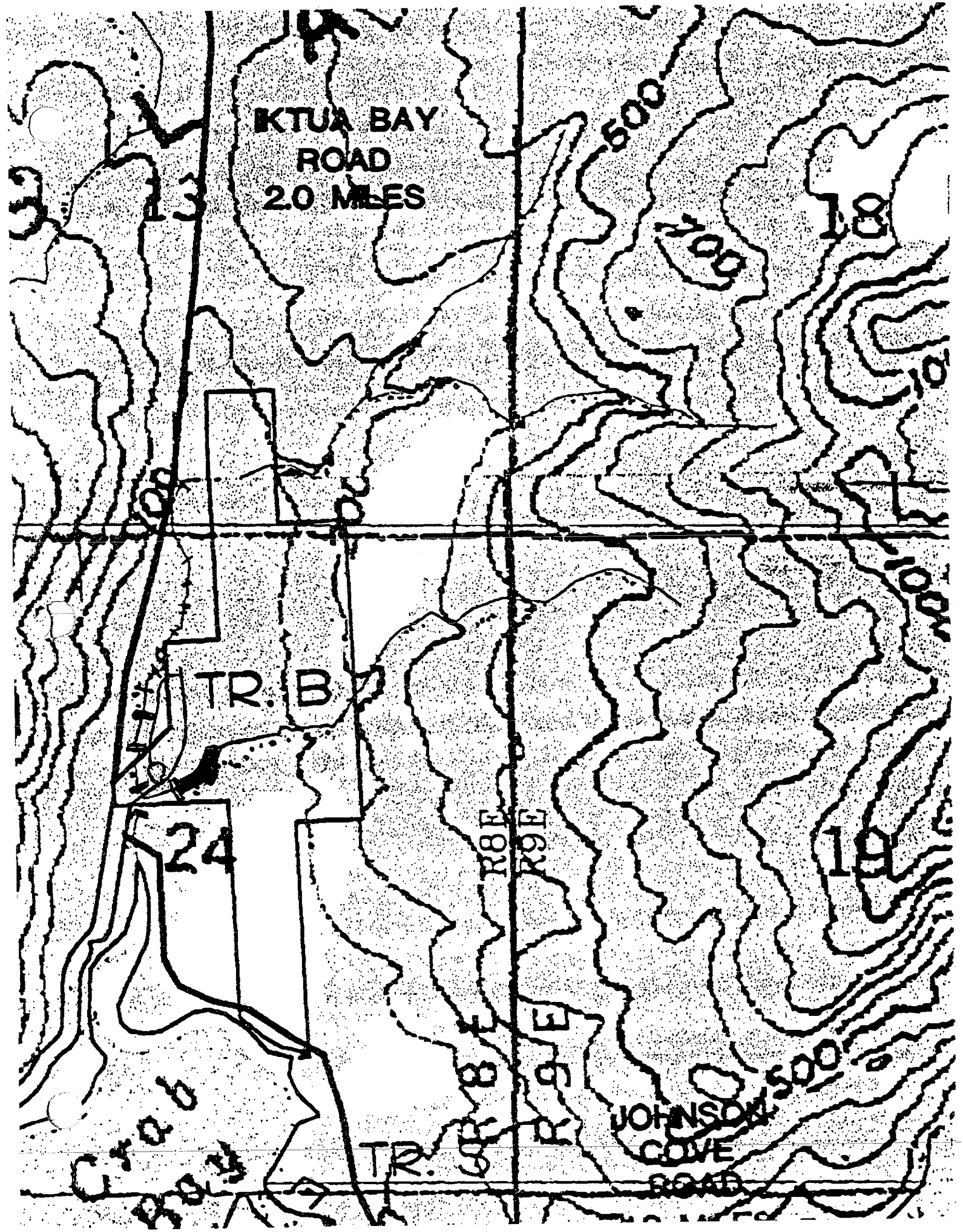
A specific protected spawning area in the rehabilitated stream should be provided in order to allow a constantly renewable resource. If adult fish are not allowed to spawn, then they will have no offspring that can hatch in order to perpetuate their life cycle. No spawning adult fish should be allowed to be molested or removed from a specifically designated spawning ground sanctuary. Locally designed restrictions and bag limits can be designed in the future to meet the specific needs and desires of the village.

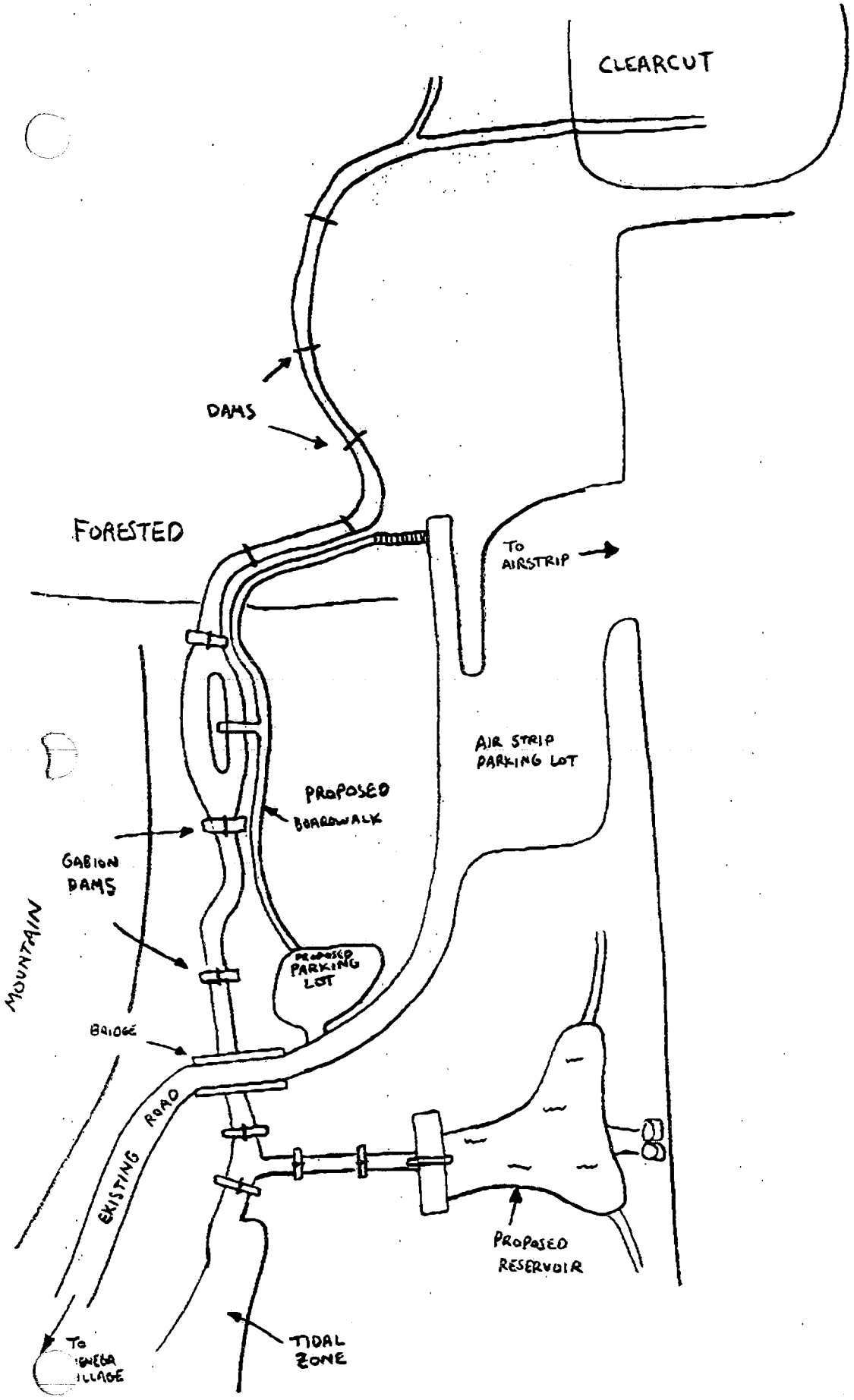
VII. TOURISM

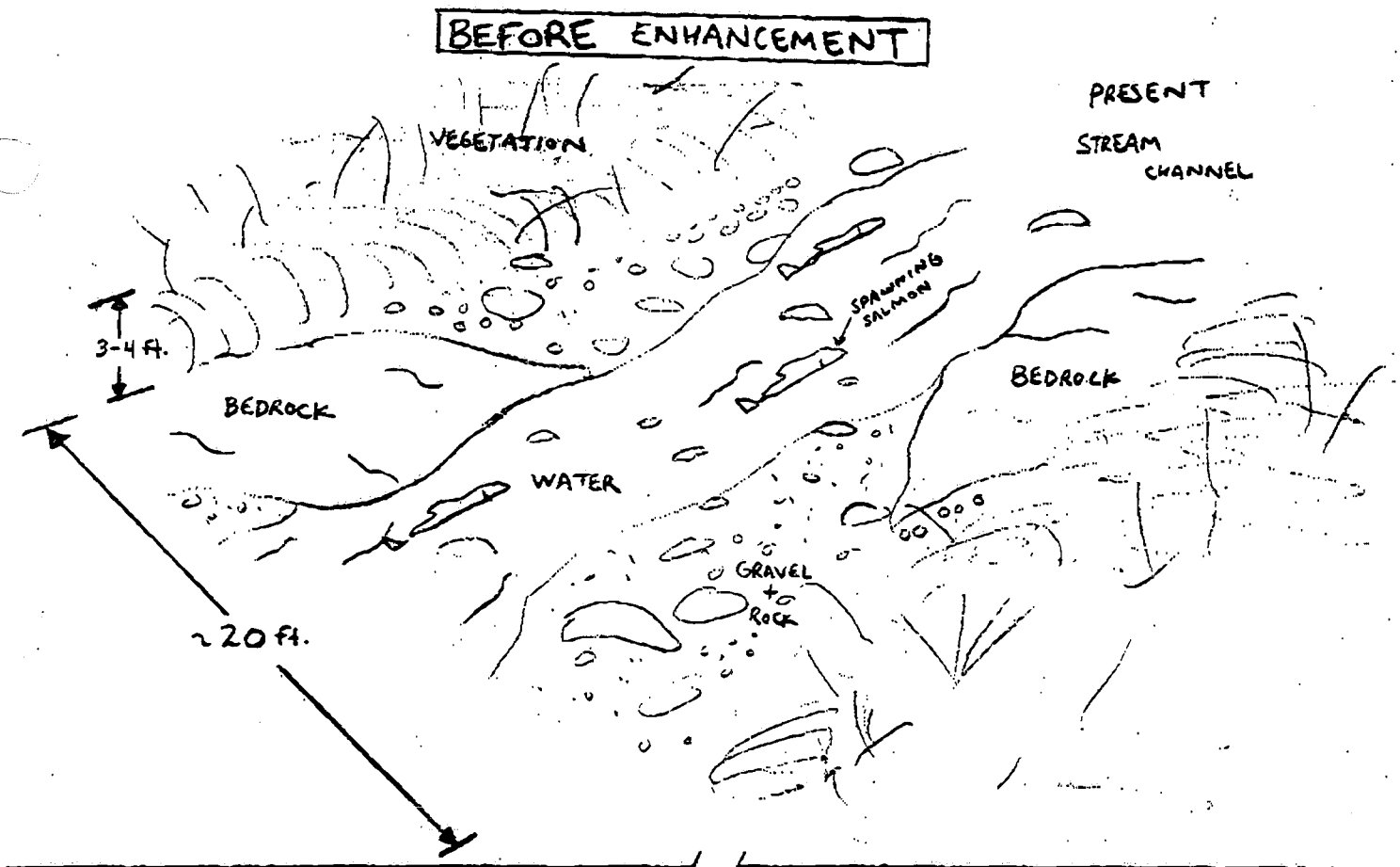
A parking area can be strategically constructed on the north side of the road, just East of the bridge. This will allow both residents and tourists to access the walkway leading to the observation deck. This public access walk will allow for easy access to the spawning areas. An observation deck and educational sign can be posted regarding the natural life cycle of the local fish, and the various stream enhancements that have been provided can also be listed and described in detail. These postings can provide credit to the funding sources that enabled them to happen. The walkway can begin at the proposed parking area and end at a stairway that leads up the airport road. This walkway loop will provide a valuable asset to both community recreation and potential tourism. The walkway should be constructed of either galvanized steel grating or fiberglass grating, as these materials will require the least amount of continual maintenance. They provide snow to fall through them and would withstand the least amount of damage from a winter snowload. The walkway grating will also allow for sunlight to access the surrounding vegetation and it will limit the erosion factor from heavy utilization of the area from human use. The walkway should be supported by posts and should have hand rails affixed. These both should be made of permanent materials that will last. Treated lumber should be avoided at all cost, due to the eventual cost of replacement from degradation in such a wet climate.

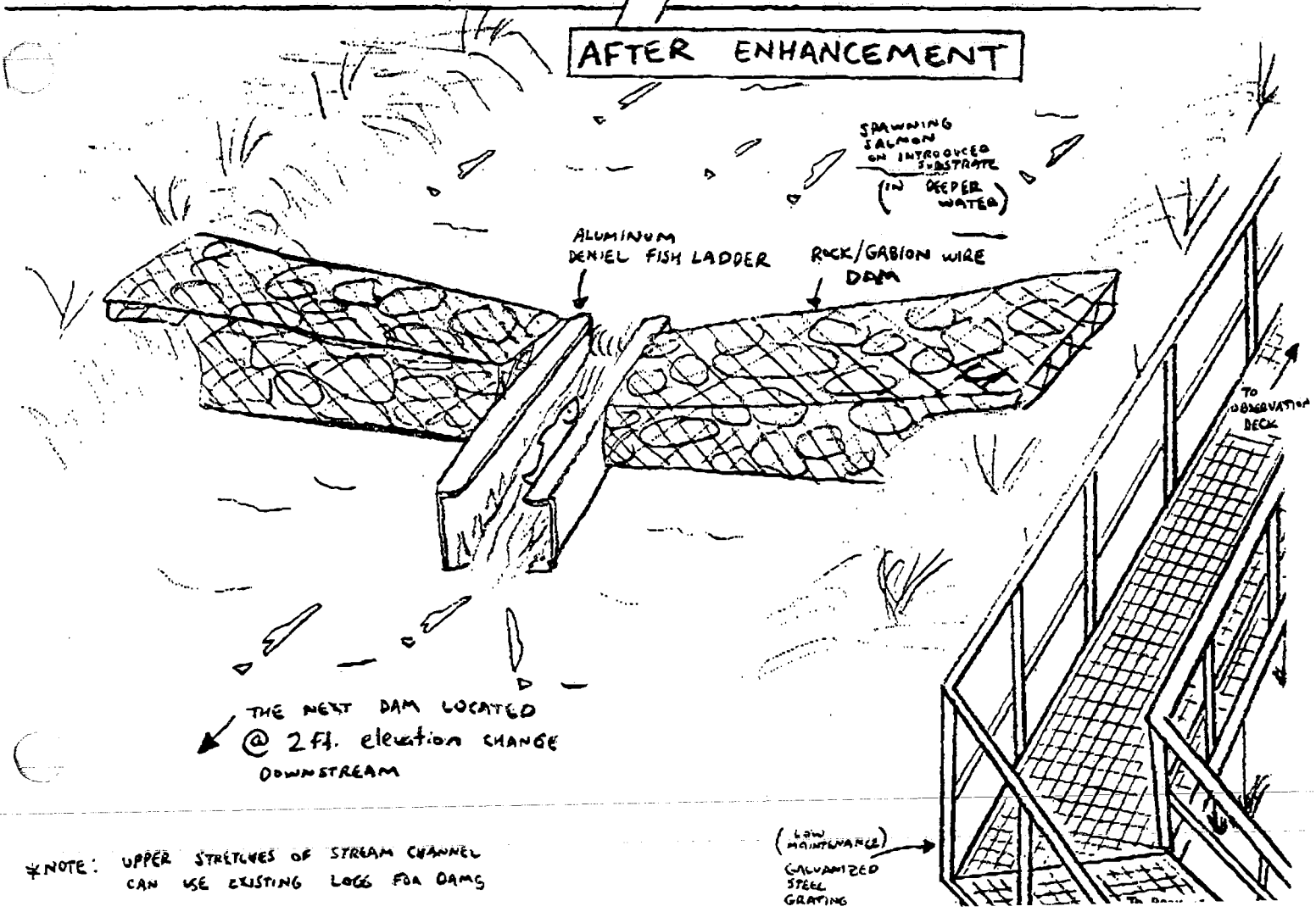
This habitat restoration project has little visible economic benefit to the community, but it does have the potential to enhance recreational opportunities that exist beyond the limits within the present watershed habitat. Such ability to directly improve the local stream ecosystem by enhancement of the existing conditions could be considered cost effective when weighing the potential results. Having a more self-sustaining fishery in addition to new recreational opportunities would be priceless. Eventually unforeseen tourism opportunities could also arise and additional expansions to this project would eventually have the potential to benefit the local community within it's limited natural resources.

Approved by Pete A Kompkoff III Tribal Administrator
Chenega IRA Council


IKTUA BAY
ROAD
2.0 MILES
500
18
TR. B
24
R8E
R9E
19
500
JOHNSON
COVE
ROAD


CLEARCUT
DAMS
FORESTED
TO AIRSTRIP
AIR STRIP PARKING LOT
PROPOSED BOARDWALK
GABION DAMS
MOUNTAIN
PROPOSED PARKING LOT
BRIDGE
EXISTING ROAD
PROPOSED RESERVOIR
TIDAL ZONE
TO CHENEGA VILLAGE





*NOTE: UPPER STRETCHES OF STREAM CHANNEL CAN USE EXISTING LOGS FOR DAMS

Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches – Submitted Under the BAA

Project Number: 01574-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: Two years starting FY 01

Cost FY 01: $134,200

Cost FY 02: $34,275

Geographic Area: Prince William Sound

Injured Resource Services: Intertidal Communities, Sediments, Subsistence, Sea Otters

ABSTRACT

Previous studies suggest that bivalve assemblages on beaches in Prince William Sound exposed to high-pressure hot-water washing during the 1989-90 shoreline treatment program 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 remain extremely disturbed and that the beaches are functionally impaired in terms of their ability to support foraging by natives and nearshore vertebrate predators. The study will also provide insights into potential remediation alternatives for restoring the biodiversity and functional aspects of these assemblages if such measures are shown to be justified.

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 (Neff et al. 1995) 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 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 using a large sprayer-head mounted on a mechanical arm.

Recent analyses of infaunal data from the NOAA study of treatment effects and recovery in intertidal sediments in Prince William Sound have concluded that infaunal assemblages remained fundamentally impaired as late as 1997. This impairment was most evident in the bivalve assemblage but was generally apparent for most assemblages of major taxa. While not always apparent from the perspective of overall species richness or abundance, the impairment is quite conspicuous from the perspective of species composition and biological function or trophic structure. For the bivalves, the burrowing suspension and deposit feeders that dominate at the unoiled, untreated (reference) sites have been replaced by surficial suspension feeders at the sites exposed to high-pressure hot-water (HP-HW) washing. This means that valuable and preferred species that typically dominate at undisturbed beaches (e.g., the littleneck clam *Protothaca staminea*, the butter clam *Saxidomus giganteus*, and various species of *Macoma* that are favored by subsistence gatherers, sea otters, and diving ducks) are replaced by a weed species, *Hiatella arctica*, and a tiny nestling clam *Rochefortia* (= *Mysella*) *tumida.* that are of little or no value to subsistence gathers or the food webs for 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 beaches are missing totally from the infauna at treated beaches. Moreover, our studies indicate that a return to the apparent climax assemblage is occurring very slowly and suggest that recovery is probably delayed by the condition of the sediments, which were also seriously disturbed by the effects of HP-HW washing.

NEED FOR THE PROJECT

The 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 and untreated, and unoiled reference sites in western Prince William Sound since 1989. We concluded 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. However, the geographic scope of our previous studies is very limited and cannot be extrapolated to the rest of the sound. Consequently, we are proposing this study to determine if the conditions that we have 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.

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. 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. 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 1996. Invertebrate groups most commonly observed were, in decreasing order of abundance, Mollusca, Polychaeta, and Crustacea. Snails and clams were the most abundant mollusks and amphipods were the most abundant crustaceans. Dominance patterns of the infaunal invertebrates, which varied according to type of treatment, appear to provide 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 rather than the primary effects of the spill itself.

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 but 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

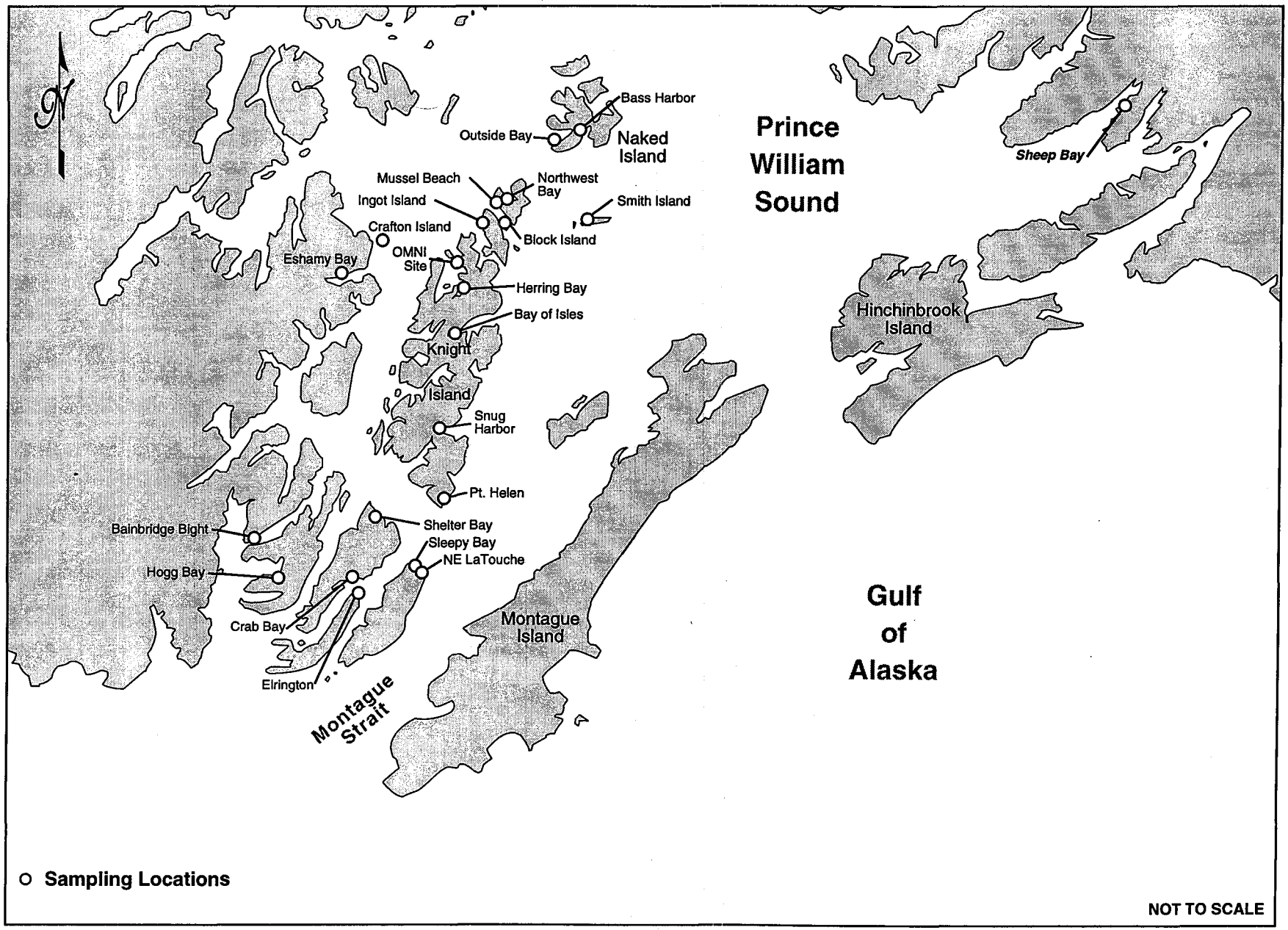


Figure 1. Prince William Sound study area and sampling locations.

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 Category 1 and 2 sites than at Category 3 sites suggesting that community succession has reached a higher level at the former sites than at Category 3 sites. All of the bivalve taxa observed were encountered at either Category 1 or 2 sites whereas only eight taxa were observed at Category 3 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 unoiled and untreated (reference = Category 1) and oiled but untreated (Category 2) sites but they were far less common at oiled and treated sites (Category 3). *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 Category 1 (reference) and Category 2 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, Categories 1 and 2 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 of *M. tumida* and two burrowing sea cucumbers with which *Mysella* could have a commensal relationship exhibited a significant positive correlation.

In contrast, Category 3 was 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 in Category 3. In terms of raw abundance, none of the four species that dominated at Category 1 (reference) or 2 sites showed any indication of significant increases at Category 3 sites during the seven-year period following EVOS (Figures 3 through 6). In contrast, *Hiatella arctica* remained

Figure 2

Trends in Average Numbers of Taxa and Individuals for Bivalve Assemblages at Variously Treated Stations in Prince William Sound

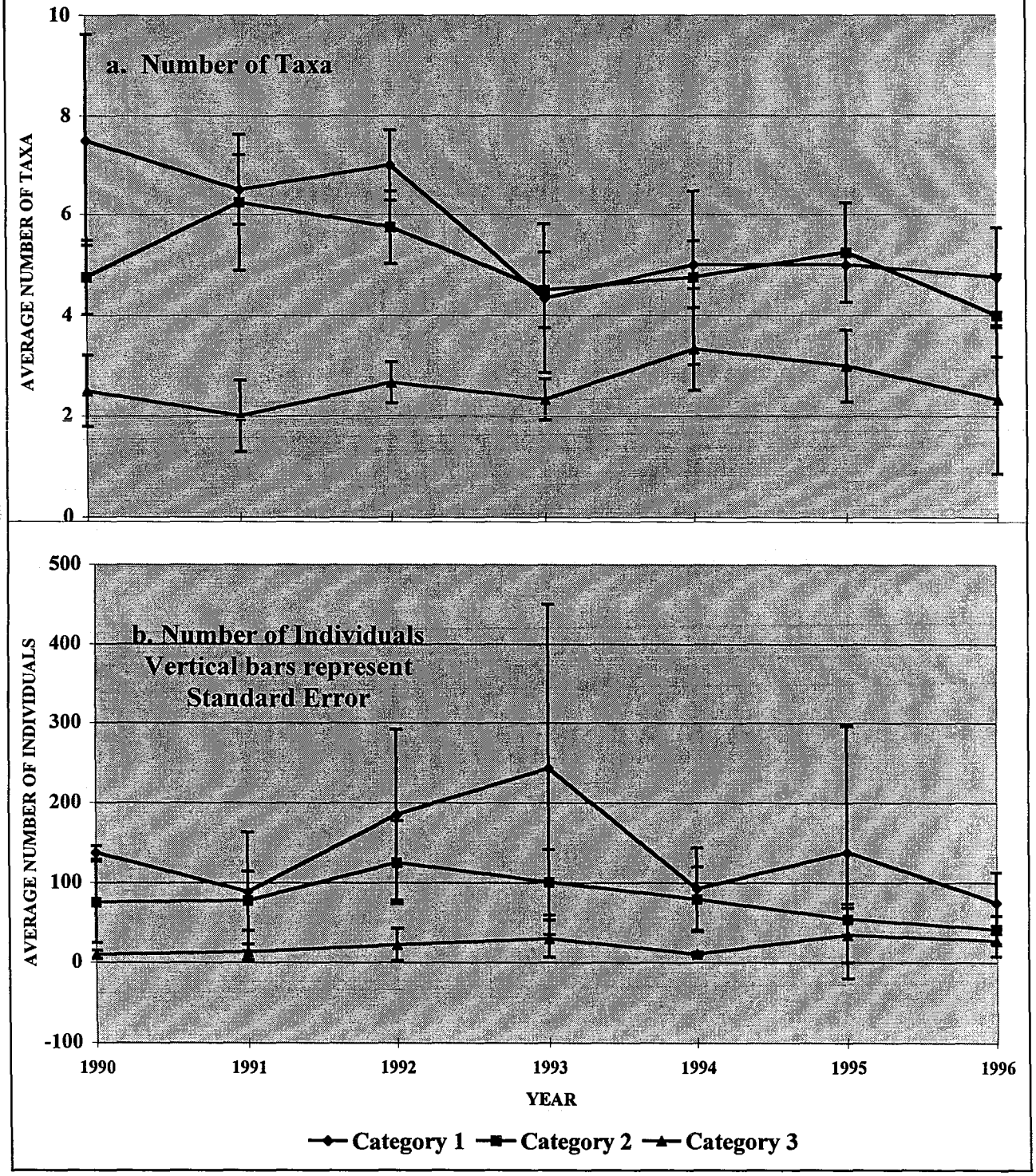


Table 1

Dominance Patterns of Infaunal Bivalves in Treatment Categories

Taxon	Category 1			Category 2			Category 3			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	0.07	0.1							2
Compsomyax subdiaphana	2	0.07	0.1	3	0.1	0.1				5
Cryptomya californica	3	0.1	0.2							3
Diplodonta aleutica				19	0.8	0.7	2	0.4	0.1	21
Hiatella arctica	76	2.6	3.8	259	11.3	9.3	269	60.4	13.5	604
Macoma spp.	30	1.0	1.5	80	3.5	2.9	1	0.2	0.1	111
Macoma balthica	181	6.3	9.1	145	6.3	5.2	19	4.3	1.0	345
Macoma inquinata	274	9.5	13.7	297	12.9	10.6	1	0.2	0.1	572
Macoma obliqua	6	0.2	0.3	1	0.04	0.0				7
Mactridae				2	0.09	0.1				2
Mya arenaria	4	0.1	0.2	1	0.04	0.0				5
Mysella tumida	1883	65.6	94.2	985	42.8	35.2	124	27.9	6.2	2992
Protothaca staminea	373	13.0	18.7	443	19.2	15.8	27	6.1	1.4	843
Saxidomus giganteus	33	1.1	1.7	58	2.5	2.1	2	0.4	0.1	93
Semele rubropicta				2	0.09	0.1				2
Tellina	1	0.03	0.1							1
Tellina modesta	3	0.1	0.2	1	0.04	0.0				4
Tellinidae				5	0.2	0.2				5
Veneridae				1	0.04	0.0				1
Total Taxa in Category	14			16			8			
Total Individuals	2871			2302			445			5618
Ave. No./Sampling Event			143.6			82.2			22.3	82.6

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

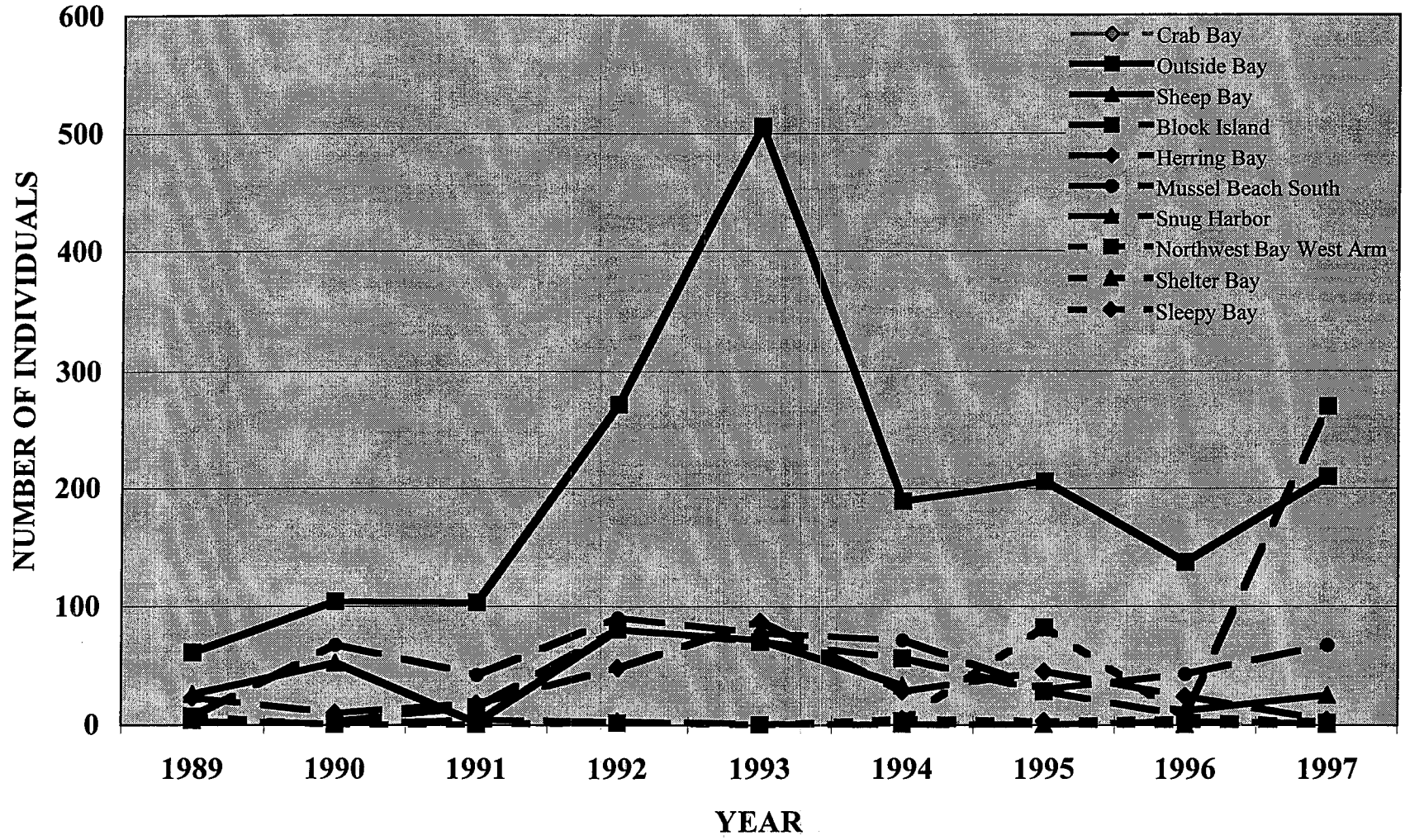


Figure 4

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

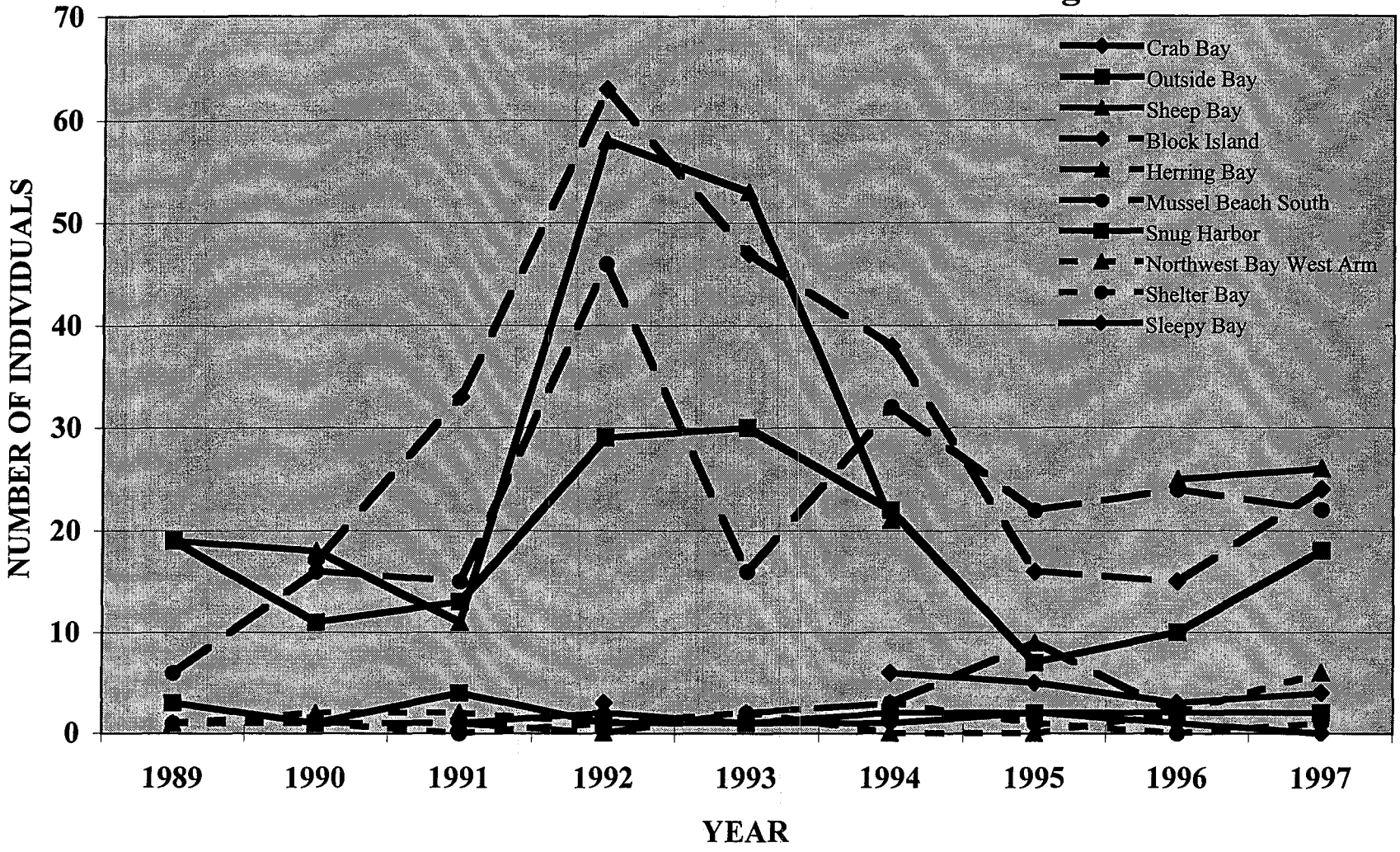


Figure 5

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

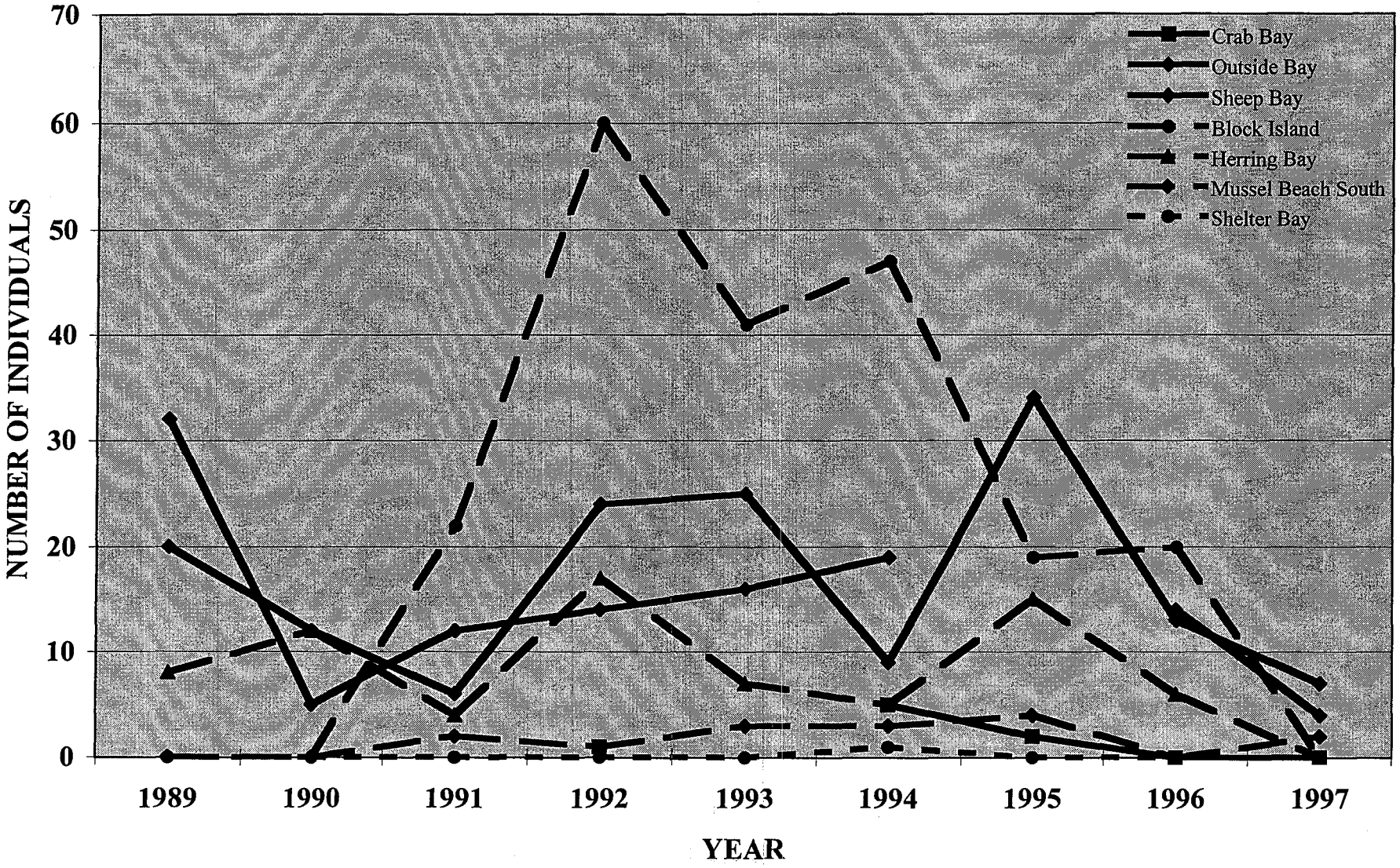
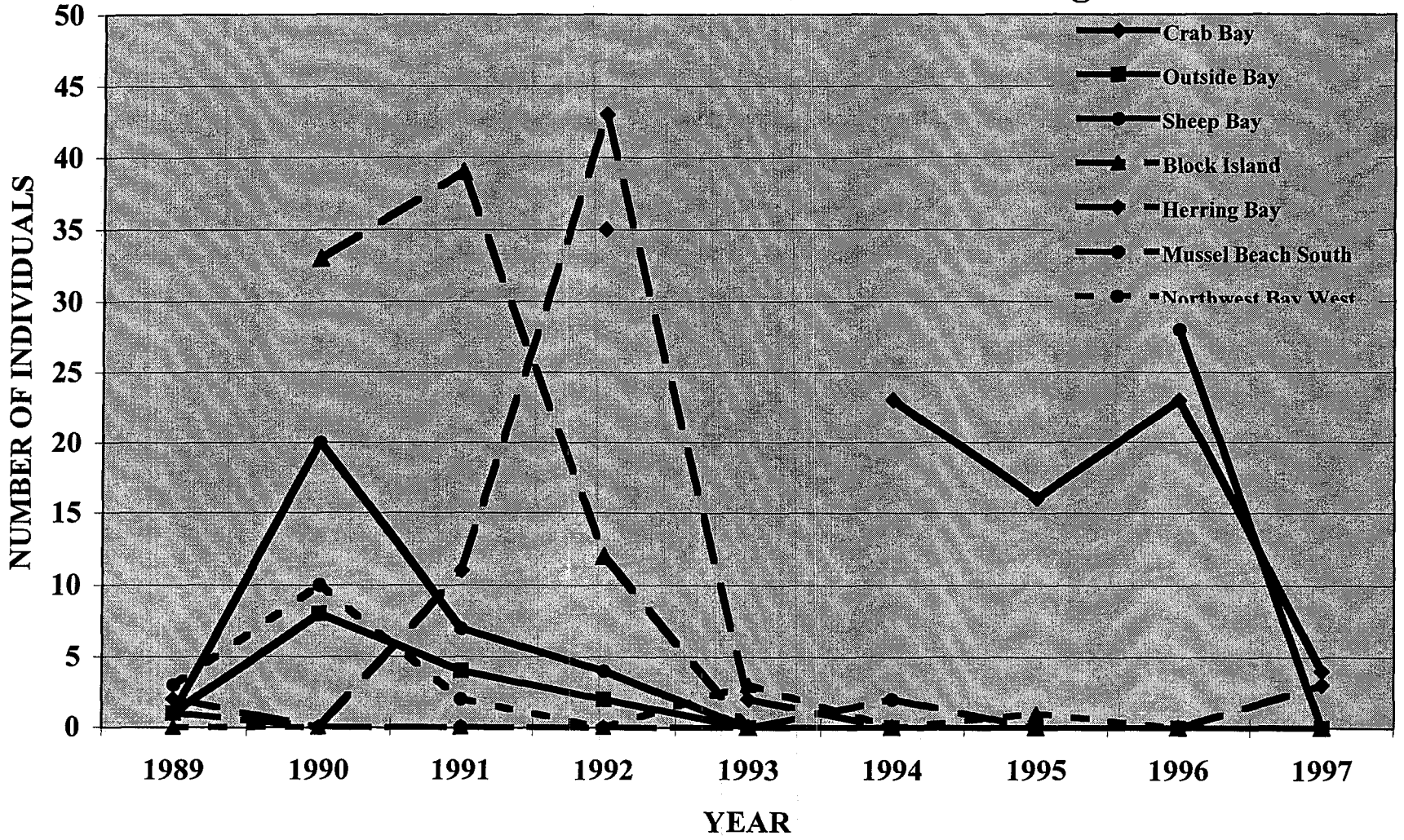


Figure 6
Trends in Numbers of *Macoma balthica* at Variously Treated Sites in Prince William Sound in Years Following EVOS



consistently the dominant species at Category 3 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 Category 3 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 Category 1 and 2 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 Category 1 than at Category 2 (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 Category 3 sites, was an order of magnitude less abundant in this category. The average number of *Mysella* per sampling event in Category 3 was an order of magnitude lower than in Categories 1 and 2 (Table 1). The species was about half as abundant as *Hiatella arctica,* the dominant bivalve in Category 3.

Abundance of *Mysella* did not exhibit strong temporal trends within any of the treatment categories although it did exhibit considerable temporal variation in abundance at some sites (especially Outside Bay and Category 3 sites; Figure 3, Table 2). The species was consistently the dominant bivalve in Category 1. In Category 2, *Mysella* was the second most abundant bivalve in 1989 and 1990 (below *Hiatella*), but was the dominant bivalve in the subsequent six years. In Category 3, *Mysella*, averaging 6.2 individual per sampling event, alternated between dominant (1989 and 1995), common (1992, 1994, 1996) and absent (1990, 1991, 1993; Table 2).

Mysella tumida probably has the potential to live for up to seven years under optimal conditions. Ockelmann and Muus (1978) reported five to seven year longevity for *Mysella bidentata* and Franz (1973) reported longevity of four to five years for *M. planulata*. Such longevity would lead to relative stability in population levels where conditions are favorable. This could explain the difference in the stability in population density observed between Category 1 and 2 (relatively stable), on one hand, and Category 3 (unstable), on the other.

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 Category 1 and 2 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 Category 1, 2, and 3 sites (Figure 4). Although the abundance of *Protothaca* was patchy among Category 1 and 2 sites, it was consistently sparse at Category 3 sites, where density was about one-tenth that of *Hiatella* (Table 1).

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

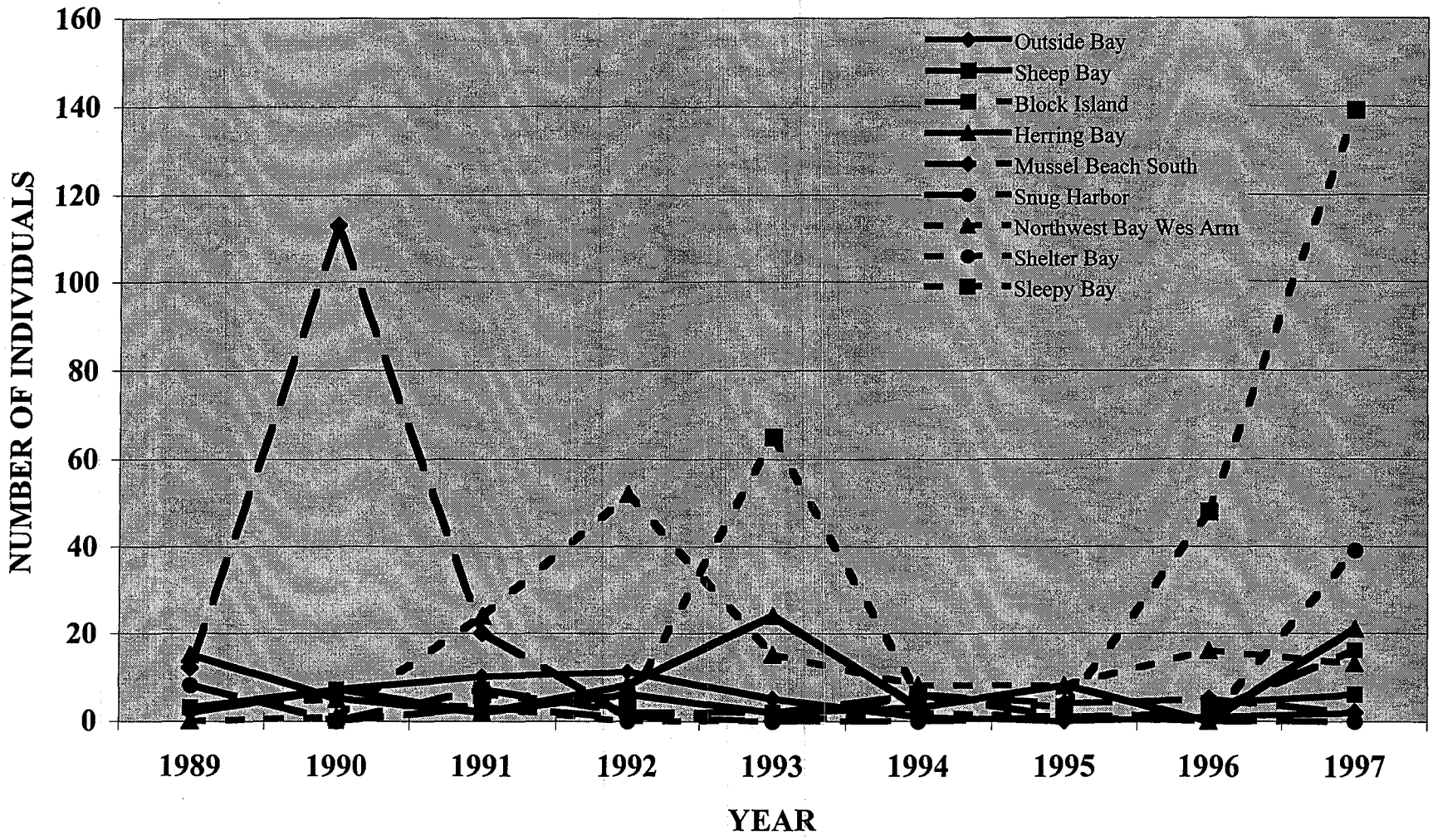


Table 2

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	Average	Std. Error
Category 1										
Hiatella arctica	2.6	5.1	7.7	3.2	1.0	2.2	0.0	4.0	3.2	0.91
Macoma balthica	1.0	10.2	5.6	7.4	0.0	6.2	5.8	17.1	6.7	2.02
Macoma inquinata	26.7	6.2	11.7	7.0	5.7	10.6	13.0	10.7	11.5	2.54
Mysella tumida	44.6	56.9	58.7	63.9	80.4	65.0	75.4	52.0	62.1	4.44
Protothaca staminea	19.5	10.6	12.8	16.2	11.6	14.6	4.3	14.4	13.0	1.69
Saxidomus giganteus	5.1	1.8	1.0	0.7	0.7	1.1	0.4	0.7	1.4	0.59
Total Individuals by Year	195	274	196	554	718	369	276	298		
Ave. No./Sampling Event*	97.5	137.0	65.3	184.7	359.0	92.3	138.0	74.5	143.5	
Category 2										
Hiatella arctica	37.2	39.2	10.4	2.4	6.5	4.7	6.5	4.2	13.9	5.74
Macoma balthica	3.2	11.0	16.2	11.0	0.5	0.6	0.0	0.0	5.3	2.43
Macoma inquinata	8.5	4.0	9.1	15.6	12.7	17.4	18.1	15.8	12.6	1.89
Mysella tumida	35.1	26.9	25.6	44.2	58.6	48.9	47.7	47.3	41.8	4.36
Protothaca staminea	12.8	11.6	17.2	22.0	16.5	23.7	22.7	26.1	19.1	2.01
Saxidomus giganteus	1.1	2.0	2.6	1.4	2.0	0.3	0.9	2.4	1.6	0.30
Total Individuals by Year	94	301	308	500	401	317	216	165		
Ave. No./Sampling Event*	31.3	75.3	77.0	125.0	100.3	79.3	54.0	41.3	72.9	
Category 3										
Hiatella arctica	15.8	31.6	86.8	83.3	89.9	51.6	11.8	79.0	56.2	12.43
Macoma balthica	15.8	52.6	5.3	0.0	3.4	0.0	1.0	0.0	9.8	6.85
Macoma inquinata	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.4	0.43
Mysella tumida	57.9	0.0	0.0	10.6	0.0	29.0	83.3	14.8	24.5	11.68
Protothaca staminea	10.5	15.8	7.9	6.1	5.6	12.9	2.9	3.7	8.2	1.72
Saxidomus giganteus	0.0	0.0	0.0	0.0	1.1	3.2	0.0	0.0	0.5	0.44
Total Individuals by Year	19	19	38	66	89	31	102	81		
Ave. No./Sampling Event*	9.5	9.5	12.7	22.0	29.7	10.3	34.0	27.0	19.3	

* Number includes taxa not included in this summary table

Also, with an average of 1.4 individuals per sampling event, it was about an order of magnitude less abundant in Category 3 than in Categories 1 and 2 (Table 1).

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 Category 1 and 2 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 Category 1 and 2 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 Category 3 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 in Category 1 to 1.0 in Category 3. 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 in Category 3, where it was twice as abundant as *Mysella tumida*, the next most abundant bivalve at Category 3 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 in Category 3, *Hiatella* only dominated the bivalve assemblage in 1991 through 1994 and in 1996. *Mysella* dominated in 1989 and 1995 and *M. balthica* dominated in 1990 (Table 2).

Patterns in Sediment Characteristics

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

Generally, sediments at all sampling sites were relatively coarse and most contained substantial quantities of pebbles. Average median grain size was finest at Category 1 (reference) sites, where PGS averaged 1.9 mm, and coarsest at Category 2, where PGS averaged >5.8 mm. Concentrations of fines in the sediments were generally low, ranging from 21.4 percent at Category 1 sites to 5.0 percent at Category 3 sites (Table 3).

In addition to fine particulates, sediments at Category 1 and Category 2 sites were characterized by higher concentrations of total organic carbon (TOC) and total Kjeldahl nitrogen (TKN) than Category 3 sites (Table 3). Highest concentrations of organics were measured at Category 2 sites and lowest at Category 3 sites. This condition is probably partially as a consequence of whether the specific beaches experienced beach washing. These differences are significant except for the comparison of TOC between the Category 1 and 3 sites, percent fines between the Category 1 and 2 sites, and PGS between Category 1 and 3. The significant differences between Category 1 and 2 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 Category 1 and 2 sites are about 50 percent lower than at Category 3 sites. This indicates that, per unit of carbon, nitrogen concentrations (largely contributed by bacteria on sediment particles) are lower at Category 3 sites than elsewhere. This suggests that nutrient quality is poorer for deposit feeders at Category 3 sites than at Category 1 and 2 sites (e.g., Newell 1965).

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 and 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 and highest at Category 1 and Category 2 sites, respectively, and differed substantially among the three categories. Nevertheless, PAH concentrations in Category 2 (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 and 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 Category 2 and 3 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). Category 1 and 2 sites supported relatively diverse robust populations of both suspension and deposit feeders and borrowing species appeared to thrive. In contrast, the relatively impoverished bivalve assemblages at Category 3 sites were strongly dominated by suspension feeders, especially *Hiatella*, that live 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 in Category 2 than in Category 1.

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
Category 1							
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
Category 2							
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
Category 3							
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

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?
Dominant Feeding Type	Suspension	Suspension	Deposit	Deposit	Suspension
Burrow Depth (cm)	Surficial or nestles in host burrows	5 to 8	5 to 15	1 to 15	Nestles on surface of substrate
Dominance Pattern	Category 1 and 2	Category 1 and 2	Category 1 and 2	Category 1 and 2	Category 3

It is likely that several physicochemical and ecological factors are combining to cause the observed differences in community structure. Physicochemical factors include the possible effects of: 1) reduced fines, 2) nutrient concentrations, and 3) nutrient quality on larval recruitment ,growth and survival of deposit-feeding bivalves at Category 3 sites. Larvae for the species that dominate at the Category 1 and 2 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 Category 3 sites (Figure 7). In contrast, they were commonly observed at most Category 1 and 2 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), sites in Category 1 and 2 are considerably more favorable for deposit feeders than in Category 3.

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 Category 2 and 3 sites, and 4) predation and/or interference exclusion of the other bivalves by *Hiatella* at Category 3 sites. The paucity of potential hosts at Category 3 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 Category 3 sites than at Category 1 or 2 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 Category 2 and 3 sites is a consequence of losses of predators following exposure to crude oil and, at Category 3 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 Category 3 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 Category 2 and 3 sites between 1990 and 1993.

Based on the apparent rates of recruitment in the dominant bivalve species, it is likely that recovery of the bivalve assemblages at the Category 3 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 Category 1 and 2 sites had significantly higher numbers of species and individuals than those at Category 3 sites.

2. Species composition and dominance patterns at Category 1 and 2 sites were very similar but differed markedly from those at Category 3 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 the 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, the 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.

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 unoiled and untreated reference sites throughout the sampling area to the degree possible.

Tides are of the semi-diurnal type with an extreme tidal excursion of about 5.5 m. We propose to sample the beaches between Mean Lower Low Water (MLLW = 0 meter) and 0.7 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 conduct an informal meeting in each location. These meetings will be organized with the assistance of Mr. Hugh Short, the Spill Area-Wide Coordinator for the Trustee Council and Dr. Henry Huntington, the Traditional Ecological Knowledge Specialist for the Council. The meetings will be facilitated by Dr. Huntington. At each meeting, we will make an informal presentation with slides and maps describing the findings of our previous studies, our conclusions, and their implications for recovery and restoration of the affected beaches in the sound. Following the presentation of results, we would describe our plans for this program, i.e., where we are going, and what we are trying to achieve. This presentation would be followed by informal roundtable discussions around maps of the region during which we would seek information on subsistence gathering practices and traditional subsistence sites.

Concerns raised about the pre-spill conditions of treated sites in the Exxon and NOAA beach recovery and treatment effects studies have compromised the significance of the findings related to these sites. We propose to avoid this problem by utilizing the traditional knowledge of the local native groups regarding subsistence beaches. Findings from our previous studies suggest we can safely assume that a functionally diverse infaunal assemblage similar to that which we currently find at our reference sites existed on beaches used for subsistence clamming by the natives. Based on their oiling and treatment histories, we propose to incorporate some of these sites into our sampling design in either the oiled and treated or reference category. Knowledge that these sites were traditionally used for subsistence eliminates the concern about whether or not they were productive prior to exposure to oiling and treatment.

In order to identify historically productive beaches for inclusion in our sampling design, 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. To facilitate this activity, Dr. Huntington will also arrange private meetings with particularly knowledgeable individuals in New Chenega, Tatitlek, Valdez, and Anchorage. Moreover, we propose to attend the restoration conference next year to increase the likelihood of identifying subsistence beaches. This conference will provide a convenient place to meet with elders who are knowledgeable about traditional subsistence patterns and locations and discuss sampling locations over maps.

We propose to hire one or two of the more knowledgeable natives to accompany us during the site reconnaissance. Their role will be to point out specific areas that were used for subsistence harvest of clams. With their help, we will attempt to identify subsistence sites that were either oiled and treated or unoiled. The latter would be considered for use as reference sites. Greatest emphasis will be placed on identifying sites that have been used for subsistence since the 1964 earthquake but selection will not be restricted to such sites. The reconnaissance survey will also allow identification of source sediments for remediation experiments.

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, in terms of the ability of treated beaches to support higher trophic levels or human subsistence foraging and in terms of recovery rates, are momentous. We believe they are significant, and that they need to be addressed to make the sound whole again in less than geologic time.

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 impact. Moreover, it will provide a detailed examination of some of mechanisms that could be driving the observed impact.

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 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.

PROJECT DESIGN

A Objectives

The purposes of this program are to determine if this condition 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 five 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_0 = 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. Species composition of the bivalve fauna is similar at treated and reference sites.

   H_a = Species composition of the bivalve fauna is richer 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, 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, tubicolous or burrowing forms are more abundant at reference sites than at treated sites.

4. H_o = Distribution of organisms at treated sites is uniform from surface to core depth.

   H_a = Distribution of organisms at treated sites is concentrated in surface sediments.

Sediment Characteristics

5. H_o = Sediment characteristics are statistically similar at treated and reference sites. Total Organic Carbon, Total Kjeldahl Nitrogen, Total Phosphorus, and C:N ratios are similar at treated and reference sites.

   H_a = Sediment characteristics are dissimilar at treated and reference sites. Total Organic Carbon is higher at treated than at reference sites. Total Kjeldahl Nitrogen, Total Phosphorus, and C:N ratios are dissimilar at treated and reference sites.

B. Methods

Approaches

The approach we are proposing to address 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 examines species composition and ecological function for the intertidal bivalve assemblage. 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 11 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 pooled 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 with 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 if found between 0 and 0.8 m above MLLW will be considered.

Five sites will be carried over into the sampling design from previous programs due to their historic value. The 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).

In addition, if suitable sites can be identified through discussions with the local native groups, several historic subsistence clamming sites will be introduced because the traditional use of these sites for subsistence indicates that they historically supported considerable bivalve resources. To the degree possible, sites identified by local native groups as having a history of subsistence usage will be incorporated into the appropriate strata. However, we will limit the number that can be added to any cell to half of the available sampling sites in order to preserve a degree of randomness to the allocation procedure. We will also review Technical Report No. 139 (Division of Subsistence) from Alaska Department of Fish and Game, which includes information on harvest areas for Chenega Bay.

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 of finding suitable sites within a cell and the need to have at least three sites to provide reasonable estimate of variability.

---

[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.

Table 5. Allocation of Potential Sampling Sites Among Geographic and Spill Exposure Strata

Strata	Oiled and Treated	Unoiled Reference
Northern Insular	8 Northwest Bay West Arm, Disk Island + 6 random sites	3 Outside Bay + 2 random sites
Northern Mainland	3 random sites	3 random sites
Southern Insular	8 Shelter and Sleepy Bays + 6 random sites	3 random sites
Southern Mainland	3 random sites	3 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

All sites will be visited 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 a list of 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 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 or 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 variable as site selection criteria would bias the results, especially for the reference sites.

Bivalve Sampling

Sample Collection and Handling

Two types of samples will be collected to describe the bivalve assemblages at the sampling sites, 15 cm-deep and 3 cm-deep cores. The primary sample type will be to sample the bivalve assemblage using five replicate cores 10.7-cm in diameter (0.009 m^2) by 15-cm deep. These cores will be collected at randomly selected locations along a 30-m horizontal transect placed at the appropriate elevation at each site.

The 3 cm-deep secondary samples will investigate the vertical distribution of the bivalve organisms. These surficial samples will be collected at only half of the sampling sites and only five replicates will be collected at each site. Each sample will be collected immediately beside one of the primary cores so that the sample types are roughly paired. The purpose of these samples is to provide insight into the vertical distribution of the bivalve organisms at the various sites. The core template be driven 3 cm into the sediments and the sediment contained will be removed and bagged separately in double labeled Ziploc bags.

Each sample will field sieved through a 1.0-mm screen, washed into a double-labeled Ziploc bag, and preserved with buffered 10% formalin-seawater solution. The samples will be stored in water-tight plastic buckets and shipped by surface carrier to the laboratory at the completion of the field work.

Lab Analysis

Following receipt of the samples in the laboratory, they will be washed and preserved in isopropyl alcohol. The samples subsequently will be sorted and bivalves will be identified to the lowest appropriate taxon. The remainder of each sample will be retained intact in case detailed taxonomic identification is determined to be valuable at a later date but detailed taxonomic analysis will not be carried out.

These bivalves will also be measured to provide insight into the size/age structure of the populations living at each site. Length or height measurements will be made with vernier calipers or ocular micrometers, as appropriate.

Sediment Characteristics

Field-preserved whole sediment samples will be collected at all sites. These will be analyzed for particle grain size, total organic carbon (TOC), and total Kjeldahl nitrogen (TKN) to provide information on a suite of pertinent sediment property covariates that appeared important to the development of infaunal assemblages in our previous studies. 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, there will be no measure of within-site variance for the sediment variables but a measure of intra-site variability is not viewed as necessary for the purposes of this study.

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, Total Kjeldahl Nitrogen, and Total Phosphates

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 impacted sites. Where possible, an exact probability and the power of the statistic will be stated. Typically, we prefer to use randomization or permutation statistical methods (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 true 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 the predictability of 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 is collected, to understand the sensitivity of the inferential tests.

First, using as pilot data the latest available set (NOAA, 1996) of infauna data, 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 controls and the washed sites (Category 1 vs. Category 3 sites). The infauna pilot data contains 3 sites (replicate means) in each category, n= 3, 3. The 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 discriminating the controls from impacted sites (Table 6).

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 categories of treatment 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.

Table 6. Power to detect proportional differences in species abundance between Reference and Oiled & 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 & Treated sites. Values with power exceeding 50% and potential indicator species are bold formatted.

	Reference		Oiled & Treated		Proportionate Detectable Effect (percent)				
Taxon	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**100**	**75**	**50**	**25**	**10**
Diplodonta aleutica	0.00	0.00	0.67	1.15	**81**	**60**	35	17	11
Mysella tumida	50.00	75.54	4.00	3.61	**83**	**62**	37	17	11
Macoma spp.	9.00	7.81	0.00	0.00	**100**	**98**	**81**	35	14
Macoma balthica	17.00	14.93	0.00	0.00	**100**	**98**	**81**	35	14
Saxidomus gigantea	0.67	1.15	0.00	0.00	**81**	**60**	35	17	11
Protothaca staminea	12.67	11.24	1.00	1.00	**100**	**100**	**97**	**54**	18
Mya arenaria	1.00	1.00	0.00	0.00	**100**	**97**	**76**	32	14
Hiatella arctica	1.67	2.08	21.33	24.44	**91**	**72**	44	19	11

A problem arises in estimating power for randomization statistics; there are currently no formulas to use for the calculations. Instead, based on the knowledge that a randomization test produces precisely the same result as a comparable parametric test when using 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, the randomization test results under these circumstances 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 & 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 (KS) test or the alternative weighted Anderson-Darling test. Two-way ANOVA's will be used to test for stratified category effects. Multivariate analyses will likely follow the combined NMDS and clustering techniques described in Clarke, 1987.

Sediment Characteristics

Physicochemical sediment characteristics will be tested for category effects using 2-sample t-tests. The data may 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:

- New EVOS Treated and Reference sites
- New EVOS Treated and NOAA Category 3 (oiled & treated sites carried over from previous studies
- Comparison Between Surficial and Whole Bivalve Samples. If there is no significant difference between whole cores and surficial (3 cm) cores at the treated sites, the surficial samples may be considered equivalent replicates of the whole cores in order to increase replication.

Logistics

3. 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. We also expect to accomplish most of the data entry and database development. Since the samples will not be submitted to the various laboratories until July 2001, it is likely that results will not be received until September or October 2001. Consequently, we do not anticipate completion of data entry and database development until November or December 2001.

A. Measurable Project Tasks for FY 01 (October 1, 2000 – September 30, 2001

October 1 – October 15 2000	Arrange and finalize contracts with subcontractors
October 15	Commence sampling site selection process by review of appropriate SCAT and shoreline treatment records
October 15 – 31	Arrange and finalize contract for support vessel logistics
November 1 - 20	**Conduct Community Involvement meetings in New Chenega, Tatitlek, or Valdez, as appropriate**

January 16-26 2001 (2 days)	Attend Annual Restoration Workshop; continue dialog with knowledgeable native regarding location of subsistence clam harvest sites
April 15	Submit annual report (FY 01 findings)
May 1 – 7	Arrange air support logistics
May 15	Finalize list of candidate sampling sites
June 3 – 12	Conduct reconnaissance survey to finalize selection of sampling sites
July 1 - 12	Conduct field sampling survey
July 13	Ship bivalve and sediment samples to respective labs for analysis
September 1 –30	Commence data entry for lab data

B. Project Milestones and Endpoints

Objective 1: Evaluate whether the depressed condition of bivalve assemblages at treated sites observed in our earlier work are general to treated sites throughout western Prince William Sound.

This objective will be addressed starting in July 2001 by collecting bivalve and sediment samples at numerous oiled and treated and unoiled reference sites in western Prince William Sound. Laboratory analysis of those samples will require at least 3 months, following which we evaluate the data to address the questions posed by the objective. Preliminary analyses will be available for inclusion in the annual report for FY 01. Final conclusions will be presented in the annual report for FY 02. We anticipate submitting a manuscript to a peer-reviewed journal describing our findings in late 2002.

Objective 2: Evaluate the role that several sediment characteristics in may play in the apparent depression of bivalve assemblages in treated sediments.

This objective will be addressed starting in July 2001 by collecting samples to evaluate the relationship between sediment samples collected from oiled and treated and unoiled reference sites in western Prince William Sound. Subsequently, we will evaluate these data to address the questions posed by the objective. Preliminary analyses will be available for inclusion in the annual report for FY 00. Final conclusions will be presented in the annual report for FY 01.

C. Completion Date

The work described in this proposal will be completed in the 2nd quarter of FY 2002, in time for presenting final results and conclusions in the annual report describing FY 2001 findings.

PUBLICATIONS AND REPORTS

Recovery of Prince William Sound Intertidal Infauna From *Exxon Valdez* Oiling and Shoreline Treatments, 1989 through 1996; Part 2 - Species Composition. MS. D. C. Lees, W. B. Driskell, J. P. Houghton, and R. H. Gilmour, and A. J. Mearns (NOAA/NOS/ORCA. This research was not funded by the EVOS Trustee Council. This will be submitted to Marine Ecology Progress Series in Fall 2000 and Spill Science & Technology Bulletin.

Annual report to EVOS Trustee Council for project activities in FY 2001 in April 2001.

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

PROFESSIONAL CONFERENCES

None currently scheduled.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We have coordinated with Mr. Hugh Short, and 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 coordinating with Dr. Steven Jewett, Univ. of Alaska, Fairbanks, and Dr. Thomas Dean, Coastal Resources Management, to discuss and share results. Furthermore, we will discuss our findings with Dr. Glenn VanBlaricom in exchange with information from his subtidal programs.

To date, we have made no effort to obtain funds from non-Trustee Council sources for this work.

PROPOSED PRINCIPAL INVESTIGATOR

Dennis C. Lees
Littoral Ecological & Environmental Services
1075 Urania Ave.
(760) 635-7998
(760) 635-7999
dennislees@earthlink.net

PRINCIPAL INVESTIGATOR

Dennis C. Lees

Mr. Lees has participated in major marine environmental studies involving traditional marine ecological assessment of benthic and nearshore fish communities as well as ecological risk assessment and ecotoxicology, sediment and effluent toxicity. He has 30 years of experience in study and evaluation of pristine conditions and development impacts in nearshore and intertidal biological systems ranging from Alaska and California to the tropical Pacific and the Arabian Gulf. He has also been involved in marine studies on Georges Bank, in the southeastern United States, and in the Gulf of Mexico.

Specific experience related to oil spills and hazardous materials 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
- Major programs involving evaluation and remediation of environmental effects of copper and PCB contamination in marine sediments on the biota living in the contaminated areas and mitigation of impacts
- 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. 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. 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 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 24 years, principally in the south-central Alaska and the Puget Sound regions but interrupted by a three-year sojourn in the Middle East. He has been working in Prince William Sound since 1977 and on the *Exxon Valdez* oil spill since March 1989. His expertise 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; bird identification; statistics, data management and computer programming. He is also an experienced SCUBA diver and an aircraft pilot (SEL endorsement).

E. Labs

Bivalve Assemblages – Littoral Ecological & Environmental Services

Sorting, identification, and measurement of the bivalves in the samples obtained in July 2001 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.

LITERATURE CITED

Bernem, K. H. V. 1982. Effect of experimental crude oil contamination on abundance, mortality, and resettlement of representative mud flat organisms in the mesohaline area of the Elbe estuary. Neth. J. Sea Research 16:538-546.

Clarke, K.R., 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18:117-143.

Driskell, W. B., A. K. Fukuyama, J. P. Houghton, D. C. Lees, A. Mearns, and G. Shigenaka. 1996. Recovery of Prince William Sound intertidal infauna from *Exxon Valdez* oiling and shoreline treatments, 1989 through 1992. pp. 362-378. IN: S. D. Rice, R. B. Spies, D. A. Wolfe and B. A. Wright eds., 1991. *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

Edgington, E.S. 1987. Randomization Tests. Statistics: textbooks and monographs, v. 77, 2nd ED. Marcel Dekker, New York, New York.

Franz, D. R. 1973. The ecology and reproduction of a marine bivalve, *Mysella planulata* (Erycinacea). Biol. Bull. Woods Hole 144:93-106.

Gulliksen, B., T. Haug, and K. Sandnes. 1980. Benthic macrofauna on new and old lava grounds at Jan Mayen. Sarsia 65(2):137-148.

Hartman, O. 1965. An Oceanographic and Biological Survey of the southern California Mainland Shelf. For California State Water Quality Control Board. Publ. No. 27.

Houghton, J. P. 1973. Intertidal ecology of Kiket Island, Washington, with emphasis on age and growth of *Protothaca staminea* and *Saxidomus giganteus* (Lamellibranchia: Veneridae). University of Washington, College of Fisheries. Doctoral Thesis.

Houghton, J. P., R. Gilmour, D. C. Lees, W. B. Driskell, and S. C. Lindstrom. 1997. Long-term recovery (1989-1996) of Prince William Sound littoral biota following the *Exxon Valdez* oil spill and subsequent shoreline treatment. For National Oceanic and Atmospheric Administration, Ocean Assessment Division.

Hylleberg, J., and V. F. Gallucci. 1975. Selectivity in feeding by the deposit-feeding bivalve *Macoma nasuta*. Marine Biology 32:167-178.

Lees, D. C., J. P. Houghton, and W. B. Driskell. 1996. Short-term effects of several types of shoreline treatment on rocky intertidal biota in Prince William Sound. pp. 329-348 IN: S. D. Rice, R. B. Spies, D. A. Wolfe and B. A. Wright eds., 1991 *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentration in marine and estuarine sediments. Environ. Mgt. 19(1):81-97.

Lopez, G. R., and J. S. Levinton. 1987. Ecology of deposit-feeding animals in marine sediments. Quart. Rev. of Biology 62(3):235-260.

MacGinitie, G. E. 1955. Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. City of Washington, Smithsonian Institution. 201 pp.

Manly, B.F.J. 1997. Randomization, Bootstrap and Monte Carlo Methods in Biology. 2nd Ed. Chapman and Hall, London, U.K.

McGreer, E. R. 1983. Growth and reproduction of *Macoma balthica* (L.) on a mud flat in the Fraser River estuary, British Columbia. Can. J. Zool. 61:887-894.

Morris, R. H., D. P. Abbott, and E. C. Haderlie. 1980. Intertidal Invertebrates of California. Stanford, CA, Stanford University Press. 690 pp.

Newell, R. C. 1965. The role of detritus in the nutrition of two marine deposit feeders, the prosobranch *Hydrobia ulvae* and the bivalve *Macoma balthica*. Proc. Zool. Soc. Lond. 144:25-45.

Ockelmann, K. W., and K. Muus. 1978. The biology, ecology and behaviour of the bivalve *Mysella bidentata* (Montagu). Ophelia 17(1):1-93.

Pearson, W. H., D. L. Woodruff, P. C. Sugarman, and B. L. Olla. 1981. Effects of oiled sediment on predation on the littleneck clam, *Protothaca staminea*, by the Dungeness crab, *Cancer magister*. Estuarine, Coastal and Shelf Science 13:445-454.

Peterson, C. H. 1979. Predation, competitive exclusion, and diversity in the soft-sediment benthic communities of estuaries and lagoons. pp. 233-264. *IN*: In: Ecological Processes in Coastal and Marine Systems (R.J. Livingston (ed.)). Plenum Publishing Corporation.

Peterson, C. H., and S. V. Andre. 1980. An experimental analysis of interspecific competition among marine filter feeders in a soft-sediment environment. Ecology 61(1):129-139.

Taghon, G. L. 1982. Optimal foraging by deposit-feeding invertebrates: roles of particle size and organic coating. Oecologia 52:295-304.

Thorson, G. 1957. Bottom communities (sublittoral or shallow shelf). Treatise on Marine Ecology and Paleoecology. (J. W. Hedgpeth). Memoir 67. Geological Society of America. Washington, D.C. pp. 461-534.

Thrush, S. F., R. D. Pridmore, J. E. Hewitt, and V. J. Cummings. 1992. Adult infauna as facilitators of colonization on intertidal sandflats. J. Exper. Mar. Biol. Ecol. 159(2):253-265.

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$69.1
Travel		$8.9
Contractual		$49.1
Commodities		$2.5
Equipment		$0.0
Subtotal	$0.0	$129.6
Indirect		$4.6
Project Total	$0.0	$134.2
Full-time Equivalents (FTE)		0.6

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY 2002	Estimated FY 2003		
		$34.3	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments: The Indirect Expense is a 5% handling charge on all Subcontractor, Travel, Contractual, and Commodities expenses.

FY01

Prepared: 4/13/00

Project Number: ~~Not Assigned~~ 01574-BAA
Project Title: Assessment of Recovery and Restoration Needs on Treated Mixed-Soft Beaches
Name: Dennis C. Lees

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2001
	D. Lees	Principal Investigator, Infaunal Analyses	3.0	12.8	0.0	38.4
	W. Driskell	Sampling Design and Statistics	2.1	9.6	0.0	20.2
	Unid. Native Consultants	Identification of Subsistence Sites	0.3	6.7	0.0	2.0
	UAF Field Techs	Sample collection and processing	1.3	6.5	0.0	8.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	6.7	35.6	0.0	
					Personnel Total	$69.1

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2001
	D. Lees, San Diego to Anchorage, Travel to point of departure for field surve	$800	2	18	120.0	3.8
	W. Driskell, Seattle to Anchorage, Travel to point of departure for field survey	$650	2	4	120.0	1.8
	D. Lees, San Diego to Anchorage, Comm. Involve mtng and annual Restorat	$800	2	4	120.0	2.1
	W. Driskell, Seattle to Anchorage, Comm. Involve mtng and annual Restorat	$650	1	2	120.0	0.9
	Auto rental for annual restoration and Community Involvement meetings	$40	8	0	0.0	0.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$8.9

FY01

Project Number: Not Assigned
Project Title: Assessment of Recovery and Restoration Needs on Treated Mixed-Soft Beaches
Name: Dennis C. Lees

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Prepared: 4/13/00

Contractual Costs:	Proposed FY 2001
Description	
Sediment Chemistry Analyses, 33 samples for TOC, TKN	3.8
Sediment Grain Size, 33 samples	2.5
Infaunal Analyses, 235 samples	17.6
Air Charter, 42 hours of air support for reconnaissance	11.6
Vessel Charter, 12 days charter, providing transportation, lodging, and food for field crew	13.5
Air Courier - Report, 5 standard Fed Ex packages	0.1
Contractual Total	$49.1

Commodities Costs:	Proposed FY 2001
Description	
Materials for sample processing onboard support vessel	1.2
Long Distance phone charges	0.4
XEROX	0.2
Film & Processing, 15 rolls of color slides	0.3
Printing	0.4
Commodities Total	$2.5

FY01

Project Number: Not Assigned
Project Title: Assessment of Recovery and Restoration Needs on Treated Mixed-Soft Beaches
Name: Dennis C. Lees

FORM 4B
Contractual & Commodities DETAIL

Prepared: 4/13/00

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2001
			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	

FY01

Prepared: 4/13/00

Project Number: Not Assigned
Project Title: Assessment of Recovery and Restoration Needs on Treated Mixed-Soft Beaches
Name: Dennis C. Lees

FORM 4B
Equipment
DETAIL

OSKAR (Ocean Station, Kodiak Alaska Region): Establisment of a long-term, real-time, moored oceanographic monitoring station in the nearshore region of the Gulf of Alaska.

Project Number:	~~New Project~~ 01577
Restoration Category:	Monitoring and Research
Proposers:	Dr. Bradley G. Stevens, NOAA/NMFS and Dr. Phyllis J. Stabeno, NOAA/PMEL
Lead Trustee Agency:	NOAA
Cooperating Agencies:	NMFS, PMEL
Alaska SeaLife Center:	No
Duration:	1st year, 3 year project.
Cost FY 01:	$136,113
Cost FY 02:	$39,626
Cost FY03:	$40,000
Geographic Area:	Gulf of Alaska, Kodiak Island Region, Chiniak Bay
Injured Resource/Service:	Subtidal communities including Tanner and king crabs, seabirds including: Marbled Murrelet, Common Murre, cormorants, Harlequin Duck, Pigeon Guillemot, Kittlitz's Murrelet. Marine mammals including: harbor seal, Steller sea lion, sea otter, killer whale. Services including: commercial fishing, recreational fishing and tourism, subsistence.

ABSTRACT

The Gulf of Alaska underwent large scale oceanographic changes after 1977, associated with major declines in the abundance of crab, shrimp, small pelagic fish, seabirds and marine mammals, and increases in salmon and groundfish The mechanism of change is poorly understood because long-term, real-time oceanographic data were not systematically collected. Future regime shifts and effects of human impacts cannot be predicted or studied without an understanding of such changes. We propose to address this problem by developing OSKAR: Ocean Station Kodiak Alaska Region, a moored instrument array on the continental shelf in the Gulf of Alaska, to collect long-term oceanographic data, and make it available to scientists via the

internet. OSKAR would eventually become the hub of most future marine research in the GOA.

INTRODUCTION

Research results from EVOS-sponsored studies have shown the Gulf of Alaska underwent a reorganization of the forage and benthic communities following a climatic change in 1977 (Anderson and Piatt, 1999). The mechanism of change is poorly understood although it is clearly related to the increase in temperature observed in the later part of the 1970s. It is important to understand how changes are either related to the mechanism, or are an integral part of the driving force of ecological change. We propose to develop a moored buoy array (OSKAR) for continuous monitoring of the ecosystem. Long-term, real-time data produced by it will help us understand the mechanisms that lead to changes in the composition of forage and benthic communities. This understanding is the key framework from which to judge the adequacy of recovery for injured species

NEED FOR THE PROJECT

A. Statement of Problem

Over the past century, large scale changes have occurred in the climatic, oceanographic, physical and biological characteristics of the North Pacific Ocean (Royer, 1989, Trenberth and Hurrell, 1995; Francis et al., 1998). The most notable change in the Gulf of Alaska occurred in 1977 and resulted in a major increase in temperature, subsequent precipitous declines in abundance of crab, shrimp, and small pelagic fish, and increases in salmon, gadids, and flatfishes (Anderson et al., 1997; Francis et al., 1998). Simultaneous but inverse changes occurred in the California current system along the west coast of the United States. This large scale atmosphere-ocean-ecosystem climate change was seen only in retrospect, and is now called the Pacific Decadal Oscillation (PDO). It is an example of a regime shift, which occurs when a long period of semi-stable ecological conditions (a state) suddenly gives way to a new set of entirely different conditions. Hollowed and Wooster (1992) have characterized these states as Type A (cold) and B (warm); the Type B state is associated with warmer sea surface temperatures, a strong Aleutian low pressure system, enhanced southwesterly winds, and increased advection of water from the North Pacific gyre into the Alaska coastal current. On a smaller scale, the El Nino/ Southern Oscillation (ENSO) occurs at intervals of 3-7 years, and also causes short term (months to years) changes in oceanographic conditions in the North Pacific. Both ENSO and the PDO are small scale manifestations of longer term low frequency oscillations in climatic conditions which have occurred on scales of 60 to 200 years, as evidenced by analysis of fish scales deposited in sediments, and tree rings (Baumgartner et al., 1992).

Major changes in the abundance of seabirds (Piatt and Anderson 1996), plankton (Brodeur et al., 1996), and marine mammals, particularly the now endangered Steller sea lion, over recent decades are also likely linked to either the ENSO or PDO. The most likely mechanism is that intensification of the Aleutian low pressure system lead to increased wind stress in the GOA, which caused a shallowing of the mixed layer depth (bringing phytoplankton closer to the surface light), and subsequent increases in zooplankton abundance and changes in zooplankton species composition (Brodeur et al., 1996; Francis et al., 1998). These conditions are apparently more

favorable for predatory groundfish than for smaller forage fish or decapod crustaceans. Changes in predator/prey abundance resulting from long term ecosystem shifts have been implicated as causes of cascade-like changes in food-web dynamics, such as the increase in predation by Orca on sea otters, and subsequent impacts on sea urchin-kelp predation dynamics (Estes et al., 1998). These ecosystem-wide changes have also led to major economic shifts in the character of coastal communities in Alaska.

A major problem in marine science is that large scale changes like the PDO have never been observed in real time, i.e., as it occurred, and have only been detected by analyzing historical data sets, which are often quite patchy. Real time observation, and prediction of such major ecological changes requires the development of a set of comprehensive leading ecological indicators; at present there is no such data set. Furthermore, most scientists and managers are only concerned about one or a few species and lack a large scale view which incorporates ecosytem wide variability.

Despite the importance of the North Pacific Ocean, and the Gulf of Alaska (GOA) in particular, as a resource for fishing and other marine related activities, there has been no long term collection of oceanographic data in the nearshore coastal region. Without such data, it is impossible to observe oceanographic trends, or to understand how the biology of fishery resources responds to such changes. Year-round temperature data is available from only a few locations, and even now, can only be retrieved once yearly. Given that such regime shifts have occurred every few decades, another shift is inevitable and may already be underway. Without real-time oceanographic data, it is impossible to observe, study or predict the occurrence of the next regime shift. The effects of human induced changes from activities such as commercial fishing and oil spills will not be clear until we can establish the magnitude and form of natural response to climate change and its underlying mechanisms.

The only way to observe oceanographic changes, and study their effects, is to establish oceanographic observatories. These consist of a moored array, essentially a buoy from which is suspended a suite of instruments to measure and record water conditions. All the instruments are proven technology; a large number of similar moorings are present along the equator for monitoring ENSO. The only similar device in the Gulf of Alaska is the C-lab buoy in Prince William Sound, which is not typical of the Kodiak regional environment. Prior to 1998, it was only in use during May-October, and was not functioning during spring plankton blooms, perhaps the most important annual oceanographic event. Due to recent staff turnover at UAF, data has not been posted on the internet since 1998.

We propose to establish such an observatory, called OSKAR, Ocean Station Kodiak Alaska Region. OSKAR is designed to provide real-time data on the oceanographic conditions over the continental shelf near Kodiak. It will be the only data buoy on the West Coast of the US which is placed in a nearshore region of productive fisheries. The Alaska Fisheries Science Center (AFSC) will provide a home for the equipment associated with OSKAR, such as the computers and telecommunications equipment necessary to provide real-time data access via the internet. The name OSKAR also honors the late Oscar Dyson, one of the pioneers of the Kodiak fishing industry.

B. Rationale/Link to Restoration

It is difficult to judge the adequacy of restoration efforts without knowledge of the degree and magnitude of natural change that has occurred due to climate change or other factors. The first step in this process is to understand how the oceanographic climate changes over time. Understanding these changes will help to elucidate the underlying mechanisms that drive biological variation in the GOA ecosystem.

C. Location

Gulf of Alaska, Kodiak Island, Chiniak Bay, and surrounding areas.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Community involvement will play a role in this project. The Kodiak Archipelago Youth Area Watch began in 2000 as a way to involve students, particularly in remote villages, in scientific monitoring of the ocean environment. In association with local area scientists, KAYAW participants are currently collecting information on water temperature, monitoring the plankton bloom with secchi disks, and examining phytoplankton for the presence of toxic species, at 6 locations around the Kodiak Archipelago. They are also collecting information on spawning activity of Pacific sandlance (Ammodytes hexapterus) and capelin (Mallotus villosus) from locations around Kodiak Island, with emphasis on beaches facing Chiniak Bay which are accessible by road for sampling. Both sandlance and capelin were probably impacted by the Exxon Valdez Oil Spill, and are critical components in the pelagic food chain. Information obtained via OSKAR will be shared with KAYAW participants, and used to understand how deep water conditions affect local, inshore, shallow water conditions, and spawning of forage fishes, as determined by KAYAW observations.

PROJECT DESIGN

A. Objectives

1. Build and install OSKAR.

2. Begin collecting and analyzing data.

B. Methods

1. Purpose - The purpose of OSKAR is to provide real-time, long term, in-situ observations of oceanographic conditions over the continental shelf in the region of Kodiak, Alaska. The data will be made available to multiple users in real time to scientists and others around the world by internet access via WWW. Data will be used to observe short and long term changes in oceanographic conditions, to develop leading indicators of such

changes, and to develop biophysical models of large and small scale oceanographic parameters. Data will also be used in local research on reproduction, recruitment and population dynamics of marine species. Examples of such biological research include long-term studies on reproduction and recruitment of Tanner crabs in Chiniak Bay (Stevens et al., 1993, 1994, 1996) population dynamics of nearshore flatfish species, timing of the phytoplankton bloom and linkages with crab and forage fish spawning cycles, changes is abundance of small pelagic fish, seabird and marine mammal studies. None of this can be accomplished without real-time information on oceanographic conditions. Long-term retrospective studies on the biodiversity of the GOA (Anderson et al. 1997) would have been, and continuation of this research will be, much more comprehensive with associated in-situ oceanographic data. Ultimately, the data would be used to create models for improved understanding of recruitment fluctuations in Gulf of Alaska marine organisms.

2. Data Management - Data from OSKAR would be sent via satellite to PMEL in Seattle. There, the data would be examined for integrity, post-processed, calibrated, and stored in a database which could be accessed at any time via the internet. Since NMFS already has the computer and internet infrastructure to handle data acquisition and distribution, this represents a considerable leveraging of assets. PMEL staff would construct, install and maintain the moored arrays, and maintain computer equipment and database integrity.

3. Structure - The station would consist of two moored arrays, anchored to the seabottom in approx 150-200 m of water, with a bouy at the surface (See Fig. 1). See Stabeno et al. (1998) for detailed description of instrumentation.

Array No.1:
A Seacat, containing a flourometer (for proxy determination of Chlorophyll-a), as well as a thermistor and conductivity sensor (for salinity) would be placed at a depth of 10 m. Microcats (for recording temperature and salinity only) would be placed at 10 m intervals from surface to bottom. This array would include a floating instrument platform at the surface, which would measure air and sea surface conditions, and contain instrumentation for power (photocells) and data transmission. Data would be transmitted by satellite to a shoreside computer, where it would be made available on the internet.

Array No. 2:
Array 2 would consist of an acoustic doppler current profiler (ADCP), placed near the seafloor. Data from the ADCP would be routed to Array No. 1 for transmission.

Both moorings would be anchored to the seafloor with retrievable subsurface acoustic links. OSKAR would be deployed from ship by personnel from PMEL (who have successfully deployed similar temporary moorings in depths to 120 m at other locations). OSKAR would be serviced annually, at which time instruments would be calibrated or replaced as necessary.

4. Benefits - Oceanographic data provided by OSKAR will be usable by local and distant

scientists studying the oceanography and marine resources of the Gulf of Alaska, including scientists from the NMFS, ADFG, and UAF, and students in Kodiak High School. Visiting scientists and students will have access to real-time oceanographic data for use in conjunction with field studies, in-situ observations or collections. The data would facilitate new collaborations between personnel of NMFS, UA, ADFG, and other agencies for long-term research. It would allow comparisons of oceanographic events on the outer continental shelf to those observed at other locations, thus fostering larger scale research activities than are currently possible. The data will support complex research activities by multiple investigators concerning long-term, large-scale ecological changes and processes, which are necessary to understand the demographic shifts currently occurring in sensitive populations, such as endangered Steller sea lions in the Gulf of Alaska. OSKAR will become the central hub for a variety of oceanographic and marine research projects which will be connected to it like spokes of a wheel.

5. Placement of OSKAR - Long term studies of Tanner crab mating and aggregation have been conducted at one site in Chiniak bay since 1991. Over 100,000 crabs gather to mate and release larvae at this site annually, and we have been monitoring water conditions there intermittently for several years. In 1999 and again in 2000 we placed temporary subsurface moorings to determine current patterns, temperature and salinity at that location (Fig 2). (Note that these temporary moorings only monitor water conditions at the bottom, and data can only be recovered when the instrument is retrieved in the fall, so they are not an adequate substitute for OSKAR).

   These preliminary observations have produced very interesting results (Fig 3): Current flow is strongly tidal and reverses with every tide change; long term mean flow (30 hr low-pass filtered) is about 3 cm/s to the SE; but in March and April 1999, mean current flow reversed to the NW for a few days following the high spring tide, coincident with the median date of crab hatching, and then during May, it reversed on both spring tides. Thus local oceanographic conditions may have important consequences for benthic fauna. For this reason, Chiniak bay is the first choice for placement of OSKAR. Another equally important reason, is that the site is adjacent to the main ship channel, and the instruments could be easily serviced on a regular basis as research vessels enter or leave the Port of Kodiak.

6. Expansion of OSKAR: We envision OSKAR as the prototype of multiple moorings which should eventually be placed in the GOA and Kodiak region. Following the initial deployment of OSKAR, and establishment of data linkages and distribution, we would build on that infrastructure by establishing additional moored oceanographic instrument arrays in areas of particular interest, perhaps with funding from the GEM program. One such location of high priority is the Alitak Bay region of SW Kodiak Island. Other regions of great interest include Shelikof Strait, the Semidi Islands, and the Barren Islands regions.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

PMEL and NMFS will coordinate mooring deployments, data recovery, and analysis. Salary costs for Dr. Phyllis Stabeno ($16,508) will be contributed as matching funds.

SCHEDULE

A. Measurable Project Tasks for FY 00 (October 1, 1999 - September 30, 2000)

October 2000: Begin purchasing equipment for OSKAR

March 2001: Assemble and deploy OSKAR
Begin collecting, analyzing, distributing data.

B. Project Milestones and Endpoints

Date	Milestone
October 2000	Begin purchasing equipment for OSKAR Assemble buoy arrays
March 2001	Deploy OSKAR; Start accumulating and editing data
April 2001	Begin distributing data and incorporating into ongoing research programs
April 2001- March 2002	Continue data collection, distribution, editing and utilization. Start development of local prediction models.
March 2002	Recover OSKAR. Inspect and replace components as necessary. Do annual maintenance. Redeploy OSKAR.
March-December 2002	Continue data collection, distribution, editing and modeling.

C. Completion Date

Construction and deployment of OSKAR will be completed in March 2001. Therafter, annual operation, maintenance and data processing will continue as long as the scientific community sees a need for the data.

PUBLICATION AND REPORTS

Construction and deployment of OSKAR is not by itself publishable scientific information. The data collected via OSKAR will be published in an annual report. It will also be used by many scientists, and preferably published along with their data.

PROFESSIONAL CONFERENCES

Information about the deployment of OSKAR, and the availability of data from it will be made available at appropriate scientific conferences, such as meetings of the North Pacific Marine Research Organization (aka PICES).

NORMAL AGENCY MANAGEMENT

The funds to conduct this project are not available from NMFS or PMEL Any funds to conduct this project will however be extremely well leveraged since the cooperating agencies will be providing some equipment and expertise that is already in hand to conduct the research and monitoring project proposed.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Data collected by OSKAR will be integrated into already council funded projects such as APEX and GEM. OSKAR will become a focal point for future studies of biological and climate change in the Gulf of Alaska.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

None, new project.

PROPOSED PRINCIPAL INVESTIGATORS

Dr. Brad Stevens, NMFS, Kodiak Fisheries Research Center, Kodiak, AK.
Dr. Phyllis Stabeno, Pacific Marine Environmental Laboratory, Seattle, WA.

PRINCIPAL INVESTIGATORS

Dr. Bradley G. Stevens.

Dr. Stevens will be responsible for coordinating the placement of OSKAR. He will also coordinate local use, distribution and availability of data through the Kodiak Fisheries Research Center. He will be responsible for submission of any project interim or final reports through the end of funding in 2001. He will be one of the principal users of data from OSKAR, and will use the data to develop models of the effects of oceanographic parameters on life history aspects of decapod crustaceans, principally Tanner crabs, *Chionoecetes bairdi.* After installation of OSKAR, the data will become investigator-independent, and will no longer require participation of Dr. Stevens in routine monitoring or distribution.

Dr. Phyllis Stabeno

Dr. Stabeno is a biological oceanographer with the Pacific Marine Environmental Laboraotory (PMEL), of NOAA, in Seattle. She has been a PI on the FOCI (Fisheries Oceanography Coordinated Investigations) project for several years. Her interest is oceanography of the northern Pacific ocean and its relationship to fisheries production (Stabeno et al. 1998). Dr. Stabeno will coordinate reception of data from satellite transmission, editing and verification of data, and make the data available to researchers via the internet. Dr. Stabeno is expected to be one of the principal users of data from OSKAR, for development of biophysical oceanographic models of the GOA.

OTHER KEY PERSONNEL

William J. Parker, Pacific Marine Environmental Laboratory, Seattle, WA.

Mr. Parker works for PMEL, and is primarily responsible for assembling and maintaining oceanographic research equipment, including the components of OSKAR. He will purchase all necessary equipment, assemble the buoy arrays, and coordinate their deployment, recovery, and annual maintenance.

LITERATURE CITED

Anderson, P. J., J. E. Blackburn, and B. A. Johnson. 1997. Declines of forage species in the Gulf of Alaska, 1972-1995, as an indicator of regime shift. Pp 531-543 in Forage fishes in Marine Ecosystems. Alaska Sea Grant Program Report No. 97-01, University of Alaska Fairbanks.

Anderson, P. J., and J. F. Piatt. 1999. *In press.* Community reorganization in the Gulf of Alaska Following Ocean Climate Regime Shift. Marine Ecology Progress Series.

Baumgartner, T. R. et. al. (1992) CalCOFI Report 33: 22-40, as cited in Francis et al., 1998.

Brodeur, R. B. Frost, S. Hare, R. Francis, and W.J. Ingraham, Jr. 1996. Interannual variations in zooplankton biomass in the Gulf of Alaska, and covariation with California current zooplankton biomass. CalCOFI Report, Vol. 37, 1996.

J. A. Estes, M. T. Tinker, T. M. Williams, and D. F. Doak. 1998. Killer Whale Predation on Sea Otters Linking Oceanic and Nearshore Ecosystems. Science 282: 473-476.

Francis, R. C., S. r. Hare, A. B. Hollowed, and W. S. Wooster. 1998. Effects of interdecadal climate variability on the oceanic ecosystems of the NE Pacific. Fish Oceanogr. 7:1-21.

Hollowed, A. B., and W. S. Wooster. 1992. ICES Mar. Sci. Symp. 195:433-444.

Piatt, J.F., and P. Anderson. 1996. Response of common murres to the Exxon Valdez iol spill

and long-term changes in the Gulf of Alaska Marine Ecosystem. In S.D. Rice , R. B. Spies, D. A. Wolfe, and B. A. Wright (eds.), Exxon Valdez Oil Spill Symposium Proceedings. American Fisheries Symposium No. 18: 720-737.

Royer, T. C. 1989. Upper ocean temperature variability in the northeastern Pacific Ocean: Is it an indicator of global warming? J. Geophys. Res. 98:4639-4644.

Stabeno, P. J., J. D. Schumacher, R. F. Davis, and J. M Napp. 1998. Under-ice observations of water column temperature, salinity, and spring phytoplankton dynamics: Eastern Bering Sea shelf. J. Mar. Resd. 56:239-255.

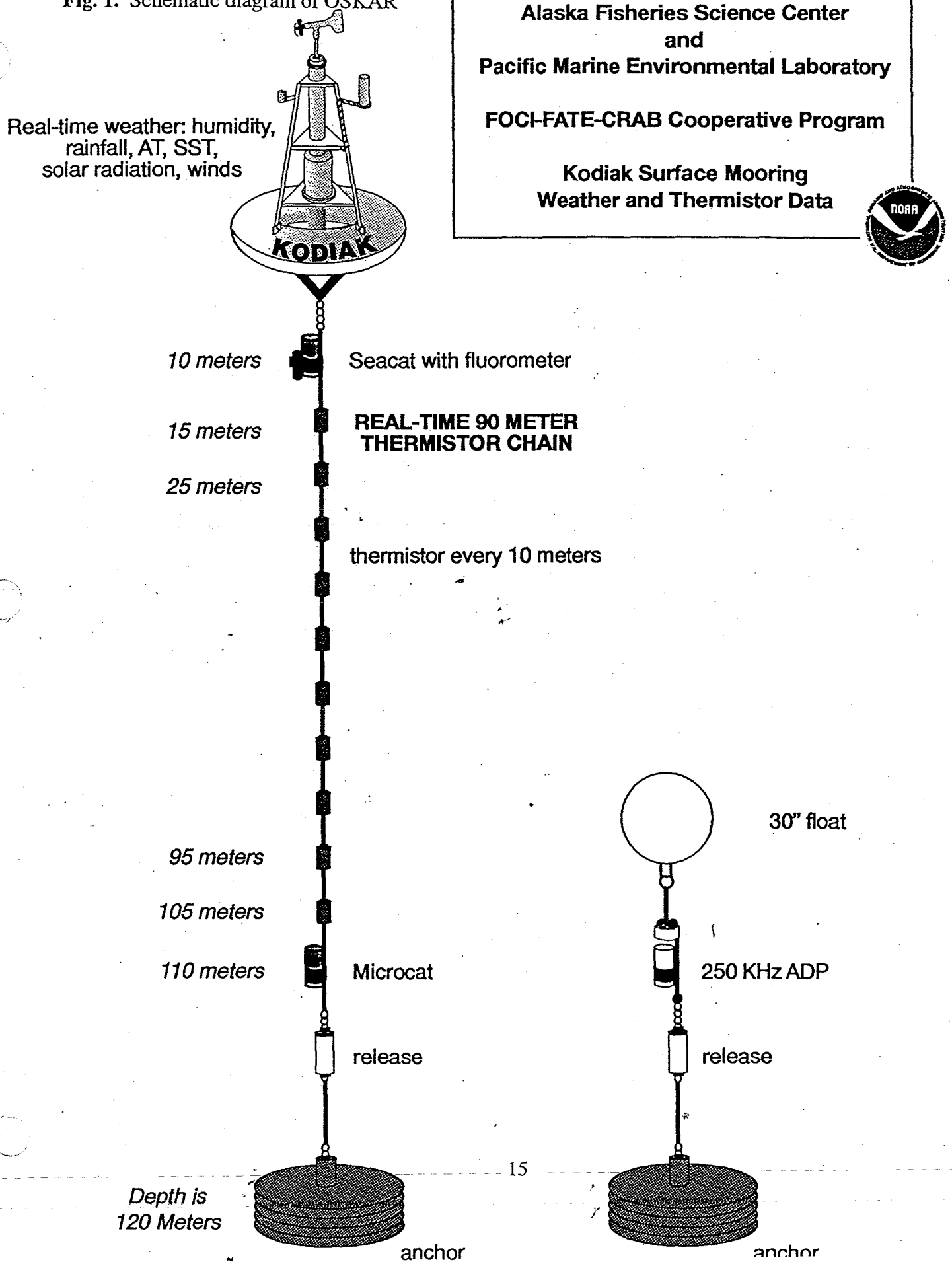
Stevens, B. G., J. Haaga, W. E. Donaldson, and S. A. Payne. 1996. Reproductive conditions of prespawning female Tanner crabs, Chionoecetes bairdi, in Chiniak and Womens Bays, Kodiak, Alaska. Pp 349-354 in High Latitude crabs: Biology, management, and economics. Alaska Sea Grant Program Report No. 96-02, University of Alaska Fairbanks.

Stevens, B. G., J. A. Haaga, and W. E. Donaldson. 1994. Aggregative mating of Tanner crabs Chionoecetes bairdi. Can. J. Fish. Aquat. Sci. 51:1273-1280.

Stevens, B. G., W.E. Donaldson, J. A. Haaga, and J. E. Munk. 1993. Morphometry and maturity of male Tanner crabs, Chionoecetes bairdi, grasping pubescent and multiparous females in shallow and deepwater environments. Can. J. Fisheries and Aquat. Sciences 50:1504-1516.

Trenberth, K. E., and J. W. Hurrell. 1995. Decadal coupled atmosphere-ocean variabtions in the north Pacific Ocean. In R. J. Beamish (ed.) Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121:15-24.

Fig. 1. Schematic diagram of OSKAR



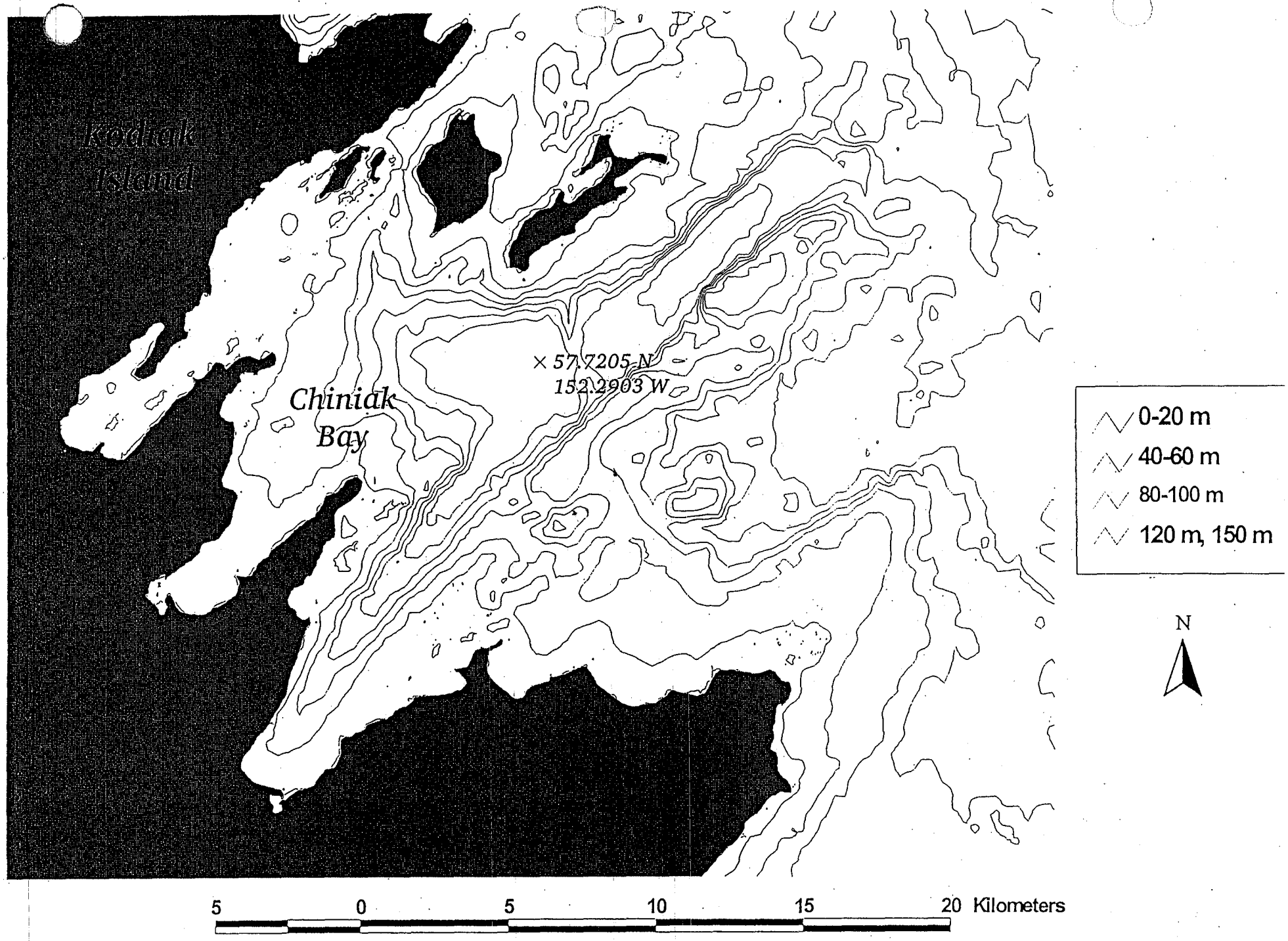


Fig. 2. Location of temporary mooring, and potential site of OSKAR, in Chiniak Bay, Kodiak Alaska.

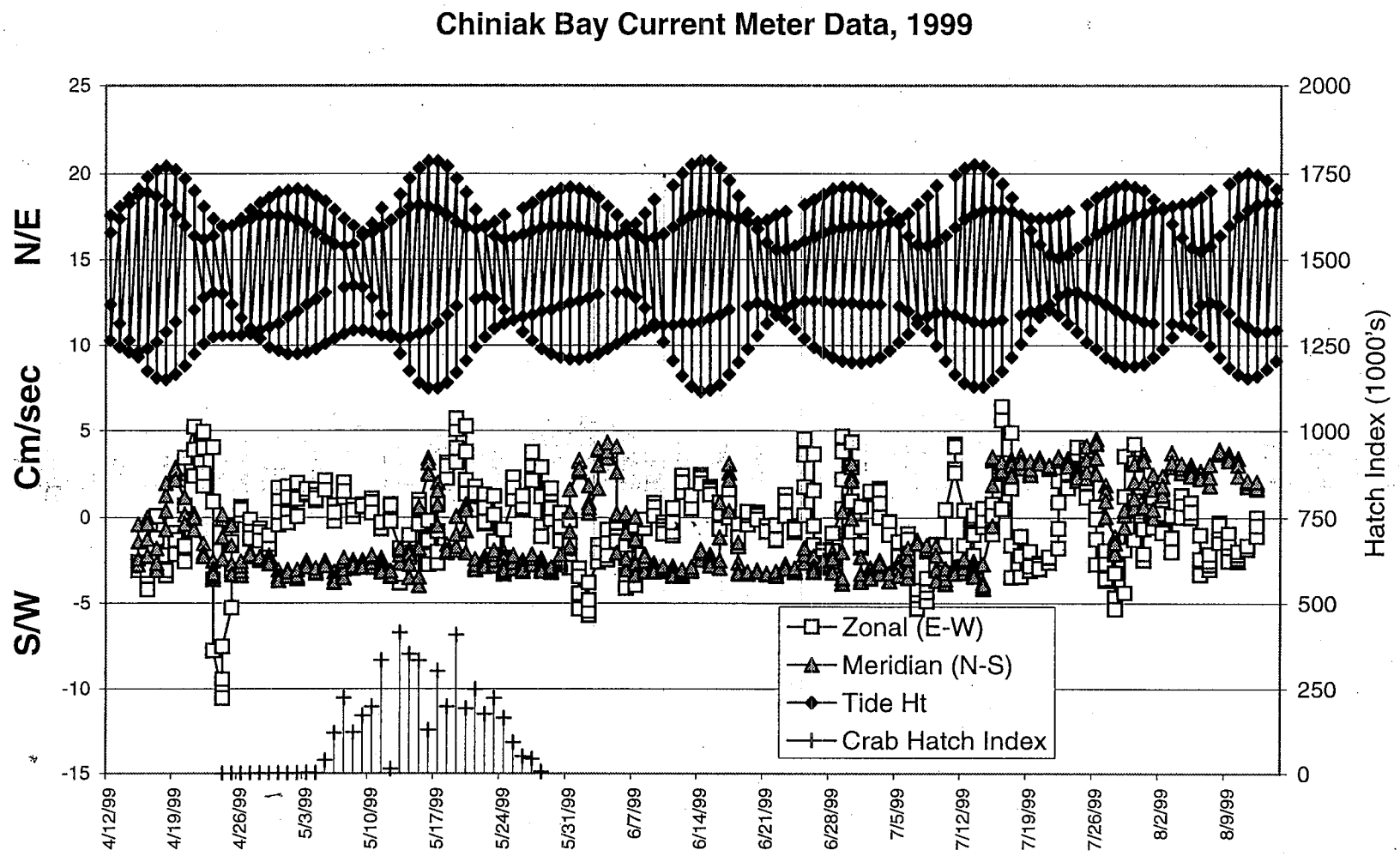


Fig. 3. Chiniak Bay current meter data from 1999 mooring. Top series shows daily tidal heights (from predictions). Middle series shows Zonal (east-west) and Meridional (north-south) vectors of current, after 30-hr low pass filtering. Bottom series shows crab hatching index, from lab studies. Note coincidence of hatching, maximum tide height, and northerly current reversal

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$24,801.0						
Travel		$0.0						
Contractual		$4,000.0						
Commodities		$0.0						
Equipment		$103,500.0						
Subtotal	$0.0	$132,301.0				Estimated FY 2002	Estimated FY2003	
General Administration		$3,812.7						
Project Total	$0.0	$136,113.7				$39,626.0	$40,000.0	
Full-time Equivalents (FTE)		0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources		$16,508.0				$16,508.0	$16,508.0	

Comments:

FY01

Prepared: 4/13/00

Project Number: 01577
Project Title: OSKAR, Moored oceanographic monitoring station
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2001
Name	Position Description					
Dr, Phyllis Stabeno	Co-P.I., Data Analyst, Project supervisor		1.0	0.0		0.0
Mr. Bill Parker	Equipment specialist		1.0	12727.0		12,727.0
TBN	Technician		1.0	12074.0		12,074.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.0	24801.0	0.0	
					Personnel Total	$24,801.0

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2001
Description					
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY01

Prepared: 4/13/00

Project Number:
Project Title: OSKAR, Moored oceanographic monitoring station
Agency: NOAA

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUST COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:		Proposed
Description		FY 2001
Argos Satellite Service Fee		4,000.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$4,000.0
Commodities Costs:		Proposed
Description		FY 2001
	Commodities Total	$0.0

FY01

Project Number:
Project Title: OSKAR, Moored oceanographic monitoring station
Agency: NOAA

FORM 3B
Contractual & Commodities DETAIL

Prepared: 4/13/00

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2001
Weather package			15,000.0
Buoy			11,000.0
Acoustic Doppler current profiler and bracket			30,200.0
Seacat			16,500.0
Microcat			3,900.0
Acoustic Releases			18,000.0
Computer and monitor			5,400.0
Engineering			3,500.0
			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**	$103,500.0

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency
Use existing Thermistor	15	NOAA

FY01

Project Number:
Project Title: OSKAR, Moored oceanographic monitoring station
Agency: NOAA

FORM 3B
Equipment
DETAIL

Prepared: 4/13/00

EXXON VALDEZ Oil Spill Trustee Council

FY 01 Detailed Project Description

Monitoring of Ecosystem Parameters along the Northern Gulf of Alaska

Project Number:	01579
Restoration Category:	Monitoring
Proposer:	ADF&G
Lead Trustee Agency:	ADF&G
Cooperating Agencies:	USGS (BRD)
Alaska SeaLife Center:	No
Duration:	1st year, 3-year project
Cost FY 2001:	$ 91.6 K
Cost FY 2002:	$ 93.2 K
Cost FY 2003:	$ 31.4 K
Geographic Area:	Lower Cook Inlet
Injured Resource/Service:	Forage Species/Commercial Fishing

ABSTRACT

This project will refine long-term monitoring techniques for forage fish populations in Cook Inlet, an area representative of ecosystem conditions and changes in the northern Gulf of Alaska. These measurements will be compared with hydroacoustic and net samples of fish to calibrate seabird performance with fish distribution and abundance, in an effort to determine the extent to which food limits the recovery of seabirds. Fish will be sampled to determine whether competitive and predatory interactions or different responses to the environment may be favoring the abundance of one fish species over another.

INTRODUCTION

The ecosystem structure in the nothern Gulf of Alaska, as indicated by the dominant fish and predator populations, exhibited a significant shift in the late 1970s and early 1980s, likely triggered by a decadal shift in climate (Figure 1; Piatt and Anderson 1996; Bechtol 1997; Anderson et al. 1997). Common murres, black-legged kittiwakes, harbor seals, and Steller sea lions are examples of apex predators, fish eaters at or near the top of the food chain. Abundances of these and other apex populations have declined in the Gulf of Alaska since the 1970s. At the same time, the gulf has undergone a drastic change in the type and abundance of forage species, such as herring, capelin, sand lance, shrimp, pollock and cod. Warming waters likely resulted in a shift from a forage population dominated by shrimp to a population dominated by fish, particularly gadid species such as pollock and cod. Small-mesh trawl surveys, conducted in Kachemak Bay in lower Cook Inlet since 1971, have produced a strong database to document these changes (Figure 1). Coupling trawl survey data with information on apex populations will allow scientists identify ecosystem links with the ultimate goals to improve: (1) monitoring of ecosystem changes; (2) identification of species or resources that are at risk; and (3) management of human use to reduce impacts on species at risk. At least five presentations and manuscripts have already resulted from related projects during FY96-99.

NEED FOR THE PROJECT

A. Statement of Problem

Fish, seabird, and marine mammal resources and services were injured by the 1989 *Exxon Valdez* oil spill. The oil spill also followed, and possibly exacerbated, a massive shift in ecosystem structure, likely related to a shift in climate and water temperatures. Concurrent with these changes, human use of natural resources has intensified in the oil spill area. Over half of the state's permanent residents live within the geographic area of the northern Gulf of Alaska and most of the state's one million tourists visit this region annually. Alaska's private sector economy depends heavily on natural resources in this region, and increasing tourism and recreational use, as well as increased commercial and sport fishing pressure, are all human activities that could affect the marine resources and ecosystem of the northern Gulf of Alaska. Human use demands for natural resources, particularly in the Cook Inlet area, can be expected to continue to increase in the future. In order to manage for optimum patterns and levels of human use, it is important to understand how ecosystem links are restructured following major perturbations, particularly how ecosystem productivity is influenced by natural changes and human activities. Critical to this understanding is long-term monitoring of a wide variety of ecosystem parameters and evaluation links among those parameters.

Standardized small-mesh trawl surveys have been conducted by the Alaska Department of Fish and Game in Kachemak Bay area since 1971. These surveys were conducted from one to three times annually as a means of assessing pink shrimp populations (*Pandalus borealis*). However, the commercial fishery has remained closed since 1986 due to a collapse of the shrimp population, and it cannot be determined when, if ever, this fishery will be reopened. Given the shrimp decline, compounded by a declining department operating budget amid increasing demands for assessment and management of other resources, the Kachemak Bay small-mesh trawl survey was reduced to a

biennial and then a triennial survey frequency. This survey has become a low department priority due to having limited direct utility for species (e.g., Tanner crab) that are actively managed by ADF&G at present. Although ADF&G recognizes the utility of this survey as a tool to monitor general ecosystem health, particularly if links can be established among ecosystem components in ways that allow a priori estimation of ecosystem changes. The department developed standardized techniques for small-mesh trawl surveys to assess pandalid shrimp, but no longer views these survey as a priority agency responsibility. This project is needed to provide the data for long-term monitoring of ecosystem health in the northern Gulf of Alaska.

B. Rationale/Link to Restoration

Seabird, marine mammal, and fish resources throughout the spill area, and particularly in Prince William Sound (Bue et al. 1998) were damaged by the 1989 *Exxon Valdez* oil spill (EVOS) and have not fully recovered (1998 EVOS Trustee Council Status Report). This project has potential for improving long-term monitoring and management of fish and marine mammal resources within the spill area and statewide. Improved resource monitoring will enable more effective evaluation of recovery efforts. It will also facilitate improved in-season management of fisheries, which will help restore injured sport, commercial, and subsistence fishing services.

Location

This project will be conducted in waters of Kachemak Bay in Lower Cook Inlet (Southern Kenai Peninsula). However, project benefits will be realized throughout the spill area along the northern Gulf of Alaska through a greater understanding of ecosystem functions.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Port Graham, Seldovia, and Nanwalek residents have a long history of using these fish resources for commercial and subsistence purposes and are concerned for the area's continuing productivity.

PROJECT DESIGN

A. Objectives

1. FY01/FY02 - Collect data to monitor and detect annual and long-term changes in the marine ecosystem along the northern Gulf of Alaska;

2. FY02 – Explore possible causes of change in the marine ecosystem, including natural variation, human influences, and their interaction, by clarifying links and temporal effects among ecosystem components;

3. FY02 - Improve the capacity to predict the status and trends of natural resources for use by resource managers and consumers; and

4. FY02 - Develop tools, technologies, and information that can help resource managers and regulators improve management of marine resources and address problems that may arise from human activities.

5. FY03 – Project Closeout; Final report writing and dissemination.

B. Methods

The null hypothesis is that fish species composition, abundance, and biomass is consistent among years. Collection and analyses of survey data with small-mesh trawl survey will reveal whether changes have occurred.

Surveys will involve 1-nautical mile tows of a 32-mm (1½") mesh trawl net with a mouth rising 18.3 m and a 17-m tickler chain (Davis 1982; Gustafson 1994). Following each tow, the tared catch weight is obtained, then the catch dumped on deck. After the tared catch weight is obtained, the entire catch will be sorted, counted, and weighed by species or major species group with the total catch subsampled as necessary.

For this analysis, field data sheets will be processed into an electronic database format that is onsistent with ongoing data synthesis projects (Paul Anderson, National Marine Fisheries Service, Kodiak, AK, personal comunication). All catch data will be converted to 1.0 nm equivalents and summarized by tow. General fish catch will be converted to kg/nm and percent catch composition.

Cooperating Agencies, Contracts, and other Agency Assistance

Data from the proposed work will also become an important component of the analyses for work proposed by scientists from the U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge (Proposal Number 01163K - "Using Predatory Fish to Sample Forage Fish"). The small-mesh trawl survey will provide data on the composition of forage species that are available to predatory fish, particularly Pacific halibut. Stomach content analysis can then be used to determine resource selectivity by predatory fish. Principal Investigator will also coordinate activities and results with scientists from Biological Resources Division, U.S. Geological Survey; National Marine Fisheries Service, Alaska Fisheries Science Center; and U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge.

SCHEDULE

Measurable Project Tasks for FY01

October-January:	Purchase field equipment and associated materials; analyses of historical survey data to evaluate survey design and modify as is appropriate.

January-April:	Arrange logistics for field work; trawl net repair and preparation.
May:	Conduct trawl survey in Kachemak Bay.
June-August:	Preliminary analyses of survey data; preparation of preliminary results for initial review.
September:	Additional data analyses and dissemination of results.

Measurable Project Tasks for FY02

October-December	Identify ecosystem links based on current and historical survey data.
November:	Present first year results at AFS meeting.
January-April:	Present results at annual EVOS workshop; turn in EVOS Annual Report, DPD, and budget for FY02 activities; arrange logistics for field work; trawl net repair and preparation.
May:	Conduct trawl survey in Kachemak Bay.
June-August:	Preliminary analyses of FY02 survey data; preparation of results for initial review.
September:	Additional data analyses, report writing, and dissemination of results.

Measurable Project Tasks for FY03

October-December	Identify ecosystem links based on current and historical survey data.
November:	Present second year results at AFS meeting.
January-April:	Present results at annual EVOS workshop; turn in EVOS Final Report; submit results to peer-reviewed journal.

Project Milestones and Endpoints

September 2001	Objective 1-2: Collect survey data and conduct preliminary analyses.
September 2002	Obj. 1-4: Collect additional data; update data analyses.
April 2003	Completion of final report; submit project results to peer-reviewed journal.

Completion Date

All project objectives will have been met by the end of FY02 and the project will close out in FY03.

PUBLICATIONS AND REPORTS

Internal (ADF&G) and external (EVOS Trustee Council, Chief Scientist, etc.) peer review of project documents (DPD, Annual and Final Reports) will occur throughout the project's duration. We will seek to present significant findings at scientific symposia (e.g., American Fisheries Society Meeting) and publish of findings in a peer-reviewed journal (e.g., Transactions of the American Fisheries Society). At least five presentations and manuscripts have already resulted from related projects during FY96-99.

PROFESSIONAL CONFERENCES

Travel funds are requested to attend the EVOS annual workshops in Anchorage. In addition, results will be presented at the annual meeting of the Alaska Chapter of the American Fisheries Society.

NORMAL AGENCY MANAGEMENT

This project coordinates and assists in acquisition of multivariate ecosystem data to aid ADF&G and other agencies with the quantification and analysis of spatio-temporal trends in abundances of forage fishes and invertebrates. These activities are critical to on-going analyses and population assessment modeling for marine birds and mammals and for judging the effects of the EVOS on them. Without support for this project our ability to conduct and support analysis of this unique and standardized 25 year data series will be severely impaired. These analyses are essential for the understanding of how forage fish abundance may have affected the dynamics of marine birds and mammals. It is against this background of ecological change that effects of the EVOS must be objectively considered. This project combines the framework for agencies to cooperate in solving problems together, with each contributing unique and necessary assets to solve these larger problems. Along with monitoring the recovery of injured resources, the proposed project will improve and compliment the department's ability to assess and manage fisheries resources within the spill area and elsewhere in Alaska. Without the Trustee Council's financial support, this project is not likely to receive agency funding in the near future.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This study addresses a number of issues related to other components of a wide variety of ecosystem projects. Direct project coordination with Cook Inlet Seabird and Forage Fish Study, and Ecology and Demographics of Pacific Sandlance (Both projects under direction of Biological Resources Division (BRD) of U.S. Geological Survey (USGS)). Project database component for PWS has been provided to Tracey Gotthardt, a graduate student under Dr. Kathy Frost studying

dietary changes in Harbor seals. In FY98, the project data was provided to Dr. Jennifer Purcell in order to analyze the changes in jellyfish over time.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Does not apply.

PROPOSED PRINCIPAL INVESTIGATOR

William R. Bechtol
Alaska Department of Fish and Game
3298 Douglas Place, Homer, AK 99603
(907) 235-8191
(907) 235-2448
bill_bechtol@fishgame.state.ak.us

PRINCIPAL INVESTIGATOR

William R. Bechtol, Research Project Leader for salmon and herring in Lower Cook Inlet and groundfish and shellfish in Cook Inlet and Prince William Sound for the Alaska Department of Fish and Game, Division of Commercial Fisheries, 3298 Douglas Place, Homer, AK, 99603.
Education: Master of Science, Fisheries, University of Alaska, 1990. Bachelor of Science, Wildlife Science, University of Washington, 1979.
Professional Experience: 1996-present: ADF&G, Commercial Fisheries, Research Project Leader, 1995-present: Primary responsibilities include assessment and research of commercial groundfish and shellfish in Cook Inlet, Prince William Sound, and state waters of the Central Gulf of Alaska, and salmon and herring in lower Cook Inlet; design and implement surveys to assess crabs, groundfish, scallops, and clams using trawl, longline, dredge, acoustic, and shovel gears, coordination of onboard observer and port sampling programs; development of age-structured models; development of fisheries regulations and management plans.
1989-1995: Regional Groundfish Biologist, ADF&G, Commercial Fisheries, Homer, Alaska. Responsibilities include research and management of commercial groundfish fisheries in Cook Inlet, Prince William Sound, and state waters of the Central Gulf of Alaska; design and implementation of port, trawl survey, and onboard observer sampling programs; herring egg deposition surveys in Prince William Sound using SCUBA; SCUBA surveys of log transfer facilities; development of fisheries regulations and management plans; (1984-1984) principally involved in design and implementation of jig, line transect, and mark-recapture surveys, including use of SCUBA, to assess pelagic and demersal rockfish resources along the outer Kenai Peninsula.

1980-1989: Fisheries Technician, ADF&G, Fisheries Rehabilitation Enhancement and Development (FRED) Div., Primary responsibilities included design and implementation of limnology surveys, particularly concerning juvenile sockeye rearing in barrier lake systems of

lower Cook Inlet and the outer Kenai Peninsula; mark-recapture surveys to assess survival from different juvenile salmon rearing strategies; and aerial surveys to assess salmon escapements.

Fisheries Research Institute, 1979: Field technician in studies of side-scanning and upward-scanning hydroacoustic estimation of sockeye salmon escapement to the Kvichak River, Alaska. American Fisheries Society, Alaska Chapter, Executive Committee, 1990-1992 and 1998-present; currently Alaska Chapter president.

Selected Publications:

North Pacific Fisheries Management Council. *Draft for Council Review.* Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis for Plan Amendment #60 to the Fishery Management Plan for the groundfish fishery of the Gulf of Alaska to prohibit non-pelagic trawl gear in Cook Inlet. Prepared by: J. DiCosimo, **B. Bechtol**, and L. Brannian. NPFMC, 605 W. Fourth Ave., Suite 306, Anchorage, AK 99501.

Bechtol, W.R. 2000. A bottom trawl survey for crabs and groundfish in the Southern, Kamishak, and Barren Islands Districts of the Cook Inlet Management Area, 8-12 June and 26 June – 1 July 1997. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 2A00-21, Anchorage, 50 p.

Trowbridge, C., N. Szarzi, and **W.R. Bechtol**. 2000. Review of commercial, sport, and personal use fisheries for miscellaneous shellfish in Lower Cook Inlet: Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A00-13, Anchorage, 39 p.

Bechtol, W.R. 2000. Preliminary evaluation of multiple data sources in an age-structured model for weathervane scallops in Kamishak Bay, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A00-03, Anchorage, 23 p.

Bechtol, W.R. 2000. Rockfish assessment in Prince William Sound, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-34, Anchorage, 36 p.

Bechtol, W.R. 1999. Prince William Sound walleye pollock: current assessment and 2000 management recommendations. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-33, Anchorage, 29 p.

Bechtol, W.R., and C.E. Trowbridge. 1999. Tanner and king crabs in the Cook Inlet Management Area: stock status and harvest strategies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-15, Anchorage, 35 p.

Otis, E.O., **W.R. Bechtol,** and W.A. Bucher. 1998. Coping with a challenging stock assessment situation: the Kamishak Bay sac-roe herring fishery. In: F. Funk, T.J. Quinn II, J. Heifetz, J.N. Ianelli, J.E. Powers, J.F. Schweigert, P.J. Sullivan, and C.-I. Zhang [eds]. Fishery stock assessment models. Alaska Sea Grant Report Report No. AK-SG-98-01, University of Alaska, Fairbanks, 1998.

Bechtol, W.R., and R.L. Gustafson. 1998. Abundance, recruitment, and mortality of Pacific littleneck clams *Protothaca staminea* at Chugachik Island, Alaska. Journal of Shellfish Research 17(4):1003-1008.

OTHER KEY PERSONNEL

John F. Piatt, PhD., Research Biologist (GS-13)

Biological Resources Division, U.S. Geological Survey
1011 E. Tudor Rd., Anchorage, AK 99503
john_piatt@nbs.gov

Paul J. Anderson, Fisheries Biologist (Research GS-12)
National Marine Fisheries Service, Alaska Fisheries Science Center
P.O. Box 1638, Kodiak, Alaska 99615
paul.j.anderson@noaa.gov

LITERATURE CITED

Anderson, P.J., J.E. Blackburn, and B.A. Johnson. 1997. Declines of forage species in the Gulf of Alaska, 1972-1995, as an indicator of regime shift. Pages 531-543 *in* Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report 97-01, University of Alaska, Fairbanks.

Bechtol, W.R. 1997. Changes in forage fish populations in Kachemak Bay, Alaska, 1976-1995. Pages 441-455 *in* Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report 97-01, University of Alaska, Fairbanks.

Bue, B. G., S. Sharr, and J.E. Seeb. 1998. Evidence of damage to pink salmon populations inhabiting Prince William Sound, Alaska, two generations after the *Exxon Valdez* oil spill. Transactions of the American Fisheries Society 127:35-43.

Davis, A.S. 1982. The commercial otter trawl shrimp fishery of Cook Inlet. Alaska Department of Fish and Game, Informational Leaflet No. 205, Juneau.

Gustafson, R. 1994. Trawl shrimp index fishing in the Southern District of the Cook Inlet Management Area, spring 1992 and 1993. Alaska Department of Fish and Game, Regional Information Report No. 2A94-23, Anchorage.

Piatt, J.F., and P. Anderson. 1996. Response of common murres to the *Exxon Valdez* oil spill and long-term changes in the Gulf of Alaska marine ecosystem. Pages 720-737 In: S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright [eds.], *Exxon Valdez* Oil Spill Symposium Proceedings, American Fisheries Society Symposium 18.

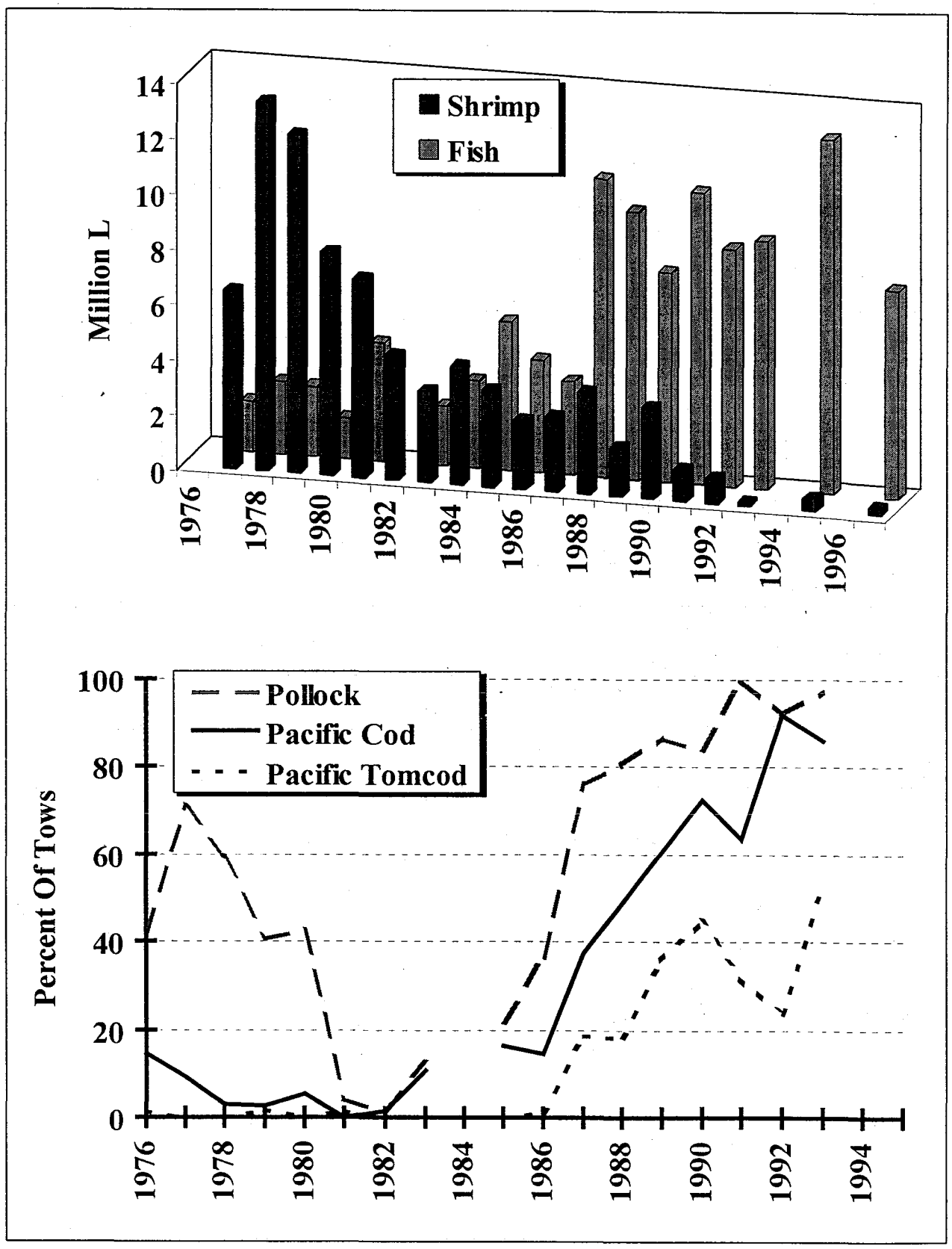


Figure 1. Changes in relative catch composition of shrimp and fish and in frequency of occurrence of gadid species in a small-mesh trawl survey, Kachemak Bay, 1976-1997.

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001
Personnel		$63.8
Travel		$2.2
Contractual		$14.0
Commodities		$1.0
Equipment		$0.0
Subtotal	$0.0	$81.0
General Administration		$10.6
Project Total	$0.0	$91.6
Full-time Equivalents (FTE)		1.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS	
Estimated FY 2002	Estimated FY 2003
$93.2	$31.4

Dollar amounts are shown in thousands of dollars.

Comments:

FY01

Prepared:

Project Number: 01579
Project Title: Monitoring of Ecosystem Parameters along the Northern Gulf of Alaska
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2001
Bechtol	Project Supervision	18 E	2.0	5.5	0.0	11.0
FB II - Vacant	Principal Investigator	16 B	12.0	4.4	0.0	52.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		14.0	9.9	0.0	
					Personnel Total	$63.8

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
EVOS Meeting	0.2	2	4	0.1	0.8
					0.0
Professional Meeting - Results Dissemination	0.3	2	8	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$2.2

FY01

Prepared:

Project Number: 01579
Project Title: Monitoring of Ecosystem Parameters along the Northern Gulf of Alaska
Agency: Alaska Department of Fish and Game

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2001
Vessel Charter - 7 d @ 1.5 K/d	10.5
Net Repair & Transport	3.5
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$14.0

Commodities Costs:	Proposed
Description	FY 2001
CLOTHING/PERSONAL PROTECTION GEAR	0.3
OFFICE SUPPLIES	0.2
SCIENTIFIC SUPPLIES	0.5
Commodities Total	$1.0

FY01

Prepared:

Project Number: 01579
Project Title: Monitoring of Ecosystem Parameters along the Northern Gulf of Alaska
Agency: Alaska Department of Fish and Game

FORM 3B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			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
High-rise Shrimp Trawl	4	ADF&G

FY01

Project Number: 01579
Project Title: Monitoring of Ecosystem Parameters along the Northern Gulf of Alaska
Agency: Alaska Department of Fish and Game

FORM 3B
Equipment
DETAIL

Prepared:

Revision and Publication of Pre- and Post-Spill Data on Health, Development, and Survival of Sea Otter Pups and Weanlings After the *Exxon Valdez* Oil Spill; Submitted Under the BAA No. 52ABNF000039

Project Number: 01581-BAA

Restoration Category: Research and Monitoring

Proposer: Lisa M. Rotterman, Ph.D.,
Enhydra Research

Lead Trustee Agency:

Cooperating Agencies:

Alaska SeaLife Center:

Duration: FY 01, 1-year project

Cost FY 01: $5.5

Cost FY 02:

Cost FY 03:

Geographic Area: No Fieldwork

Injured Resource/Service: Sea Otters and the Nearshore Ecological Community

ABSTRACT

Final revision and publication of a manuscript containing pre- and post-spill data on the health and survival of sea otter pups and weanlings will be undertaken so as to: a) understand EVOS damage to marine mammals and related natural communities; b) evaluate sea otter population processes affecting recovery; c) evaluate future response and restoration strategies; and d) generate benchmarks of sea otter population status.

INTRODUCTION

Sea otters were severely impacted by the T/V *Exxon Valdez* oil spill (EVOS) and could not yet have recovered fully from the impacts of the spill. Their current status relative to recovery is unclear. This project would:

1) Result in significant advances in the level and availability of knowledge concerning persistent impacts of the EVOS on the health and survival of pup and weanling sea otters.

No new field work or data acquisition is proposed in this project. The investigator proposes to:

a) undertake needed revisions in graphics, and text needed to permit publication of a paper on the health and survival of pup and weanling sea otters following the EVOS in the general scientific literature.

b) make minor undertake minor revisions to data analyses to permit publication of a paper on the health and survival of pup and weanling sea otters following the EVOS in the general scientific literature

c) make the detailed information on EVOS impacts on sea otter pups and weanlings available to all interested persons through publishing in the general scientific literature.

This paper, which has already undergone two thorough reviews, provides information on new and previously unexplored aspects of the effects of the EVOS on sea otters, contains new and expanded analyses of the post-spill data, and contains analysis and integration of multi-year pre-spill data. Thus, publication of this paper will result in a greatly improved and more complete understanding of the spill's impacts on sea otters and the factors impacting recovery. It contains information crucial to understanding the process of recovery of the nearshore ecological community, to evaluating alternative response and restoration strategies, and to evaluating monitoring and damage assessment study methodology. Culmination of the project will be the preparation of manuscripts, and the publication in the primary scientific literature of 5 papers, containing many new, and all previously unpublished, data and findings.

Pre-spill and post-spill data are from the investigators' studies between May 1984 and Nov. 30, 1991 in both Eastern Prince William Sound (EPWS) and western Prince William Sound (WPWS).

A. Relevant Background

Dr. L. Rotterman, who will undertake this project, began studies of sea otter development, reproduction, survival, population structure, behavior, growth, body condition, and movements in 1984. Working in collaboration with Dr. C. Monnett, she and Dr. Monnett pioneered large scale studies, including radio-telemetry studies and growth studies, of sea otter pups and weanlings, conducting studies in both eastern and western PWS. In 1987, they initiated a comprehensive study of adult female reproduction, survival, body condition and movements. When the spill occurred, they were halfway through a study of 59 radio-instrumented sea otter females.

The proposers were the Principal Investigators on key sea otter damage assessment studies. Between 1989 and Nov. 30, 1991, they conducted year-round intensive field studies, including studies of: 1) female reproduction, health, and survival (PI: C.M.); 2) post-weaning survival (PI:

L.M.R.); 3) movement patterns (PI: C.M.); 4) determination of the fate of sea otters released from EVOS treatment centers (PI: C.M.); 5) blood chemistry and hematology of adult females and weanlings (PI: L.M.R.); and 6) pre- and post-spill aerial (and to a lesser extent, boat) marine mammal surveys in Prince William Sound (using funding from the Mineral's Management Service).

These post-spill studies, which were unprecedented in both scope and content, were highly successful resulting in the acquisition of key information on the spill's impacts on sea otters. Dr. Monnett and Dr. Rotterman captured hundreds of sea otters, radio-instrumented 100 adult females and 64 pups, monitored 45 radio-instrumented otters from the treatment centers, and collected samples and carcasses for studies of toxicology, pathology, and clinical blood studies.

A key finding from their post-spill studies was that the post-weaning survival of sea otters born into the spill area more than a year after the spill was very poor, and was significantly lower than their concurrent counterparts in the unoiled eastern Sound. This finding remains, to date, the most definitive evidence of persistent damage to sea otters from EVOS (see below for further discussion).

Additionally, they demonstrated that female reproductive and survival rates were normal in the spill region in 1990 and 1991, but that adult females in the spill region may have higher rates of liver dysfunction compared with their counterparts in the eastern sound.

Their study of treatment center otters showed that survival and pupping rates of the animals released from the treatment centers was very low and was followed by an increase in mortality in the recipient population.

Their study of movements confirmed that significant interchange was not occurring among oiled (in WPWS) and unoiled (in EPWS) sea otter study populations, a finding crucial to evaluation of all post-spill studies. These movement studies also produced data that provides insight into the recovery process by showing that sea otters from EPWS were not emigrating to the west, and thus, would not be affecting recovery rates.

All funding for these studies, including all professional and technician salaries, ended without notice on Nov. 30, 1991, when invoices for payment were returned. After several months, and the loss of experienced support staff, 3.5 months of salary were provided to cover:

1) preparation of 5 draft and final reports summarizing over two and a half years of continuous, year-round field work; and

2) all activities necessary to end this massive study (e.g., inventory and clearing of warehouses and offices, relocation of staff, etc.).

No significant closeout funding was provided between 1993-1995 for any of the investigator's spill studies as it was for all other comparable studies and only 3.5 months of salary was provided in 1992 (see below). The 3.5 months of salary was insufficient to permit full analysis of all post-spill data, to permit analyses or integration of pre-spill data, and, thus, to develop manuscripts for publication.

Despite the short time frame allotted for report preparation, the proposers reported the basic results, addressing all contracted objectives from these studies, in final unpublished reports in

1992. The aforementioned reports were accepted by the contracting agency as final reports with only minor modification being requested and made. These reports, **unchanged in content from the versions submitted in 1992,** were finally submitted by the U.S. Fish And Wildlife Service to the Trustee Council as final reports in 1995. This delay, which was not linked in any way to the investigators, resulted in the erroneous, and previously stated, notion that the investigators had previously had significant delays in producing final reports on their work. This erroneous notion underlay the Trustee Council decision to insist that further funding for the investigators could not be provided during manuscript preparation, only after final approval on finished products. (See below).

However, the stated objectives of the NRDA reports were very simple (e.g., did survival rates of weanlings in unoiled versus oiled habitat differ?).

The population studies were highly praised by key sea otter peer reviewers advising the Chief Scientist. One investigator wrote something to the extent that before the successful completion of these studies, no one would have thought them possible.

Funding for 2 months of work for production of this paper was authorized previously by the Trustee council. This level of funding corresponded to a level meant only to prepare papers for publication from final reports. In this case, however, significant data preparation, data integration, data analyses, and literature review were required in addition to the typical manuscript preparation and manuscript revisions. Additionally, having been given the erroneous impression that the investigators had had significant delays previously in producing final reports on their work, the Trustee Council insisted that the investigators only be paid when products were finished, rather than the usual process in which salary is provided to afford the investigators the opportunity to undertake the needed work. This policy, when coupled with huge delays (many months) in funding availability, delays in review by the Trustee Council, and related delays of payment for products made it impossible for the investigator to work continuously on this paper and related papers, as originally planned. Half of the authorized amount ($5,000 was provided after submission of the first draft of the paper in 1998 to the contracting agency. After explaining the problems with the situation to agency contracting contacts (i.e., that it was very difficult to survive not knowing when payment might occur) and ensuring that delays in final product completion were acceptable, the investigator accepted other, immediate paying forms of employment, delaying completion of this product. However, without warning or notice, the funding previously authorized for completion of this work was withdrawn sometime in 1999. Unaware of this change, I worked many hours on revisions to manuscript data analyses and text suggested after Trustee Council review, and general peer review of previous drafts of the manuscript. This work was undertaken in good faith, with the previously agreed upon assumption that I would receive compensation when the paper was finalized for publication.

Thus, funding is now requested to permit completion of revision necessary for publication.

B. Work Undertaken With Previous Funding

In August of 1996, funding was approved by the Trustee Council to permit one member of the collaborative team to spend 1.5 months on each of 4 papers to undertake analyses and writing

necessary to produce papers for the scientific literature based on the investigator's previous work.

A contract to L.M. Rotterman for $40,200 for this project was approved and activated on February 1, 1997. To date, the investigator has made the following progress towards completion of the goals of the FY 1997 project: 1) completion of a manuscript entitled "Health, development, and survival of sea otter pups and weanlings" (referred to hereafter as the "pup-weanling" paper), revision of this manuscript after Trustee Council review, submission for general peer review; 2) completion of a manuscript entitled "Length-mass relationships in sea otters in Prince William Sound after the T/V Exxon Valdez oil spill, submitted and under revision in the general scientific literature. 3) Significant progress has been made on data analyses and writing related to paper "Survival and reproduction of female sea otters in Prince William Sound, AK after the T/V Exxon Valdez oil spill, a paper targeted for Marine Mammal Science.

Please note that the full funding amount associated with manuscript production was only received after completion of the "Length-mass" paper. Only half of the authorized funding was received for the pup-weanling manuscript. No funding was received for work on the adult female survival and reproduction paper or for work towards any other manuscripts.

In addition to the pup-weanling and length-mass papers, the authors of these papers currently have 2 other, (non-Trustee funding-related) sea otter papers and one paper on avian ecology submitted or in revision following favorable scientific peer review for publication in the general scientific literature.

Extensive new data and analyses are presented in the pup/weanling paper and the length/mass papers referred to above. Actual time devoted to completion was well in excess of that for which funding was requested or provided, as anticipated both by the investigators and by peer reviewers.

In the pup/weanling paper, data from multiple independent pre- and post-spill studies of hundreds of radioinstrumented females and their pups, of radio-instrumented pups and weanlings, and of tagged pups are analyzed and integrated. Data on birth timing, body condition, health, dependency periods, survival, and other indices are all presented. In the corresponding report, the only objective was to determine whether the survival of weanlings in the eastern sound differed from that observed in the western sound.

A brief summary of important new data and findings resulting from these efforts, which involved: extensive new data preparation, summarization and analysis; integration of pre- and post-spill data bases; integration of data from independent post-spill studies; and literature review; and manuscript preparation, are given briefly below:

The purpose of the pup/weanling paper was to compare and to discuss measures of, and factors related to, the survival, development, and health of young sea otters through the period of dependency and after permanent separation from their mothers, and in so doing, to gain information necessary to determine whether there were chronic impacts of the 1989 T/V EXXON VALDEZ oil spill (EVOS) on the local populations of sea otters. The individuals

studied were born in Prince William Sound, on average, more than a year after the T/V Exxon Valdez discharged oil into the sound and were not even conceived when the spill occurred.

Findings presented in the paper confirm and strengthen the result presented in the final report (prepared in 1992) that post-weaning mortality was significantly and unusually low, compared to both pre-spill and post-spill studies. Proportions of individuals surviving after weaning in WPWS after EVOS were significantly lower in 1990 than in each of 3 separate studies in EPWS, one conducted concurrently and 2 conducted before EVOS.

Data on the survival of pups and weanlings were integrated in this paper and show that very few of the pups born in 1990 could have survived to ever contribute to population recovery as breeders. Although survival of this cohort was normal in the spill zone while maternal care was provided, there are multiple forms of evidence that indicated they were not as healthy as their EPWS counterparts during the pup period and may have been compromised at the time of weaning. Some evidence suggests that growth rates were negatively impacted and dependency periods lengthened. Both before and after the spill, pups tended to be born later in the year in WPWS than in EPWS. Pups captured in WPWS during 1990 had less mass and shorter total body length than pups caught in EPWS, but body condition (i.e., weight corrected for length) was similar.

When all forms of evidence from this study are considered in concert with evidence (discussed below) from the length mass paper, and with findings from other investigators regarding the persistence and distribution of oil in the environment and in sea otter prey in the period between 1989 and 1991, a pattern emerges that suggests that multiple oil-related factors likely contributed to the extremely high post-weaning mortality that was documented.

In the paper on length-mass relationships, we present new findings that show that the mean mass, adjusted for total body length, of male and female sea otters inhabiting oil-affected regions of Prince William Sound after the T/V *Exxon Valdez* oil spill was significantly less than that of individuals captured in the same or adjacent habitat in western Prince William Sound approximately a decade earlier, and than that of individuals inhabiting unoiled habitat in eastern Prince William Sound between 1984-1990.

C. Relationship to other projects

This project is relevant to the Nearshore Vertebrate project which seeks to monitor the recovery of sea otters and to determine factors that may be limiting recovery. It provides information on oil spill damage and benchmarks that are necessary for achieving an understanding of sea otter recovery and gauging population status relative to recovery. It provides information on population status and the movements of individuals critical to designing studies aimed at elucidating factors impacts recovery and to monitoring recovery. It provides information directly relevant to evaluating monitoring methodology and evaluating previous evidence regarding post-spill population status.

NEED FOR THE PROJECT

A. Statement of Problem

Sea otters were one of the species most heavily impacted by the *Exxon Valdez* oil spill. Their current status is unclear. Recent Trustee Council documents list sea otters as "not recovered".

This project will result in the publication of previously unanalyzed and unavailable pre- and post-spill data on sea otters directly needed to:

* evaluate monitoring methodology and interpretation of data regarding post-spill population status

* design studies aimed at elucidating factors impacting recovery sea otters and the nearshore ecosystem;

* provide information regarding population structure necessary and critical to the understanding of population processes impacting recovery (e.g., immigration or emigration), evaluating study design, and modeling and understanding the likely course of recovery of sea otters affected by the oil spill;

* evaluate past and formulate future oil spill response policy

* better understand the geographic extent of damage to sea otters from the spill, and hence, better understand the process of recovery

None of the data proposed to be included in the revised manuscript from the Principal Investigator's marine mammal studies between 1984 and 1991 are currently available in the primary scientific literature. Lack of development of existing post-spill and pre-spill data from the principal investigators' studies on sea otter movements, the reproduction and survival of treatment center otters, habitat use, carcasses, and distribution and abundance relative to oiling in Prince William Sound, AK and adjacent regions has greatly constrained the ability of interested scientists, spill residents, and others to achieve a full understanding of the spill's impacts on sea otters and on the ecosystems in which they play a vital part. It has hampered the interpretation of related findings from other spill-related studies. It has hampered development of meaningful recovery models for sea otters, and resulted in some sea otter-related restoration activities proceeding without important benchmarks against which to gauge current population status relative to recovery.

This project will aid restoration by providing detailed data on EVOS damage to sea otters, without which restoration planning is hobbled. It will also aid restoration by providing benchmarks useful for assessing population status relative to recovery.

Key peer reviewers have consistently recommended that these investigators be provided support to enable them to fully develop their findings and to make them available to the general scientific community via publication in the primary literature. In 1991, for example, the key sea otter peer reviewer wrote "A complete analysis of the data from instrumented otters in Prince William Sound would certainly be a worthy objective and hopefully the Fish and Wildlife Service will be able to see that funding is available so that a complete analysis is carried out" (D. Siniff in a letter to C. Gorbics, Nov. 14, 1991).

Thus, funding is needed to permit the Principal Investigator the time needed to undertake the final writing and analyses required to permit publication of this important body of information regarding sea otter pups and weanling in the scientific literature. This proposal seeks a very small amount of funding to make this happen.

B. Rationale/Link to Restoration

As noted throughout this proposal, information to be published as a result of the proposed work will provide benchmarks against which population status relative to recovery can be gauged. They will provide information valuable to planning future response efforts. They also provide baseline data that can serve as benchmarks of normalcy against which to evaluate whether further damage is occurring.

Lacking the information to be made available if funding is provided, the scientific community and the public have not been able to fully evaluate and to understand the impacts of the spill on sea otters. Some publications have reported that there essentially was little relevant baseline, yet many years of comparable data exist on the key pieces of information necessary to evaluate damage and to monitor recovery.

Without reliable and detailed data on the population structure it is not possible to form conclusions about recovery status or to understand mechanisms impacting recovery.

C. Location

This project will be undertaken from the Principal Investigator's office in Anchorage, Alaska. The project's benefits will be realized globally, as information will be published in the primary literature and, thus, will be available to all interested persons.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

The Principal Investigators strongly support greater involvement of spill-area residents in Trustee Council restoration activities. The Principal Investigators have been residents of the spill area since 1984. This project involves only the development, integration and publication of data from studies already conducted. No new field work is proposed here and no technician aid is requested. Since the primary objectives of the proposal are to develop, integrate and publish results from the Principal Investigators' long-term studies, they will undertake all data analyses and writing required for project completion. Thus, it is unclear how, or if, additional spill area residents, other than the Principal Investigators, could be involved in implementation. However, the Principal Investigators would be willing to coordinate with the Spill Area-Wide Coordinator for the Trustee-sponsored Community Involvement Project to enhance communication of research findings from these projects to local communities.

Both before and after the spill, the Principal Investigators have ensured that interested members of the Native community had access to the findings from their research. For example, in the past, the authors have provided summaries of findings from their studies orally at meetings of the Alaska Sea Otter Commission, and provided copies of research publications to local Native corporations and to the Alaska Sea Otter Commission. Communication of the results from this project could take similar forms, or could involve non-technical oral presentations to community groups or the dissemination of reprints to local libraries. At present, no funds are requested to permit such enhanced communication. If the project is funded and activities such as community visits or reprint dissemination is requested by the spill Area-Wide Coordinator, the budget will need to be adjusted accordingly.

PROJECT DESIGN

A. Objectives

The general objectives of this proposal are to make needed final revisions and to undertake other actions necessary to permit publication in the general scientific literature of a manuscript on the health and survival of sea otter pups and weanlings following the EVOS.

The objectives of this paper have been previously described and are repeated in the section entitled "publications and reports".

B. Methods

The purpose of this project is to conduct data and manuscript revision needed to publish a manuscript in the primary literature. No new field work or data collection is proposed.

The paper of concern here incorporates data from studies conducted in Prince William Sound by the Principal Investigator and primary collaborator during 1984-1989 with post-spill data.

No new field work is proposed as part of this project.

The section on "Publications" summarizes the types of data to be analyzed, integrated and presented in this paper. Background on the basic methods that were employed in the collection of the data to be analyzed is also presented in the "Publications" section.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

None

SCHEDULE

A. Measurable Project Tasks for FY 98 (October 1, 1996-September 30, 1997)

Assuming a starting date of October 1, 2000, a manuscript having the title similar to the following will be submitted to the peer review literature on, or before, the date indicated. Other key dates are listed below.

October 1, 2000: Begin revision of data analyses, and manuscript text needed for paper submission

February 1, 2000: Submit paper "Health, Development, and Survival of Sea Otter Weanlings and Pups after the Exxon Valdez Oil Spill" to the peer review literature for review

January 16-26: Attend Annual Restoration Workshop

B. Project Milestones and Endpoints

The project objectives will be met when this manuscript is accepted for publication in the primary literature.

C. Completion Date

The project will be completed when the manuscript is submitted, on, or before, Sept. 15, 2001.

PUBLICATIONS AND REPORTS

Below, information is provided on the manuscript to be revised and submitted for publication in FY 2001 under this proposal.

1) Title: Health, development, and survival of sea otter pups and weanlings in Prince William Sound after the T/V Exxon Valdez oil spill

Targeted Journal: Journal of Mammalogy

When manuscript will be submitted: By January 1, 1997

Subject and Justification:

This paper will make available to the lay and scientific communities the most direct evidence available for a chronic, population-level impact of the Exxon Valdez oil spill on the survival of sea otters. A unique, multi-year, data base on the development, health, and survival of sea otter pups and weanlings will be integrated and summarized, including directly comparable data from the spill area both before and after the spill.

In this paper, the authors will:

1) Analyze, incorporate, and interpret data on pup survival following weaning and on factors that may aid in the interpretation of survival findings, such as: a) pup body condition; b) pup growth rates; c) pup dependency periods; and d) the timing of key milestones such as birth and weaning.

2) Summarize and analyze pre-spill data on post-weaning survival rates and on the aforementioned factors collected by the Principal Investigators between 1984 and 1988.

3) Compare data collected on the development, health, and survival of sea otter pups and weanlings inhabiting oil-impacted areas of PWS with comparable data collected concurrently on sea otters in unoiled areas, and with the pre-spill, multi-year, data.

Data available from studies of radio-instrumented and tagged sea otter pups and weanlings living in oiled portions of western Prince William Sound (WPWS) will be compared with pre-spill data from WPWS and to pre- and concurrent post-spill data on otters inhabiting non-oiled areas in

eastern Prince William Sound (EPWS). Parallel development and comparison will be made of all available data sets.

The pre-spill data were collected by the Principal Investigators in non-oil spill studies between 1984 and 1989.

The findings from the resulting data development, analyses, summarization, and publication are crucial to: a) understanding the magnitude, levels, and mechanisms of chronic impacts of the spill on sea otters; b) future monitoring of population status; c) determination of current population status relative to full recovery; d) evaluation of potential courses of recovery of sea otters; and, hence, e) recovery of the nearshore ecosystem of which sea otters are a vital component.

The data to be presented will provide baseline values for key development variables and population parameters that can act as benchmarks against which to evaluate the status of the population relative to recovery.

The proposed data development and paper publication will make available findings identified by Trustee Council peer reviewers as part of a body of data critical to the development of meaningful efforts to model the potential recovery of the population(s) of sea otters damaged by the Exxon Valdez oil spill.

PROFESSIONAL CONFERENCES

None

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is directly relevant to the Nearshore Vertebrate Ecosystem Project. Publication of these papers will provide information crucial for understanding current population status. It will provide benchmarks for population status in key areas.

This project will provide information key to evaluation and interpretation of certain monitoring techniques and study designs in the Nearshore Ecosystem Project.

PROPOSED PRINCIPAL INVESTIGATOR

Lisa M. Rotterman, Ph.D.
Enhydra Research
Address:
P.O. Box 243884
Anchorage, AK 99524
Telephone: 907-345-0020
email: RottermanL@gci.net

PRINCIPAL INVESTIGATOR

Dr. Lisa M. Rotterman will be Principal Investigator on this project. In addition to having extensive research experience in the spill region, the Principal Investigator is an Alaska resident and resided in the spill region between 1984 and 1997.

Working in full collaboration, Dr. Monnett and Dr. Rotterman have conducted original research on sea otter population ecology, behavior, development, and genetics in Alaska since 1984. Their sea otter research has included, but not been limited to, research on sex-, age-, and locality-specific: survival rates and causes; reproductive patterns and rates; movement patterns; morphology; body condition; and growth. They have also conducted studies on sea otter population structure and molecular and population genetics. Their sea otter studies have been multi-year, year-round studies in which hundreds of radio-instrumented individuals are studied intensively. They have developed indices by which to assess and compare sea otter populations status generally, and under different resource regimes, specifically.

Dr. Monnett and Dr. Rotterman pioneered studies on sea otter pups and weanlings. At the time of the spill, and until their studies were taken over by government researchers in 1992, they were the only scientists in the world to have conducted large-scale growth and telemetry studies on these age classes. This work permitted the post-spill studies on weanling survival, which produced the most definitive evidence of chronic damage to sea otter populations from the spill to date.

Dr. Monnett and Dr. Rotterman hold the best, most comparable, and in many cases the only baseline data available on the growth, reproduction, body condition, survival and movements of sea otter females, pups and weanlings in Prince William Sound.

As discussed more below, Dr. Monnett and Dr. Rotterman collaboratively conducted much of the post-spill field research on sea otters until 1992. They conducted pre- and post oiling marine mammal surveys in WPWS in 1989, including surveys initiated on the day of the spill. They captured, instrumented and monitored approximately a hundred and sixty sea otters in order to evaluate the impacts of the spill on adult female and weanling survival, health, and movements, and on female reproduction. They collected hundreds of samples for toxicology, pathology, blood chemistry and other studies. They also successfully undertook studies to evaluate the efficacy of the post-spill sea otter rehabilitation program by monitoring the post-release fate of sea otters from the treatment centers.

Dr. Monnett and Dr. Rotterman have written over 30 reports and publications based on their sea otter research.

Individual information about the qualifications of the principal investigator is provided below.

Dr. Rotterman was the Principal Investigator on two major facets of the post-spill sea otter studies: 1) studies aimed at determining the impact of the spill on weanling survival; and 2) the impacts of the spill on the health of adult female and weanling sea otters as assessed through evaluation of blood chemistry and hematology. She has a Ph.D. and a M.S. from the Department of Ecology and Behavioral Biology at the University of Minnesota and a B.S. from the University of Maryland in the field of Conservation and Resource Development, with speciality in Fish and Wildlife. The specialities of her Ph. D. program were population and community ecology, evolution, and behavior. She has a second area of Ph.D.-level expertise in the fields of

population, quantitative, and molecular genetics and earned a minor in Genetics as part of her Ph.D. program.

The topic of her Ph.D. dissertation was the impacts of population fragmentation and reduction on genetic variability and structure within and among populations of sea otters, and the implications of current genetic status to long-term viability. The field portions of her doctoral research were undertaken in Alaska, particularly in Prince William Sound. She was twice appointed as a Guest Researcher in the Laboratory of Viral Carcinogenesis in the Genetics Section at the National Cancer Institute, National Institutes of Health where the laboratory portions of her doctoral research was undertaken.

In addition to her research on sea otter ecology and genetics, she has many years of experience conducting research in the fields of avian ecology and non-human primate toxicology and infant development. She has additional research experience on other marine mammals, and caribou.

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$5.0						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$5.0				Estimated FY 2002		
Indirect		$0.5						
Project Total	$0.0	$5.5						
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Prepared:

Project Number: 01581-BAA
Project Title: Revision and Publication of Sea Otter Pup/Weanling Manuscript
Name: Dr. Lisa Rotterman

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2001
Dr. Lisa Rotterman	Principal Investigator		1.0	5.0		5.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	5.0	0.0	
					Personnel Total	$5.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY01

Prepared:

Project Number:
Project Title: Revision and Publication of Sea Otter Pup/Weanling Manuscript
Name: Dr. Lisa Rotterman

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed
Description	FY 2001
Contractual Total	$0.0

Commodities Costs:	Proposed
Description	FY 2001
Commodities Total	$0.0

FY01

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Contractual &
Commodities
DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			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	

FY01

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Equipment
DETAIL

Development, Integration, Analysis and Publication of Critical Information on Sea Otters in Prince William Sound and Adjacent Areas; Submitted Under the BAA # 52ABNF000039

Project Number: 01582-BAA

Restoration Category: Research and Monitoring

Proposer: Lisa M. Rotterman, Ph.D.,
Enhydra Research

Lead Trustee Agency:

Cooperating Agencies:

Alaska SeaLife Center: No

Duration: FY 01, 1st year, 1-year project

Cost FY 01: $39.1

Cost FY 02:

Geographic Area: No Fieldwork

Injured Resource/Service: Sea Otters and the Nearshore Ecological Community

ABSTRACT

This project will provide information about the survival, reproduction, population structure, movements, habitat use, or rehabilitation of sea otters in PWS and adjacent areas. Findings from this project are crucial to: a) evaluation of past, current and future monitoring and assessment study techniques and design; b) establishment of benchmarks against which to gauge current status relative to recovery; c) formulation of future spill response; d) interpretation of monitoring and damage assessment results and modeling of sea otter recovery; e) evaluation of the impacts of restoration activities on sea otter recovery; and f) elucidation of processes (e.g., immigration or emigration) impacting the course of recovery.

INTRODUCTION

Sea otters were severely impacted by the T/V *Exxon Valdez* oil spill (EVOS) and, based on demographic considerations alone, could not yet have recovered fully from the impacts of the spill. Their current status relative to recovery is unclear. They are described as having not recovered in current EVOS Trustee Council publications. This project would:

1) provide information about sea otter population structure and movement patterns crucial for:

   a. understanding population processes such as immigration and/or emigration affecting population recovery
   b. interpreting data about the impacts of the spill
   c. evaluating the total geographic area over which sea otter populations may have been impacted by the spill
   d. understanding, predicting, and modeling the processes impacting recovery
   e. interpreting survey data and other data aimed at assessing population status relative to recovery
   f. evaluating past, current and future techniques and study design used to monitor population status and being used to identify factors that may be hindering the recovery of sea otters and the nearshore ecological community.

2) result in significant advances in the level and availability of knowledge about trends in sea otter population size and distribution in the years preceding the spill;

3) provide information valuable in assessing the likely impacts of completed and proposed restoration activities and future habitat use policies on the recovery of a seriously EVOS-injured species and its associated ecological community.

4) provide benchmarks related to the survival of sea otters against which the current status of the population relative to recovery can be gauged.

5) provide information necessary for formulating future response policy.

6) result in significant advances in the level and availability of knowledge concerning persistent impacts of the EVOS on the survival of adult sea otters.

7) result in significant advances in the level and availability of knowledge about factors related to the survival and reproduction of sea otters released from post-EVOS treatment centers, and hence, provide information crucial to the development of future oil spill response strategy along the west coast of North America.

8) result in a greatly improved and more complete understanding of the spill's impacts on sea otters and the factors impacting recovery.

Thus, this project will produce information crucial to understanding the process of recovery of the nearshore ecological community, to evaluating alternative response and restoration strategies and to evaluating monitoring and damage assessment study methodology.

The **investigators emphasize** that this project is not a project in which finished reports, based on Trustee-funded research, simply need to be transformed into papers suitable for publication in the peer review literature. Rather, the investigators propose to:

a) **Undertake new and extensive data preparation and summarization and statistical analyses** of pre- and post-spill data on sea otters and other marine mammals from studies conducted between 1984 and early 1992.
b) **Integrate extensive, unique, and unpublished pre-spill baseline data** based on year-round field studies over many years with year-round post-spill data;
c) Prepare papers for publication in the primary scientific literature, making the information available to all interested persons.

New and previously unexplored scientific issues will be examined. In most cases, the data to be analyzed are the only data of their kind available for sea otters in the spill region. In all cases they represent the best and most extensive data on the topic available for sea otters in the EVOS area, and, in many cases, there are no comparable data available on sea otters.

Culmination of the project will be the preparation of manuscripts and the publication in the primary scientific literature of 8 papers (5 in year 1 and 3 in year 2), containing almost entirely new, and all previously unpublished, data and findings.

Pre-spill and post-spill data are from the investigators' studies between May 1984 and Nov. 30, 1991 in both Eastern Prince William Sound (EPWS) and western Prince William Sound (WPWS).

A. Relevant Background

Dr. L. Rotterman, who will undertake this project, began studies of sea otter development, reproduction, survival, population structure, genetics, behavior, growth, body condition, and movements in 1984. Working with Dr. C. Monnett, she help to pioneer large-scale studies, including radio-telemetry studies and growth studies, of sea otter pups and weanlings, conducting studies in both eastern and western PWS. In 1987, they initiated a comprehensive study of adult female reproduction, survival, body condition and movements. Working with Dr. D. Siniff, Dr. Monnett and Dr. Rotterman initiated studies in 1984 designed specifically to develop and test indices of individual and population condition in sea otters (*e.g.*, pup growth studies, which had not previously been undertaken anywhere). When the spill occurred, they were halfway through a study of 59 radio-instrumented sea otter females.

The proposers were the Principal Investigators on key sea otter damage assessment studies. Between 1989 and Nov. 30, 1991, they conducted year-round intensive field studies, including studies of: 1) female reproduction, health, and survival (PI: C.M.); 2) post-weaning survival (PI: L.M.R.); 3) movement patterns (PI: C.M.)M.); 4) determination of the fate of sea otters released from EVOS treatment centers (PI: C.M.); 5) blood chemistry and hematology of adult females and weanlings (PI: L.M.R.); and 6) pre- and post-spill aerial (and to a lesser extent, boat) marine

mammal surveys in Prince William Sound (using funding from the Mineral's Management Service) (PI:C.M.). They collected over a hundred samples for clinical blood studies, hydrocarbon analyses and painstakingly recovered carcasses for necropsy and histopathology.

These post-spill studies, which were unprecedented in both scope and content, were highly successful resulting in the acquisition of key information on the spill's impacts on sea otters. Dr. Monnett and Dr. Rotterman captured hundreds of sea otters, radio-instrumented 100 adult females and 64 pups, monitored 45 radio-instrumented otters from the treatment centers.

A key finding from the post-spill studies of Monnett and Rotterman was that the post-weaning survival of sea otters born into the spill area more than a year after the spill was very poor, and was significantly lower than their concurrent counterparts in the unoiled eastern Sound. This finding remains, to date, the most definitive evidence of persistent damage to sea otters from EVOS (see below for further discussion).

Additionally, they demonstrated that female reproductive and survival rates were normal in the spill region in 1990 and 1991, but that adult females in the spill region may have higher rates of liver dysfunction compared with their counterparts in the eastern sound.

Their study of treatment center otters showed that survival and pupping rates of the animals released from the treatment centers was very low and was followed by an increase in mortality in the recipient population.

Their study of movements confirmed that significant interchange was not occurring among oiled (in WPWS) and unoiled (in EPWS) sea otter study populations, a finding crucial to evaluation of all post-spill studies. These movement studies also produced data that provides insight into the recovery process by showing that sea otters from EPWS were not emigrating to the west, and thus, would not be affecting recovery rates.

Despite the short time frame allotted for report preparation, the proposers reported the basic results, addressing all contracted objectives from these studies, in final unpublished reports in 1992. However, the stated objectives of the post-spill damage assessment studies were very simple, e.g., to determine whether post-weaning survival in oiled versus non-oiled areas did, or did not, differ.

The aforementioned reports, while produced very quickly and without significant technical staff, were accepted by the contracting agency as final reports with only minor modification being requested and made. However, these reports were not finalized by the contracting agency until May 1995. No content modifications were requested of the investigators between the submission of the final version of reports in 1992 and the agency certification of documents as "Final Reports" in 1995.

The population studies were highly praised by key sea otter peer reviewers advising the Chief Scientist. One investigator wrote something to the extent that before the successful completion of these studies, no one would have thought them possible.

Previous proposals have provided extensive discussions of relevant background. Suffice it to say that sufficient funding has never been provided to complete the tasks proposed here. Because of this, funding is now being requested to enable the necessary effort to ensure that unique and valuable data are developed and the relevant findings made available through the peer-reviewed primary scientific literature.

B. Work Undertaken With Previous Funding

In August of 1996, funding was approved by the Trustee Council to permit one of the investigators to spend 1.5 months on each of 4 papers to undertake analyses and writing necessary to produce 4 papers. Two papers under this contract were submitted to the Trustee Council: funding for 1.5 papers was received and we have submitted a companion proposal to provide funds that would permit completion of that paper. No other funding was received. The amount of time spent in the data preparation, data integration, data analyses, literature review, and manuscript preparation was well in excess than that for which funding was provided. In the current proposal, we have made more realistic assessments of the task at hand and the time needed for completion.

Thus, herein, we request funding to undertake lengthy data analyses, literature review, and manuscript preparation needed to complete one of the remaining 2 papers (on survival of females after the EVOS in oiled and unoiled areas) and to permit extensive analyses, literature review, and manuscript preparation, revision, etc., for a new paper on either the post-release survival of sea otters released from the post-EVOS treatment centers or the movement patterns of sea otters following the EVOS. We have provided a choice of these two papers for the Trustee Council, but only request funding for a total of two papers.

The fourth paper (on age-specific reproduction) originally proposed cannot be undertaken because it requires too great a commitment of time from Dr. Monnett, who, due to other employment, is not available to undertake the necessary extensive data preparation for that paper.

To date, Dr. L. M. Rotterman has: 1) submitted and revised a manuscript for publication entitled "Length-mass relationships and total body length in sea otters in Prince William Sound before and after the T/V Exxon Valdez oil spill" to the journal Marine Mammal Science following submission in August 1997 of the manuscript to the NMFS for Trustee review and revision; 2) completed and submitted to the Trustees, submitted for general peer review, and partially revised analyses and writing in a manuscript entitled "Health, development, and survival of sea otter pups and weanlings", formatted for publication in Marine Mammal Science (referred to hereafter as the "pup/weanling paper (half of funding received); and 3) begun data preparation and analyses for a paper "Survival and reproduction of female sea otters in Prince William Sound, AK after the T/V *Exxon Valdez* oil spill (no funding was received by the investigators for this paper).

Extensive new data and analyses are presented in the pup/weanling paper and the length/mass papers referred to above. Indeed, the length-mass paper was a completely new undertaking, requiring all new data analyses, literature review, etc. Actual time devoted to completion was well in excess of that for which funding was requested or provided, as anticipated both by us and by peer reviewers.

For example, in the pup/weanling paper, data from multiple independent pre- and post-spill studies of hundreds of radio-instrumented females and their pups, of radio-instrumented pups and weanlings, and of tagged pups are analyzed and integrated. Data on birth and weaning timing, body condition, growth rates, health, dependency period, and survival are all presented. In the corresponding report, the only objective was to determine whether the survival of weanlings in the eastern sound differed from that observed in the western sound.

A brief summary of important new data and findings resulting from these efforts, which involved: extensive new data preparation, summarization and analysis; integration of pre- and post-spill data

bases; integration of data from independent post-spill studies; literature review; and manuscript preparation, are given briefly below:

In the paper on length-mass relationships and total body length in sea otters, we:

1) documented that the mean mass, adjusted for total body length, of male and female sea otters inhabiting oil-affected regions of Prince William Sound after the T/V *Exxon Valdez* oil spill was significantly less than that of individuals captured in the same or adjacent habitat in western Prince William Sound approximately a decade earlier, and than that of individuals inhabiting unoiled habitat in eastern Prince William Sound between 1984-1990;
2) documented that pre-spill, mean adjusted body mass of females in WPWS was significantly greater than in EPWS;
3) documented that, contrary to published predictions of other authors, the body condition of sea otters in EPWS did not change over the 7 years of our study despite dramatic changes in distribution and abundance, and despite sea otter densities that were the highest ever reported;
4) reviewed, and summarized all pre- and post-spill evidence from other studies, including prey studies, oil contamination studies, and sea otters foraging studies, relevant to interpreting data on potential factors impacting body condition and total body length in sea otters in PWS;
5) concluded that evidence strongly suggests that relatively lower post-spill body mass resulted from one or more EVOS-related factors including damage to prey, prey and habitat contamination, harm to individual health, and disturbance;
6) showed that there was no evidence to suggest that sea otter population condition was poor in WPWS just before the spill for any reason, including, but not limited to, prey availability;
7) documented that both pre- versus post-spill body condition and TBL in mature females, and sea otter foraging studies, indicate adequate and improving prey resources in WPWS between the late 1970s and the spill;
8) documented that the mean TBL of mature females captured pre-spill in WPWS was significantly less than that of pre- and post-spill EPWS and post-spill WPWS females;
9) concluded that body condition and TBL are informative indices of current (at time of sampling) and past population condition in sea otters, respectively.

The paper on length-mass and total body length of sea otters was submitted to the Trustees for review in August of 1997. Trustee peer review was quite favorable (Appendix I) and only minor modifications were required prior to journal submission. The authors received trustee peer review comments in December 1997. Results from this work were presented in poster form at the 1998 Trustee Restoration meeting in Anchorage in January 1998 (this poster was mysteriously removed from the room by unknown persons). The revised manuscript was submitted to the journal Marine Mammal Science in January 1998 and is currently under review.

Payment for the length-mass and body length paper (the first payment to be received for this project) was received in mid-March 1998, which allowed the investigators to make computer-related purchases needed to complete the paper on pups and weanlings, and on post-EVOS female reproduction and survival.

The purpose of the pup/weanling paper was to compare and to discuss measures of, and factors related to, the survival, development, and health of young sea otters through the period of dependency and after permanent separation from their mothers, and in so doing, to gain information necessary to determine whether there were persistent impacts of the EVOS on the local populations of sea otters. The individuals studied were born in Prince William Sound, on average,

more than a year after the T/V *Exxon Valdez* discharged oil into the sound and were not conceived when the spill occurred.

As noted above, our pup/weanling product differs greatly from the report on the same topic, which was focused solely on the issue of whether survival differed between concurrently studied cohorts in EPWS versus WPWS.

As part of this product, we prepared, summarized, integrated and analyzed relevant data from all of our previous work on the pups of instrumented females, radio-instrumented pups and weanlings, and tagged (but not instrumented) pups, dating back to 1984.

Because we had data from a number of years prior to the spill, we were able to examine the range of variability observed in factors of interest over time and to evaluate data on sea otters in the oil spill zone in that context.

Findings presented in the paper confirm and strengthen the result presented in the final report (prepared in 1992) that post-weaning mortality was significantly and unusually low, compared to both pre-spill and post-spill studies. Proportions of individuals surviving after weaning in WPWS after EVOS were significantly lower in 1990 than in each of 3 separate studies in EPWS, one conducted concurrently and 2 conducted before EVOS.

Data on the survival of pups and weanlings were integrated in this paper and show that very few of the pups born in 1990 could have survived to ever contribute to population recovery as breeders.

The existence of multiple independent data sets made it possible to undertake multiple and independent analyses aimed at evaluating a given issue, such as birth timing, and strengthened interpretation over that possible given a more limited approach, such as that based solely on comparison of oiled versus unoiled concurrent peers.

Although survival of the 1990 WPWS cohort was normal in the spill zone while maternal care was provided, there are multiple forms of evidence that indicated they were not as healthy as their EPWS counterparts during the pup period and may have been compromised at the time of weaning. Evidence indicates that, after the EVOS, the growth rates of sea otter pups in WPWS were negatively impacted and dependency periods lengthened. Pups captured in WPWS during 1990 had less mass and shorter total body length than pups caught in EPWS, but body condition (i.e., weight corrected for length) was similar.

Data in this paper show that significant differences in timing of births and weanings exist between EPWS and WPWS.

When all forms of evidence from this study are considered in concert with evidence from the length- mass paper, and with findings from other investigators regarding the persistence and distribution of oil in the environment and in sea otter prey in the period between 1989 and 1991, a pattern emerges that suggests that multiple oil-related factors likely contributed to the extremely high post-weaning mortality that was documented.

Our confidence in our interpretation of these findings is strengthened by the fact that the results obtained using multiple and independent samples and different analytical approaches were generally consistent.

The paper on female reproduction and survival following the spill provides evidence indicating that, in 1990 and 1991, the survival and reproduction of females in the EVOS area was not

abnormally low, but that survival in EPWS declined substantially after the release of treatment center otters into EPWS.

C. Relationship to other projects

We believe that this project is crucial to the interpretation of findings from the Nearshore Vertebrate project which seeks to monitor the recovery of sea otters and to determine factors that may be limiting recovery. It provides information on oil spill damage and benchmarks that are necessary for achieving an understanding of sea otter recovery and gauging population status relative to recovery. It provides information on population status and could, if the movement paper is chosen, provide information on the movements of individuals **critical to evaluating the design of past, present and future studies** aimed at elucidating factors impacts recovery and to monitoring recovery. It provides information directly relevant to evaluating monitoring methodology and evaluating past, current and future evidence regarding post-spill population status.

NEED FOR THE PROJECT

A. Statement of Problem

Sea otters were one of the species most heavily impacted by the Exxon Valdez oil spill. Their current status is unclear. Recent Trustee Council documents list sea otters as "not recovered".

This project will result in extensive new analyses, integration, and publication, of pre- and post-spill data on sea otters directly needed to:

* evaluate monitoring methodology and interpretation of data regarding post-spill population status
* design studies aimed at elucidating factors impacting recovery sea otters and the nearshore ecosystem;
* provide information regarding population structure necessary and critical to the understanding of population processes impacting recovery (e.g., immigration or emigration), evaluating study design, and modeling and understanding the likely course of recovery of sea otters affected by the oil spill;
* evaluate past and formulate future oil spill response policy
* better understand the geographic extent of damage to sea otters from the spill, and hence, better understand the process of recovery

None of the data proposed to be analyzed, integrated and published here from the Principal Investigator's marine mammal studies between 1984 and 1991 are currently available in the primary scientific literature. Lack of funding to permit the investment of time and effort needed to develop existing pre- and post-spill data from the principal investigators' studies on sea otter movements, reproduction and survival of treatment center otters, habitat use, carcasses, and distribution and abundance relative to oiling in Prince William Sound, AK and adjacent regions has greatly constrained the ability of interested scientists, spill residents, and others to achieve a full understanding of the spill's impacts on sea otters and on the ecosystems in which they play a vital

part. It has hampered the interpretation of related findings from other spill-related studies. It has hampered development of meaningful recovery models for sea otters, and resulted in some sea otter-related restoration activities proceeding without important benchmarks against which to gauge current population status relative to recovery.

Information about population structure in and near the spill zone is needed to achieve a full understanding of both the geographic area over which sea otter populations or subpopulations were impacted by the spill, to understand the population processes impacting recovery, to interpret data on distribution and abundance over time, to formulate meaningful population models of recovery, and to evaluate the design of assessment and monitoring studies.

Information about factors affecting sea otters treated and released from post-EVOS treatment centers is critical to the formulation of future oil spill response policy and to evaluating the full extent of damage to sea otters from the Exxon Valdez oil spill.

This project will aid restoration by providing detailed data on EVOS damage to sea otters, without which restoration planning is hobbled. It will also aid restoration by providing benchmarks useful for assessing population status relative to recovery.

As noted in the background section, funding has never been provided to permit more than the most basic analyses of the relevant post-spill data necessary to address simple litigation-driven objectives.

Key peer reviewers have consistently recommended that these investigators be provided support to enable them to fully develop their findings and to make them available to the general scientific community via publication in the primary literature. In 1991, for example, the key sea otter peer reviewer wrote "A complete analysis of the data from instrumented otters in Prince William Sound would certainly be a worthy objective and hopefully the Fish and Wildlife Service will be able to see that funding is available so that a complete analysis is carried out" (D. Siniff in a letter to C. Gorbics, Nov. 14, 1991).

Thus, funding is needed to permit the Principal Investigators the time needed to undertake the considerable effort required to initiate the data preparation, extensive new analyses, data integration, literature review and writing required to ensure that the full value of the data and findings from this considerable and unique body of work is realized and available to the public and scientific communities. Peer reviewers to Trustee Council staff have repeatedly recommended that such funding be made available. This proposal seeks a relatively small amount of funding to undertake extensive data preparation, data analyses, manuscript preparation and publication. However, the investigators emphasized that this project has a large data preparation and analysis component and goes far beyond the process needed to convert a report into a publishable paper. Thus, funding requested is more reflective of the bare minimum time that will be spent than in the first proposal.

B. Rationale/Link to Restoration

As noted throughout this proposal, information to be published as a result of the proposed work will provide benchmarks against which population status relative to recovery can be gauged. They will provide information valuable to planning future response efforts. They also provide baseline

data that can serve as benchmarks of normalcy against which to evaluate whether further damage is occurring.

Due to lack of support to enable further data summarization and analyses, including the integration of a massive amount of baseline data from studies conducted prior to the spill, the scientific community and the public have not been able to fully evaluate and to understand the impacts of the spill on sea otters. Some publications have reported that there essentially was little relevant baseline on sea otters, and thus, that differences observed were difficult to interpret. However, many years of comparable data exist on the key pieces of information necessary to evaluate damage and to monitor recovery.

Without reliable and detailed data on the population structure it is not possible to evaluate various alternative interpretations of data collected to assess damage and to monitor recovery, to form conclusions about recovery status, or to understand mechanisms impacting recovery.

C. Location

This project will be undertaken from the Principal Investigator's offices in Anchorage, AK. The project's benefits will be realized globally, as information will be published in the primary literature and, thus, will be available to all interested persons.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

The Principal Investigators strongly support greater involvement of spill-area residents in Trustee Council restoration activities. The Principal Investigators have been residents of the spill area since 1984. This project involves the development, integration and publication of data from studies already conducted. No new fieldwork is proposed here and no technician aid is requested. Since the primary objectives of the proposal are to develop, integrate and publish results from the Principal Investigators' long-term studies, they will undertake all data analyses and writing required for project completion. Thus, it is unclear how, or if, additional spill area residents, other than the Principal Investigators, could be involved in implementation. However, the Principal Investigators would be willing to coordinate with the Spill Area-Wide Coordinator for the Trustee-sponsored Community Involvement Project to enhance communication of research findings from these projects to local communities.

Both before and after the spill, the Principal Investigators have ensured that interested members of the Native community had access to the findings from their research. For example, in the past, the authors have provided summaries of findings from their studies orally at meetings of the Alaska Sea Otter Commission, and provided copies of research publications to local Native corporations and to the Alaska Sea Otter Commission. Communication of the results from this project could take similar forms, or could involve non-technical oral presentations to community groups or the dissemination of reprints to local libraries. At present, no funds are requested to permit such enhanced communication. If the project is funded and activities such as community visits or reprint dissemination is requested by the spill Area-Wide Coordinator, the budget will need to be adjusted accordingly.

PROJECT DESIGN

A. Objectives

The general objectives of this proposal are to prepare, integrate and summarize data, conduct extensive new analyses, conduct needed literature review and summarization, and produce eight manuscripts for publication containing findings from large, multi-year pre- and post-spill studies of sea otters and post-spill studies of other marine mammals, in Prince William Sound and the Gulf of Alaska in order to:

a) provide critical information about the population structure, movements, survival, habitat use, and the efficacy of rehabilitation programs of sea otters in PWS and adjacent areas;
b) permit evaluation of past, current and future monitoring and assessment study techniques and design and aid in the design and evaluation of future monitoring study design (movement paper);
c) establish benchmarks against which to gauge the current population status of sea otters relative to recovery (survival and movement papers);
d) formulate future spill response and restoration strategies (rehabilitation paper);
e) interpret monitoring and damage assessment results (all);
f) permit meaningful modeling of sea otter recovery (all);
g) evaluate impacts of restoration activities on sea otter recovery (all);
h) elucidate processes (e.g., immigration or emigration) impacting the course of recovery (movement paper).
i) enhance understanding of the habitat requirements of sea otters (movement paper)
j) enhance understanding of the process of recolonization and population ecology of sea otters (movement paper)
k) generate benchmarks of sea otter population status relative to recovery.

This project will provide information about the population ecology, movements, survival, habitat use, and rehabilitation and of sea otters in PWS and adjacent areas. Findings from this project are crucial to: a) evaluation of past, current and future monitoring and assessment study techniques and design; b) establishment of benchmarks against which to gauge current status relative to recovery; c) formulation of future spill response; d) interpretation of monitoring and damage assessment results and modeling of sea otter recovery; e) evaluation of the impacts of restoration activities on sea otter recovery; and f) elucidation of processes (e.g., immigration or emigration) impacting the course of recovery.

The objectives associated with the analyses and other activities associated with each of the 3 papers (of which we propose to do 2) are described in the section entitled "publications and reports". However, in order to facilitate evaluation of the objectives of the project as a whole, a brief listing of the specific objectives of the analyses to be undertaken and the structure of the papers to be written are given below by paper. The amount of funding requested for each major portion of the project, given as amount of time for which funding is requested, is provided at the end the description of activities related to each paper.

1) Title: Survival and reproduction of female sea otters in Prince William Sound, AK after the T/V Exxon Valdez oil spill

The purpose of this paper is to publish information on the impact of the T/V Exxon Valdez oil spill on the survival and the reproduction of female sea otters residing in oiled portions of Prince William Sound. In order to do so, additional data crunching and analyses are required. Comparison will be made of rates of survival and pupping of female sea otters in EVOS-oiled areas and otters inhabiting adjacent unoiled areas in Prince William Sound. Two independent data sets from the unoiled areas will be used for comparison with the EVOS affected area: one from a concurrent post-spill study, and the other from studies conducted prior to the spill from 1987 through the end of 1989. Additionally, data on pregnancy detection rates and premature fetal loss will be incorporated.

The publication of this paper, based on the observations of approximately 100 radio-instrumented females will make available the best, most reliable existing evidence regarding the chronic impacts of the EVOS on survival and reproduction of sea otters in spill-affected areas. The paper will summarize part of a body of data identified by Trustee peer reviewers as those data necessary for development of meaningful models to predict the recovery of EVOS-affected sea otter populations.

Funding requested: 3 months

2) "Movements of weanling and adult female sea otters in Prince William Sound, Alaska, after the T/V Exxon Valdez oil spill" objectives:

a) summarize movement data crucial to achieving a full understanding of the damages to the affected population(s) and the likely course of recovery of that population;
b) provide information necessary to evaluate the basic design of many of the sea otter damage assessment studies and for guiding other analyses (e.g., to evaluating the assumption that the location of capture is indicative of the general area of residence and that sea otters from groups compared in other studies (e.g., the weanling study) do not live in the same habitat at any time;
c) to evaluate whether there is significant immigration or emigration of sea otters into, or from, the oil spill affected region in general and whether sea otters within the oil spill affected region appear to be preferentially using or avoiding the most heavily oiled areas, and in so doing to provide data necessary to understand and to be able to make predictions about the recovery of sea otters in the oil spill affected areas.

Time for which funding is requested: 4.0 months.

3) "Survival and reproduction of sea otters released from treatment centers after the T/V Exxon Valdez oil spill" objectives:

a) analyze unique data and present findings on the survival and the reproduction of sea otters that were captured in oiled habitat after the Exxon Valdez oil spill, treated at centers established in response to the spill, and released back into unoiled habitat in PWS in the summer of 1989
b) compare the survival and reproduction of the treated animals to similar data on the recipient population collected concurrently, and prior to the spill
c) to examine factors possibly related to survival (e.g., age, condition upon capture, movement after release, center where treated, etc.)

d) to present data and findings critical to the evaluation of the efficacy of sea otter response and rehabilitation strategies
e) to provide information needed to evaluate the total extent of damage done to sea otter populations affected by the EVOS.

Time for which funding is requested: 4.0 months.

B. Methods

The purpose of this project is to conduct extensive new analysis of existing data, integrate data from pre- and post spill studies, and to produce and submit five manuscripts for publication in the primary literature. No new field work or data collection is proposed.

We emphasize that extensive data preparation, data summarization, new analyses, new integration of findings and literature review, etc., will be undertaken and presented in these most of these manuscripts. Some of the data, which will be summarized and analyzed here, were collected during NRDA studies and much of it was not. While directly relevant to interpreting oil spill impacts on, and recovery of, marine mammals and associated ecosystems, most of the findings to be contained within the papers have not been previously summarized in NRDA final reports. Thus, the final products will, in scope and content, go far beyond the objectives and products of previously funded Trustee Council activities and, hence, provide information previously unavailable. As such, this project requires considerably more time for completion beyond the time necessary to make the transition between report and publishable paper.

Where possible, papers will incorporate additional data from studies conducted in Prince William Sound by the investigators during 1984-1989. Much of the data to be analyzed and presented in publishable papers is from both pre-spill and post-spill studies conducted by the authors.

The section on "Publications" summarizes the types of data to be analyzed, integrated and presented in each paper. Background on the basic methods that were employed in the collection of the data to be analyzed are also presented in the "Publications" section.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

None

SCHEDULE

A. Measurable Project Tasks for FY 01 (October 1, 2000-September 30, 2001)

Assuming a starting date of October 1, 2000, the following is and intended schedule for this project in the interval October 1, 2000-Sept. 30, 2001 (dates are target dates; products may be completed before these dates):

October 1 2000-April 2001:	Undertake needed data preparation summary, analyses, literature review, and manuscript preparation for first drafts of papers

May 2001-Sept. 30, 2001	Submit papers for review by Trustee Council, make revisions, submit
Sept. 30, 2001	to scientific journals, revise, resubmit

B. Project Milestones and Endpoints

The project objectives will be met when each successive manuscript is submitted first for review by Trustee Council peer reviewers, and lastly for journal review prior to publication in the primary literature.

C. Completion Date

The first year of the project will be completed when the last manuscript is submitted, on, or before, Sept. 30, 2001.

PUBLICATIONS AND REPORTS

Below, information is provided on the types of data, comparisons to be made, and the manuscripts to be developed and submitted for publication in FY 2000 under this proposal.

1) Title: Survival and reproduction of female sea otters in Prince William Sound, AK after the T/V Exxon Valdez oil spill

Targeted Journal: Marine Mammal Science

When manuscript will be submitted to NMFS: By August 1, 2001

Subject and Relevance to Restoration:

The purpose of this paper is to publish information on the impact of the T/V Exxon Valdez oil spill on the survival and the reproduction of female sea otters residing in oiled portions of Prince William Sound. In order to do so, additional data crunching and analyses are required. Comparison will be made of rates of survival and pupping of female sea otters in EVOS-oiled areas and otters inhabiting adjacent unoiled areas in Prince William Sound. Two independent data sets from the unoiled areas will be used for comparison with the EVOS affected area: one from a concurrent post-spill study, and the other from studies conducted prior to the spill from 1987 through the end of 1989. Additionally, data on pregnancy detection rates and premature fetal loss will be incorporated.

The publication of this paper, based on the observations of approximately 100 radio-instrumented females will make available the best, most reliable existing evidence regarding the chronic impacts of the EVOS on survival and reproduction of sea otters in spill-affected areas. The paper will summarize part of a body of data identified by Trustee peer reviewers as those data necessary for development of meaningful models to predict the recovery of EVOS-affected sea otter populations.

2) Title: Movements of Weanling and Adult Female Sea Otters in Prince William Sound, Alaska, After the T/V Exxon Valdez Oil Spill.

Targeted Journal: Marine Mammal Science, Journal of Mammalogy, or Canadian Journal of Zoology

When Manuscript will be Submitted: By August 1, 2001

Subject and Relevance to Restoration:

In order to provide movement data necessary to address the issues discussed below, we monitored the movements of radio-instrumented weanling and adult female sea otters between October, 1989, and November, 1991. We made observations on individuals inhabiting the area affected by the oil spill in western Prince William Sound (WPWS) and on individuals living in ostensibly unaffected habitat in eastern Prince William Sound (EPWS).

Final analyses of these data (final with respect to the following issues only) will be undertaken, needed literature review undertaken, and a manuscript for publication in the peer reviewed scientific literature will be prepared.

In previous studies it has been well documented (e.g., Garshelis et al. 1984; Monnett 1988) that sea otters in Prince William Sound are capable of moving long distances. Given the great potential mobility of sea otters documented in other studies, movement data are needed to:

- test assumptions about the reliability of capture or single point observation location as a reliable indicator of the region normally inhabited
- test assumptions about the discreteness of compared groups of animals.
- understand and to be able to make predictions about the recovery of sea otters in the oil spill affected areas.
- provide information critical to interpreting information currently being collected about population status relative to recovery and potential factors limiting recovery
- provide information needed to model the recovery of sea otters in EVOS-affected areas

Thus, findings to be presented in the proposed paper will provide information about sea otter movements and population structure critical to the evaluation of past, current, and future techniques and study designs aimed at monitoring the recovery of affected sea otter populations and the associated nearshore ecological community.

Relatedly, in order to interpret data within the oil spill zone, it is necessary to understand the movements of individuals being studied relative to categorization of habitat with regard to oiling.

Movement data are needed to evaluate whether there is significant immigration or emigration of sea otters into, or from, the oil spill affected region in general and whether sea otters within the oil spill affected region appear to be preferentially using or avoiding the most heavily oiled areas. Without such data, it is not possible to meaningfully model or to interpret population recovery.

Data to be reported herein will provide information needed to model recovery of sea otters in affected areas in Prince William Sound by providing information about whether the recovery of the sea otter population in the oil spill affected region of Prince William Sound will likely be a direct function of the rates of survival and reproduction of the sea otters in the affected habitat or whether there is significant influence from emigration or immigration from or to the area.

Findings from this paper will provide information on whether sea otters tend to avoid oiled habitat, and hence, provide information critical to the evaluation of data on distribution and abundance of sea otters over time in certain areas as an indicator of population recovery.

or

3) Title: Survival and reproduction of sea otters released from treatment centers after the T/V Exxon Valdez oil spill

Targeted Journal: Conservation Biology

When manuscript will be submitted: By August 1, 2001

Subject and Relevance to Restoration:

This paper will present findings on the survival and the reproduction of 45 sea otters that were captured in oiled habitat after the Exxon Valdez oil spill, treated at centers established in response to the spill, and released back into unoiled habitat in PWS in the summer of 1989. Data of the survival and reproduction of these animals will be compared to similar data on the recipient population collected concurrently, and prior to the spill. Factors possibly related to survival (e.g., age, condition upon capture, movement after release, center where treated, etc.) will be examined.

The data to be presented in this paper are the only existing data available for evaluating the long-term fate of sea otters released into their natural habitat following a large-scale oil spill and subsequent rehabilitation effort. Hence, they are critical for the evaluation of the efficacy of the rehabilitation strategy and for the planning of future response policy. They also provide insight into the probable fate of the other sea otters released from the EVOS treatment centers back to the wild and so provide heretofore unconsidered information relevant to assessing the total damage to, and, hence, the full recovery of, sea otter populations from the Exxon Valdez oil spill.

PROFESSIONAL CONFERENCES

Funding for registration and travel expenses needed to permit the Principal Investigator to present a paper at, and to attend, one professional conference (the American Society of Mammalogy Annual Meeting) in FY 2001 is requested. No previous conference funding has ever been provided to the Principal Investigator to present findings from the extensive and long-term EVOS-related studies of these investigators.

No presentation of the findings from the long-term studies of these investigators has been made to the American Society of Mammalogy, despite the obvious relevance of this research to its members.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is directly relevant to the Nearshore Vertebrate Ecosystem Project. Publication of these papers will provide information crucial for understanding current population status. It will provide benchmarks for population status in key areas.

This project will provide information key to evaluation and interpretation of certain monitoring techniques and study designs in the Nearshore Ecosystem Project.

This project is proposed as a two year project. A two-year commitment by the Trustee Council will permit the investigators to invest in data preparation in year one to make work in year two more efficient.

PROPOSED PRINCIPAL INVESTIGATOR

Lisa M. Rotterman, Ph.D.
Enhydra Research
P.O. Box 243884
Anchorage, AK 99524

PRINCIPAL INVESTIGATOR

Dr. Lisa M. Rotterman will be Principal Investigator on this project and Dr. Charles Monnett will be the Primary Collaborator. In addition to having extensive research experience in the spill region, the Principal Investigator is a spill area resident and has resided in the spill region since 1984.

Working in full collaboration, Dr. Monnett and Dr. Rotterman have conducted original research on sea otter population ecology, behavior, development, and genetics in Alaska since 1984. Their sea otter research has included, but not been limited to, research on sex-, age-, and locality-specific: survival rates and causes; reproductive patterns and rates; movement patterns; morphology; body condition; and growth. They have also conducted studies on sea otter population structure and molecular and population genetics. Their sea otter studies have been multi-year, year-round studies in which hundreds of radio-instrumented individuals are studied intensively. They have developed indices by which to assess and compare sea otter population status generally, and under different resource regimes, specifically.

Dr. Monnett and Dr. Rotterman pioneered studies on sea otter pups and weanlings. At the time of the spill, and until their studies were taken over by government researchers in 1992, they were the only scientists in the world to have conducted large-scale growth and telemetry studies on these age classes. This work permitted the post-spill studies on weanling survival, which produced the most definitive evidence of chronic damage to sea otter populations from the spill to date.

Dr. Monnett and Dr. Rotterman hold the best, most comparable, and in many cases the only baseline data available on the growth, reproduction, body condition, survival and movements of sea otter females, pups and weanlings in Prince William Sound.

As discussed more below, Dr. Monnett and Dr. Rotterman collaboratively conducted much of the post-spill field research on sea otters until 1992. They conducted pre- and post oiling marine mammal surveys in WPWS in 1989, including surveys initiated on the day of the spill. They captured, instrumented and monitored approximately a hundred and sixty sea otters in order to evaluate the impacts of the spill on adult female and weanling survival, health, and movements, and on female reproduction. They collected hundreds of samples for toxicology, pathology, blood chemistry and other studies. They also successfully undertook studies to evaluate the efficacy of the post-spill sea otter rehabilitation program by monitoring the post-release fate of sea otters from the treatment centers.

Dr. Monnett and Dr. Rotterman have written over 30 reports and publications based on their sea otter research.

Individual information about the qualifications of the two researchers are provided below.

Dr. Rotterman was the Principal Investigator on two major facets of the post-spill sea otter studies: 1) studies aimed at determining the impact of the spill on weanling survival; and 2) the impacts of the spill on the health of adult female and weanling sea otters as assessed through evaluation of blood chemistry and hematology. She has a Ph.D. and a M.S. from the Department of Ecology and Behavioral Biology at the University of Minnesota and a B.S. from the University of Maryland in the field of Conservation and Resource Development, with specialty in Fish and Wildlife. The specialties of her Ph. D. program were population and community ecology, evolution, and

behavior. She has a second area of Ph.D.-level expertise in the fields of population, quantitative, and molecular genetics and earned a minor in Genetics as part of her Ph.D. program.

The topic of her Ph.D. dissertation was the impacts of population fragmentation and reduction on genetic variability and structure within and among populations of sea otters, and the implications of current genetic status to long-term viability. The field portions of her doctoral research were undertaken in Alaska, particularly in Prince William Sound. She was twice appointed as a Guest Researcher in the Laboratory of Viral Carcinogenesis in the Genetics Section at the National Cancer Institute, National Institutes of Health where the laboratory portions of her doctoral research was undertaken.

In addition to her research on sea otter ecology and genetics, she has many years of experience conducting research in the fields of avian ecology and non-human primate toxicology and infant development. She has additional research experience on other marine mammals, and caribou.

OTHER KEY PERSONNEL

Dr. Monnett will be the Primary Collaborator on this project. Dr. Monnett was the Principal Investigator on several key portions of the post-spill sea otter studies: 1) studies aimed at evaluating the impact of the spill on female health, reproduction and survival; 2) studies of the movement patterns of sea otters after the spill; 3) studies aimed at determining the efficacy of the sea otter rehabilitation program; and 4) pre- and post-spill aerial (and to a lesser extent, boat) marine mammal surveys (sea otters, harbor seals, sea lions, and other marine mammals) in oiled and adjacent areas of PWS, which he initiated on the morning of the spill.

Dr. Monnett has a Ph.D. from the Department of Ecology and Behavioral Biology at the University of Minnesota and a B.S. from the University of Washington in Zoology. He also has training in the veterinary sciences and is a certified veterinary technologist. He holds a private pilot's license and is certified as a commercial diver.

The topic of Dr. Monnett's Ph.D. dissertation was "Patterns of Movement, postnatal development and mortality of sea otters in Alaska" in which studies of sea otter pups and weanlings were pioneered.

In addition to his research on sea otters, he has many years of experience conducting research in the fields of avian ecology and non-human primate toxicology and infant development. He also has additional research experience on other marine mammals.

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Budget Category:	Authorized FY 2000	Proposed FY 2001	LONG RANGE FUNDING REQUIREMENTS					
Personnel		$35.0						
Travel		$0.5						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0						
Subtotal	$0.0	$35.5				Estimated FY 2002		
Indirect		$3.6						
Project Total	$0.0	$39.1						
Full-time Equivalents (FTE)		0.7						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Prepared:

Project Number: 01582-BAA
Project Title: Development, Inteegration, Analysis and Publication of Critical Information on Sea Otters in Prince William Sound and Adjacent Areas
Name: Lisa M. Rotterman, Enhydra Research

FORM 4A
Non-Trustee
SUMMARY

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2001
Lisa M. Rotterman, Ph.D.	Principal Investigator		7.0	5.0		35.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		7.0	5.0	0.0	
					Personnel Total	$35.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Travel to and attendance of American Society of Mammalogists	0.5	1		0.0	0.5
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.5

FY01

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Personnel
& Travel
DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

Contractual Costs:	Proposed
Description	FY 2001
Contractual Total	$0.0

Commodities Costs:	Proposed
Description	FY 2001
Commodities Total	$0.0

FY01

Prepared:

Project Number:
Project Title: Development, Integration, Analysis, and Publication of Critical Information on Sea Otters in PWS and Adjacent Areas
Name: Lisa M. Rotterman, Ph.D., Enhydra Research

FORM 4B
Contractual & Commodities
DETAIL

2000 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1999 - September 30, 2000

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2001
			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	

FY01

Prepared:

Project Number:
Project Title:
Name:

FORM 4B
Equipment
DETAIL