PROPOSAL SIGNATURE FORM

THIS FORM MUST BE SIGNED BY THE PROPOSED PRINCIPAL INVESTIGATOR AND SUBMITTED ALONG WITH THE PROPOSAL. If the proposal has more than one investigator, this form must be signed by at least one of the investigators, and that investigator will ensure that Trustee Council requirements are followed. Proposals will not be reviewed until this signed form is received by the Trustee Council Office.

By submission of this proposal, I agree to abide by the Trustee Council's data policy (*Trustee Council Data Policy**, adopted July 9, 2002) and reporting requirements *(Procedures for the Preparation and Distribution of Reports***, adopted July 9, 2002).

PROJECT TITLE: Bioavailability and Effects of Lingering Oil to Littleneck Clams (*Protothaca staminea*) and Population Recovery Status in Prince William Sound

Printed Name of PI: Gary Shigenaka

Signature of PI: _____ Date _____

Printed Name of co-PI: Allan K. Fukuyama

Signature of co-PI: _____ Date _____

Printed Name of co-PI: Douglas A. Coats

Signature of co-PI: _____ Date _____

Trustee Council Use Only Project No._____ Date Received: _____

FY07 INVITATION
PROPOSAL SUMMARY PAGE

Project Title: **Bioavailability and Effects of Lingering Oil to Littleneck Clams (*Protothaca staminea*) and Population Recovery Status in Prince William Sound**

Project Period: 1 October 2006 — 30 September 2008

Proposer(s): Gary Shigenaka (NOAA), Allan Fukuyama (University of Washington), and Douglas Coats (Marine Research Specialists)

Study Location: Prince William Sound, AK and Kasitsna Bay, AK

Abstract: We propose to investigate the current status of a key intertidal infaunal organism, the littleneck clam (Protothaca staminea). In doing so, we will determine recovery status of P. staminea across different site impact categories monitored over a long term (1990-2000) by NOAA, and we will also characterize the biological availability of lingering oil at these sites. These results can be evaluated in the context of other EVOSTC projects gauging impacts to and status of clams in the spill-affected area, and ultimately can be used to determine the need for further research or remedial action.

FUNDING: (Includes Trustee Agency 9% G&A)

FY 07 = $ 239.9K

TOTAL EVOS Funding Requested: $ 239.9K

Non-EVOS Funding In-Kind Contributions:

FY 07 = $ 26.0K

TOTAL Non-EVOS Funding In-Kind: $ 26.0K

TOTAL of Combined EVOS & In-Kind: $265.9K

Date: 1 December, 2006

POPULATION RECOVERY STATUS OF LITTLENECK CLAMS (*Protothaca staminea*) IN PRINCE WILLIAM SOUND AND BIOAVAILABILITY OF LINGERING OIL

PROJECT PLAN

NEED FOR THE PROJECT: Statement of Problem

In response to the FY07 EVOS Trustee Council Invitation, NOAA/OR&R proposes to investigate the current status of a key intertidal infaunal organism, the littleneck clam (*Protothaca staminea*). In doing so, we will determine recovery status of *P. staminea* across different site impact categories monitored over a long term (1990-2000) by NOAA, and we will also characterize the biological availability of lingering oil at these sites. These results can be evaluated in the context of other EVOSTC projects gauging impacts to and status of clams in the spill-affected area, and ultimately can be used to determine the need for further research or remedial action.

Between 1990 and 2000, NOAA/OR&R conducted a long-term monitoring program in Prince William Sound to evaluate the effects of both oil and cleanup activities on intertidal communities. The results and details of this effort have been discussed at length elsewhere (see, for example, Houghton et. al., 1996; and Coats et al., 2003). Although a number of consistent long-term trends in impact and recovery were noted over the course of our monitoring, the recovery trajectory exhibited by littleneck clam populations at the surveyed beaches was different and anomalous (Shigenaka et al., 1999; Fukuyama et al., 2000). Unlike many other intertidal resources, the population of these clams exhibited a regularly increasing abundance at impacted sites relative to control sites throughout the sampling. When sampling was discontinued in 2000, populations at control and impacted sites had converged, but there was no evidence that the populations had stabilized. There is an intriguing and as yet unanswered question as to whether impacted clam populations continued to increase after 2000, eventually surpassing populations at control sites. This may have occurred because this organism favors the altered, post-spill habitat with reduced fine sediments. Alternatively, increased survival of these clams may be due to reduced predation or less subsistence collection. In any regard, resampling these sites would allow valuable insight into the current status of the clam populations.

Tissue chemistry results generated in the NOAA/OR&R monitoring effort reflected a declining, level of hydrocarbon exposure to the clams (Roberts et al. 1999). The biological consequences of this exposure were not determined, although Downs et al. (2002) demonstrated through the use of a suite of molecular biomarkers that another clam species (*Mya arenaria*) exposed in situ to lingering *Exxon Valdez* oil was biologically impaired.

In this proposed work, we will address the question of population recovery status relative to the monitoring baseline established between 1990 and 2000, and the biological availability of residual oil 18 years after the *Exxon Valdez* spill. This information will aid the Trustee Council in updating the status of a non-recovered resource, in determining if lingering oil represents a threat to exposed resources, and also in deciding whether remedial or restoration actions are necessary for the littleneck clam stocks judged to be at risk from lingering *Exxon Valdez* oil.

NEED FOR THE PROJECT: Relevance to Trustee Council Goals and Scientific Priorities

The 2007 Invitation for Proposals states the following:

> **In general, the Council seeks proposals that measure the exposure to and effects of recovering or not recovered resources to lingering oil. Additionally, the Council is interested in the recovery process of resources that may not be currently exposed to lingering oil but are still not recovered. Finally, the Council is interested in funding work that directly addresses restoration of human services which are still not considered recovered…**
>
> **…In order to determine if lingering oil is still impacting intertidal communities, the Council seeks proposals that include an ecological risk assessment of the invertebrate infaunal community. Projects should aid in the Council's determination of future restoration strategies, including monitoring or physical removal of the oil.** Additionally, these studies should evaluate the exposure and effects of oil on deep-burrowing invertebrates, because much of the unweathered, more toxic lingering oil remains below the low water line.

Concerning the recovery status of clams, the 2006 Injured Resources and Services Update states:

> *Injury* Clams are widely distributed throughout the oil spill area. They can be found in a variety of substrates and are most abundant in the lower intertidal and subtidal zones. Clams are important prey for various fish and wildlife resources including sea otters, some sea birds, sea ducks and others.
>
> The magnitude of the immediate impacts of oil on clam populations varied depending on species of clam, degree of oiling and location. Although direct mortality of some clam species like littlenecks and butter clams were assessed for several years after the spill, other more sensitive species, (e.g., Macoma and Mya spp) were not the focus of much study, and the immediate impact of the oil to these species remains unknown. In 1990 and 1991, growth of littleneck clams at oiled sites was less than at reference sites, and growth rate was directly proportional to hydrocarbon concentrations. Additionally, mortality was higher and growth rates lower in clams transplanted from oiled areas to clean areas, 5 -7 years after the spill.
>
> Clean-up technologies were detrimental to clam populations and included hot water, high pressure washing, manual and mechanical scrubbing and physical removal of oiled sediments. Hot water washing caused thermal stress, oil dispersal into the water column, animal displacement and burial, and the transportation of fine grain sediment from the upper intertidal into the lower intertidal zone. Early assessments reported that clean-up activities resulted in reductions in clam abundance and distribution on treated (oiled-but-treated) beaches up to three years after the spill.
>
> *Recovery Objective* Clams will have recovered when population and productivity measures (such as size and distribution) at oiled sites are comparable to populations and productivity measures at unoiled sites, taking into account geographic differences.
>
> *Recovery Status* Studies have indicated that abundances of some species of clams were lower on treated beaches through 1996. Densities of littleneck and butter clams were depressed through 1997 on cleaned mixed-sedimentary shores where fine sediments had been washed

down the beach during pressured water treatments.

As part of an investigation of sea otter populations conducted from 1996-1998, researchers compared clam densities between oiled sites on Knight Island and unoiled sites on Montague Island. They reported an increase in mean size of littlenecks and butter clams at Knight Island, where numbers of sea otters, a major predator of clams were significantly reduced. Absolute densities of littlenecks and butter clams were not different between oiled and unoiled sites; however, oiled sites had fewer juvenile clams and lower numbers of other clam species. In 2002, differences in species richness, diversity and abundance of several species were still measurable between cleaned (oiled and treated) and untreated (oiled but untreated) beaches. Moreover, as of 2005, several wildlife species that use the intertidal zone and feed on clams (e.g., harlequin ducks and black oystercatchers) are still being exposed to oil. These resources are included on the injured resources list and although the exact route of oil has not been established for these birds, it is likely they are ingesting oil with their prey.

Some overlap occurs between areas where lingering oil and populations of littleneck and butter clams co-exist. Given the burrowing behavior of these animals, it is likely they would be exposed to oil as they dig into the subsurface sediments known to contain oil. In fact, it has been demonstrated that littleneck clams exposed for a year to the surface layer of contaminated sediments did not accumulate oil, but if the clams were buried in sediments mixed with oil, accumulation did occur.

Clam populations found on oiled but untreated beaches have likely recovered from the effects of the spill. However, several factors continue to impact clam populations on oiled and treated beaches: Abundances and distribution differences are still measurable between cleaned and untreated sites; Lingering oil occurs in habitats with clams, and exposure of clams to oil could result in upper trophic level predators eating contaminated prey; Other species on the injured resources list are still being exposed to oil and are known to forage on clams. **Based on all of the evidence summarized above, clams continue to be recovering, but are not yet fully recovered from the effects of the oil spill.**

Our proposed work is directly relevant to these entreaties and the current state of knowledge, and is consistent with the priorities identified by the Trustee Council for FY2007. Not only will the study compare current abundance levels at beaches monitored continuously between 1990 and 2000 to determine status of recovery using that metric, but it will also characterize current conditions of hydrocarbon exposure and biological availability. This will provide key pieces of information for consideration of the need for restoration strategies in a resource of substantial importance to recovering wildlife resources in the spill-affected region, as well as Alaskan subsistence, recreational, and commercial fishing communities.

Recognizing that these field excursions are rare opportunities to sample the relatively remote Prince William Sound environment, we will also collect additional samples (grain size, total organic carbon) and measurements (age and size distribution, species diversity) to be archived in the event that we identify a project need and are able to expand the scope of the study to address that need.

We believe that the extensive experience and backgrounds of the assembled team provide the capability and the appropriate skills necessary to successfully design and implement a focused research study, and deliver results that will be of interest, importance, and relevance to the Trustee Council and to the public.

PROJECT DESIGN: Introduction

The littleneck clam, *Protothaca staminea*, is a common inhabitant of the lower intertidal zone on well-sheltered Pacific coast beaches and estuaries with a component of mud or sand. It ranges from Cape San Lucas in Baja, California north to the Aleutian Islands in Alaska (Chew and Ma, 1987). Its wide geographic distribution and relative accessibility in the intertidal zone has made *P. staminea* an important commercial and recreational shellfish species. In Washington state, for example, where sheltered bays and the enclosed waters of Puget Sound provide favorable habitat and growing conditions, the littleneck clam is a mainstay of the commercial clam harvest. Between 1990 and 1995, commercial landings averaged 90 metric tons, with an annual value of about $480,000 (NMFS, 1997).

In Prince William Sound, *P. staminea* is frequently encountered on gravel beaches, and the clam is a regular part of the subsistence diet for native villagers residing in the region. According to Stratton and Chisum (1986), in the 1960s hardshell clams were a wintertime staple for residents of the village of Chenega; up to 300 lbs. per household (and a mean of 102 lbs.) were harvested. While butter clams (*Saxidomus gigantea*) constituted the majority of the harvest, littlenecks were also popular. Stratton and Chisum found in a subsequent survey in 1986 that clams remained a desired and harvested subsistence resource, but respondents noted that more effort was required than in the 1960s due to competition stemming from heavy sea otter predation.

The *Exxon Valdez* oil spill affected many beaches with resident populations of littleneck clams. Because of its widespread occurrence in the intertidal environment of Prince William Sound, *P. staminea* has been a key taxon in the infaunal community monitored by NOAA/OR&R in its long-term monitoring of impact and recovery from the spill. The littleneck clam is also of interest due to its role as a recreational and subsistence resource and important prey item for other organisms frequenting the intertidal zone.

A number of researchers have described oil-related effects in *P. staminea*. Anderson et al. (1979) exposed *P. staminea* clams to sediments contaminated with 1237 parts per million (ppm) weathered Prudhoe Bay crude oil for 54 days, and found a survival rate of 85 percent. This compared to a survival rate of only 17 percent in the clam *Macoma inquinata*. In the same experiment, Augenfeld et al. (1980) also described effects of the 54-day exposure to oiled sediments on the condition indices (a ratio of dry tissue weight to shell size) and content of 17 amino acids of the exposed clams. Condition index values declined in both species when exposed to oil, but the relative decrease was greater in *Macoma* than in *P. staminea*. The latter also showed a proportionally smaller decrease in levels of free amino acids when exposed to oil. The researchers attributed the differences in survival, condition index ratios, and amino acid content to the difference in feeding habit and presumed difference in exposure to hydrocarbons: that is, *P. staminea* is a filter feeder, while *Macoma* is a deposit feeder.

Pearson et al. (1981) discussed sublethal behavioral changes in *P. staminea* due to oil exposure that affected their susceptibility to predation by Dungeness crab (*Cancer magister*). They found that crabs ate more clams from oiled sand than from clean sand, and attributed this result to the fact that the clams did not burrow as deeply or as quickly in oiled sand as they did in clean material.

Impacts of the *Exxon Valdez* oil spill were most pronounced in the middle to upper intertidal portions of Prince William Sound beaches, because the oil tended to strand at those elevations and shoreline cleanup was concentrated there. Littleneck clams—generally residing lower in the intertidal and under the surface of the beach substrate—would have been expected to have avoided, to some extent, the habitat disruption from oil exposure and intrusive cleanup techniques. Nevertheless, acute impacts were noted anecdotally during the first year of the spill. Houghton et al. (1996), for example, observed "dead or moribund" *P. staminea* clams on the surface of an oiled and uncleaned beach at the head of the west arm of Northwest Bay in April 1989. After washing of this beach took place in June of 1989, much-reduced clam densities were found, as well as more dead animals and evidence that populations had been buried under layers of washed beach material. These observations suggested immediate impacts to *P. staminea* clams from oil exposure alone, as well as the hydraulic washing technique extensively utilized in the first year of the response.

There is evidence that these acute impacts may have been followed by longer-term injuries to clam populations. A recent study sponsored by the Trustee Council (Lees and Driskell, in preparation) concluded that densities of longer-lived clams remained depressed at oil and cleanup-affected sites in Prince William Sound through 2002. The authors suggested that reduced clam densities decreased the capability and capacity of the impacted areas to support larger predators, such as sea otters, and linked ongoing impacts to disruptions in the armoring layer of beaches.

Between 1990 and 2000, the NOAA/OR&R Prince William Sound Long-Term Monitoring Program documented a consistent pattern of recovery for a number of intertidal biota (see, for example, Coats et al., 2003; and Coats et al., 1999). Between 1990 and 1993, numbers of taxa and other cumulative species parameters exhibited dramatic increases at impacted sites relative to controls. Following these rapid post-disturbance rebounds, changes occurring at oiled sites generally tracked those at the unoiled reference sites. We termed this pattern of similarity in tracking "parallelism," and have suggested it as one way to consider the complex question of recovery in Prince William Sound.

Figure 1 illustrates an example of this pattern for total infaunal abundance. The reasons for examining temporal trends in abundance vs. simple within-year variability become apparent in Figure 1A, which is a $\log_{10}$-transformed plot of infaunal abundance with range limits shown as an indication of variability around the means. This standard data portrayal seems to reflect a degree of annual site category variability too great for meaningful interpretation. However, shifting to analysis of longer-term temporal trends may be more appropriate and enlightening. By doing so, the role of within-year variability is much reduced because the precision of temporal trends is much greater than the precision conveyed by traditional presentations of

single-year variability. Figure 1B illustrates temporal trend analysis for the total infaunal abundance results, with the significance of the differences between impact groups shown for three six-year periods. Note that while the trends over time after 1990 demonstrate a "parallelism" or similarity in pattern that we equate with one form of recovery, the absolute levels of abundance remain depressed at the washed sites through 1997—which could be taken as a sign of *non*-recovery if in fact the key benchmark is absolute convergence with reference levels.

However, one of the key assumptions in the analytical framework established for parallelism is that in the absence of pre-spill data, we cannot assume conditions at the reference sites and the impacted sites were absolutely the same; in fact, systematic environmental differences between control and impacted sites are to be expected for reasons unrelated to oiling or shoreline cleanup. The inherent variability of the Prince William Sound environment has represented one of the major challenges to tracking the signal of disturbance over a longer time frame. For any given group of ostensibly similar sites, it is possible that some combination of orientation, circulation, fetch or other external factor would shift abundance or number of taxa or any other metric we choose to monitor up or down, and because these differences cannot be randomized, recovery assessments based on direct comparison of levels at control and impacted sites cannot be statistically supported. Parallelism assumes that while absolute values may not be directly comparable for the purposes of recovery determination, trends over time can be used to determine when communities or conditions at sites are responding to larger environmental influences in similar ways. Thus, we use parallel trends over time as one indication of recovery.

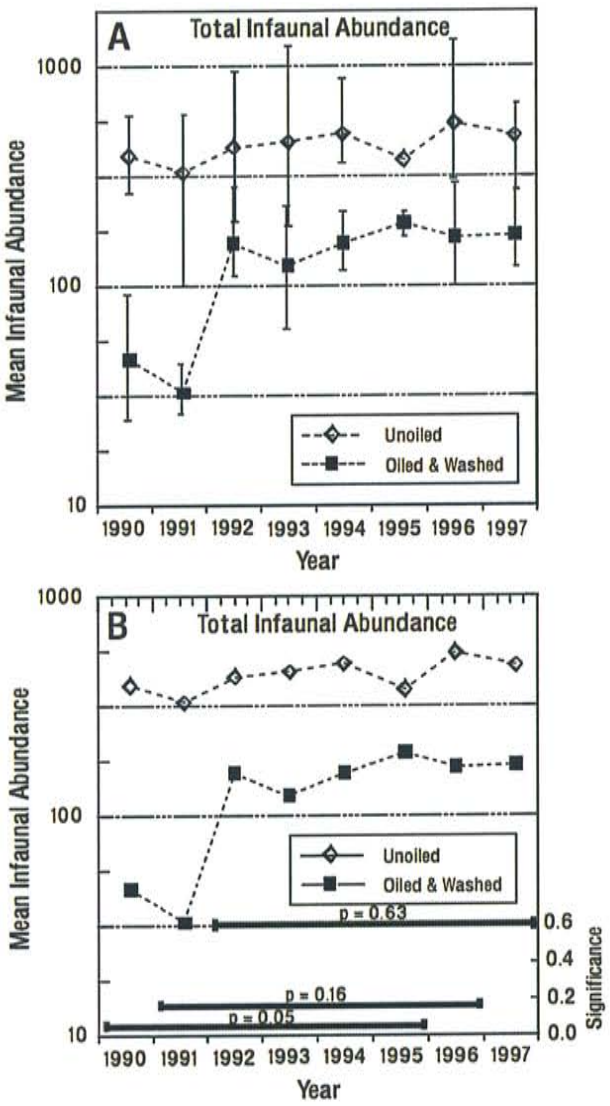

Figure 1. Mean infaunal abundance at unoiled and oiled/washed NOAA/HAZMAT monitoring sites, 1990-1997. Note log scale for y-axes. (A) includes range limits and illustrates inherent advantages of temporal trend analysis over analysis of within-year variability; (B) portrays standard presentation for temporal trend analysis (parallelism) with significance plots over six-year time periods.

In analyzing the large amount of data collected in the NOAA/OR&R monitoring program, the consistency with which parallelism occurs has been impressive, across many intertidal organisms, both epibiotic and infaunal. Yet, while this kind of pattern is common, that for

littleneck clams is an exception. Specifically, *P. staminea* did not show the immediate depression in numbers followed by a burst of recruitment at impacted sites in the first few years; and also did not reflect the initial lack of parallelism with reference sites described above and in Figure 1. In fact, clams at the oiled/washed sites show a remarkably similar pattern of abundance to clams at unoiled reference sites from the beginning of the monitoring effort (Figure 2). However, the differences in absolute mean abundance of clams at oiled/washed sites and unoiled reference sites resembles the differences noted for total infaunal abundance in Figure 1.

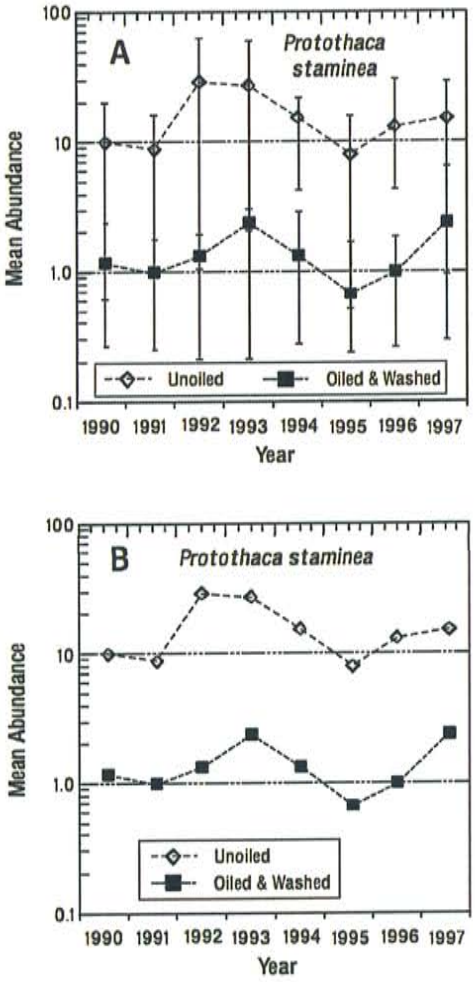

Figure 2. Mean abundance of *Protothaca staminea* at unoiled and oiled/washed NOAA/HAZMAT monitoring sites, 1990-1997. Note log scale for y-axes. (A) includes range limits and illustrates inherent advantages of temporal trend analysis over analysis of within-year variability (see text).

In this case, it is possible that these clam abundance data and the absolute differences between control and impacted (oiled and washed) sites reflect a spill impact. Despite the similarities in the time trends between clams at unoiled and oiled/washed sites (Figure 2), a closer examination of the recent results suggests that the *P. staminea* populations at the impacted sites may actually be reflecting a slow and subtle recovery in absolute abundance. Specifically, the abundance data for unoiled sites and for oiled/washed sites steadily converged beginning in 1992 (Figure 3).

Abundance trends for *P. staminea* showed significant differences between unoiled and oiled/washed populations over much of the monitoring period (Fig. 3b). Impacts to *P. staminea* populations at oiled/washed sites were documented by Shigenaka et al. (1999), who concluded that oil and shoreline cleanup activities resulted in adverse impacts reflected by abundance levels and tissue chemistry results.

By the year 2000, however, abundances in core samples appeared to finally converge (Fig. 3a). Based upon an endpoint of absolute convergence, *P. staminea* populations might have been considered to have recovered. But from a parallelism standpoint, divergent population trends were still apparent in 2000 (Fig. 3c). Unfortunately, the long-term monitoring program transitioned to a new phase in 2000 and clam sampling did not take place. *Therefore, we do not know if the populations stabilized after 2000, or if abundance trends continued to show divergent patterns. The sampling we have proposed for FY2007 would permit us to answer this lingering question about recovery status for littleneck clams.*

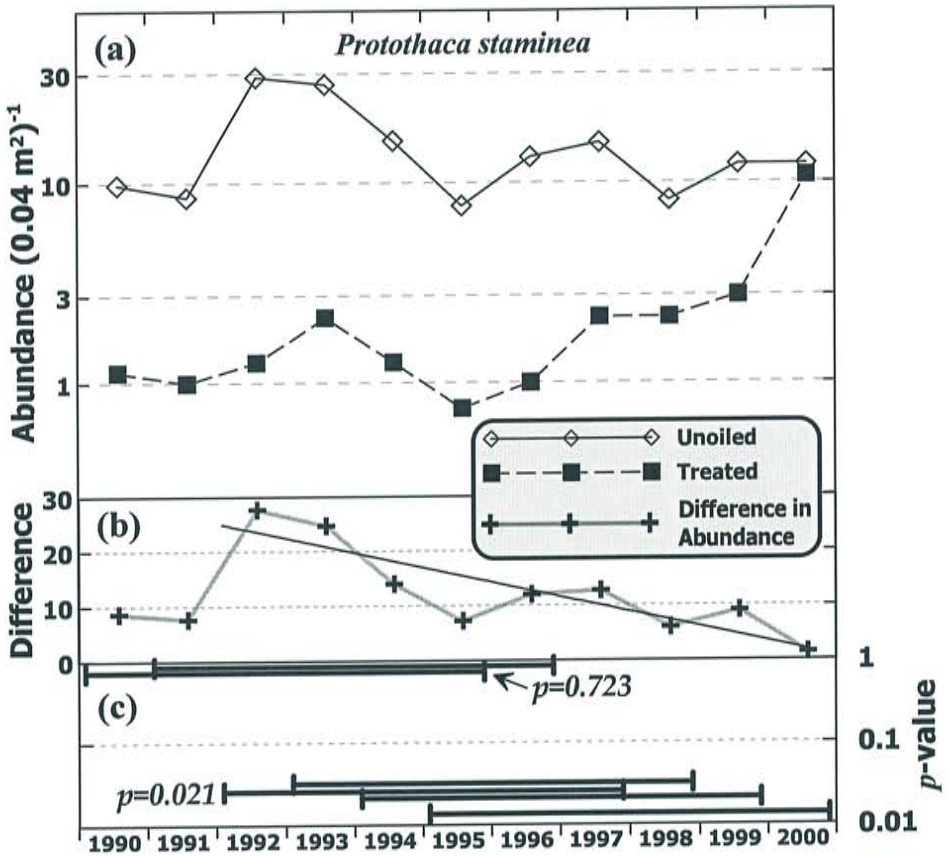

Figure 3. Trends in *P. staminea* populations at unoiled sites and sites that were oiled and washed, 1990-2000. (a) shows trends in abundance; (b) same data, plotted as differences between unoiled and oiled/washed; (c) strength of trend over 6-year time periods.

The NOAA monitoring data suggested a spill-related impact to clams in Prince William Sound, and other measurements we generated in support of that program supported that conclusion. Shigenaka et al. (1999) summarized clam-related results through that time and concluded that *P. staminea* monitored in the effort reflected ongoing impacts from the spill. For example, tissue

chemistry results showed large declines in aromatic hydrocarbon concentrations between 1990 and 1992. However, statistically significant differences between results for oiled sites and unoiled sites remained until at least 1997.

The sum of the information generated from our study will provide a the basis from which the Trustees will be able to consider status of clam population recovery, health impacts from lingering oil, and the risk to consuming populations—both wildlife and human.

PROJECT DESIGN: Objectives

Our overall objectives for the study are to provide relevant, meaningful scientific information that will contribute to discussions about recovery status and biological availability of lingering oil. This information is intended for use by the Trustees in their consideration of recovery status for an important intertidal resource and the need for restoration or remediation as it pertains to littleneck clams. To these ends, we will test the following hypotheses:

- **Using recovery metrics from the 1990-2000 NOAA monitoring program, littleneck clam populations at surveyed sites have attained recovery endpoints in 2007.**
- **No significant differences in chemistry (tissue levels or distribution of hydrocarbons) can be discerned in clams collected at oiled and unoiled sites in Prince William Sound.**

We will meet our stated objectives and test the hypotheses through the following discrete activities:

1. Measure current abundance levels of littleneck clams at 10 sites in Prince William Sound surveyed between 1990 and 2000 and determine if current conditions reflect a "recovered" or "recovering" status;
2. Measure sediment and tissue hydrocarbon levels at oiled and unoiled locations in Prince William Sound;

Secondary project objectives

The scope of the project is designed to address the primary objectives listed above. However, we will also collect and archive additional samples and measurements to permit us to explore other questions—if we identify a scientific justification, and if the budget permits. For example, we will collect and archive sediment grain size core samples and will enumerate population metrics for other bivalve species at the project sites. If there appear to be rationale for investigating additional questions and the budget will support it, we will proceed with processing and analysis.

PROJECT DESIGN: Procedural and Scientific Methods

As noted above, our overall objectives for the study are to provide relevant and meaningful scientific information that will contribute to discussions about recovery status and biological availability of lingering oil, and the need for restoration or remediation as it pertains to littleneck clams.

Recovery status

In order to evaluate the current recovery status of *P. staminea* clams at sites monitored over the long-term, we will repeat the clam survey procedures used in the 1990-2000 NOAA program. Specifically, we will revisit the ten original locations by vessel in July 2007. At each site, the previously surveyed lower intertidal transect will be relocated. Four 0.25 m^2 quadrats will be excavated (taking care to not sample areas excavated in the past). Excavated clams will be used

for size and age analysis and tissue metrics. We will also take five random cores along the same transect using a modified hand-held cylindrical clam gun. The corer, 10.5 cm in diameter by 15 cm in length, samples an area of 0.009 m^2. Cores will be sieved through a 1.0 mm screen and all clams encountered will be reserved for analysis.

In 2007, we propose to resample the sites to answer the population abundance-level question. Core samples will be collected at ten sites we monitored between 1990 and 2000, numbers of littleneck clams will be determined, and the results analyzed against the existing data to determine status of *P. staminea* population recovery. The statistical basis for analyzing field results is discussed in detail in Coats et al. (2003).

Biological availability of lingering oil

This will be evaluated in the field and in the laboratory by collecting and analyzing sediments from oiled and unoiled beaches where clams are sampled, and pairing the sediments with tissue hydrocarbon analyses. Chemical analysis will utilize gas chromatography/flame ionization detector and gas chromatography/mass spectrometry.

Clam samples will be excised from the shell using an acetone-cleaned stainless steel scalpel. Each sample will then be stored in a separate pre-cleaned Teflon tube with a Teflon lid and flash frozen in liquid nitrogen cryo-shipper. Samples will remain frozen until extraction can occur. Extraction will be done using modified NOAA Status and Trends protocols (Lauenstein and Cantillo 1998). An aliquot from each sample will be removed for moisture content analysis. Approximately 5-10 g will be weighed out to the nearest 0.1 g and placed into a glass beaker with 50 g of solvent washed sodium sulfate and homogenized with a tissumizer for 2 minutes. Appropriate polycyclic aromatic hydrocarbon (PAH) internal standards will then be added along with 100 ml dichloromethane, sonicated for 3 minutes and decanted into 500 ml round bottom flask using a glass funnel with glass wool topped with sodium sulfate. Extraction will be repeated twice more with 75 ml dichloromethane each and decanted. The combined organic phases will then evaporated to near dryness, and re-dissolved in 1 ml hexane. The extracts will be further purified by silica gel-alumina column chromatography. Field blanks, laboratory blanks, matrix spikes and duplicates will be included for each set of samples collected.

All extracts will be analyzed by combined gas chromatography–mass spectrometry (GCMS) using a Varian Saturn II GCMS equipped with a 30 m DB-5 fused silica column for qualitative and quantitative identification of 37 individual PAH's including parent compounds and homologues. Oven temperature program will be held at 50°C for two minutes and then programmed from 50°C to 280°C at 6°C min-1 and held at 280°C for 15 minutes with helium as the carrier gas. The mass spectrometer will scan from mass 40-500 in 0.5 sec at an ionization potential of 70 eV. All mass spectral data will be compared to spectra produced by authentic standards and to previously published library spectra and by quantifying the base peak ion of each PAH against the base peak of the internal standard. The laboratory minimum detectable amounts have been calculated at 100 ng/g of extracted tissue samples. Laboratory analytical precision has been previously determined in our laboratory by making replicate injections of PAH standards to ascertain reproducibility. Standard deviations for the standards used indicated a maximum laboratory error of ± 11%, and an average standard deviation of ± 3%.

Description of Study Area

Field sampling for the project will take place in Prince William Sound, AK. Biological analysis of samples will occur at the Edmonds, WA, laboratory facility of Fukuyama-Hironaka Taxonomic and Environmental. Should project requirements dictate the need for physical characterization of sediments (grain size, total organic carbon), analyses would take place in lab facilities of Marine Research Specialists (MRS) in Ventura, CA. Finally, chemical processing and analysis will take place at the Institute for Environmental Studies of Louisiana State University in Baton Rouge, LA.

The previously monitored clam collection locations in the Sound are:

Outside Bay:	60°38'17"N 147°27'02"W
Sheep Bay:	60°41'06"N 145°56'22"W
Bainbridge Bight:	60°06'59"N 148°14'48"W
Snug Harbor:	60°15'43"N 147°45'57"W
Herring Bay:	60°27'25"N 147°42'30"W
Mussel Beach:	60°32'10"N 147°36'56"W
Northwest Bay West Arm:	60°32'38"N 147°36'09"W
Shelter Bay:	60°07'06"N 147°57'24"W
Sleepy Bay:	60°03'56"N 147°50'08"W
Block Island:	60°31'48"N 147°36'24"W

SCHEDULE: Project Milestones

Objective 1. Assess *P. staminea* population recovery status
To be met by December 2007
Objective 2. Determine biological availability of lingering oil
To be met by December 2007

SCHEDULE: Measurable Project Tasks

FY07, 1st quarter (October 1, 2006-December 31, 2006)
November: Project funding approved by Trustee Council
FY07, 2nd quarter (January 1, 2007-March 31, 2007)
Project funding received by program office
Project contracts finalized
FY07, 3rd quarter (April 1, 2007-June 30, 2007)
Gear and supplies purchased and shipped to field staging area (Cordova or Anchorage)
FY07, 4th quarter (July 1, 2007-September 30, 2007)
July 9-18: Field work in Prince William Sound
Ship field samples to appropriate analytical facility
Begin laboratory analyses
FY08, 1st quarter (October 1, 2007-December 31, 2007)
Complete laboratory analyses
Begin statistical analysis
FY08, 2nd quarter (January 1, 2008-March 31, 2008)
January 23-27 Annual Marine Science Symposium
January-March: continue analysis

FY08, 3rd quarter (April 1, 2008-June 30, 2008)
Begin report writing
FY08, 4th quarter (July 1, 2008-September 30, 2008)
June-August: Report writing.
September 30: Submit final report to Trustee Council Office.

Incorporation and involvement of local commercial resources

It is our intent and preference to charter the vessel for our July collections in Prince William Sound locally, either in Prince William Sound or Cook Inlet. We have contacted the operators of the vessels Auklet (based in Cordova) and Babkin (based in Anchorage) to determine availability for our field work.

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Chew, K.K. and A.P. Ma. 1987. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest)—common littleneck clam. U.S. Fish and Wildlife Service Biological Report 82(11.78). U.S. Army Corps of Engineers, TR EL-82-4. 22 pp.

Coats, D.A., E. Imamura, A.K. Fukuyama, J.R. Skalski, S. Kimura, and J. Steinbeck. 1999. Monitoring of biological recovery of Prince William Sound intertidal sites impacted by the Exxon Valdez oil spill—1997 biological monitoring survey. NOAA Technical Memorandum NOS OR&R 1. 73 pp. + appendices.

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Downs, C.A., G. Shigenaka, J.E. Fauth, C.E. Robinson, and A. Huang. 2002. Cellular-physiological assessment of bivalves after chronic exposure to spilled *Exxon Valdez* crude oil using a novel molecular diagnostic biotechnology. Environ. Sci. Technol. 36: 2987-2993.

Downs, C.A.. 2005. Cellular diagnostics and its application to aquatic and marine toxicology. In: Techniques in Aquatic Toxicology, vol. 2: G. Ostrander (ed.). CRC Press, Inc. Boca Raton, Florida.

Fukuyama A.K., G. Shigenaka, and R.Z. Hoff. 2000. Effects of residual *Exxon Valdez* oil on intertidal *Protothaca staminea*: mortality, growth, and bioaccumulation of hydrocarbons in transplanted clams. Mar Poll Bull 40:1042-1050

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Lees, D.C. and W.B. Driskell. 2006. Assessment of bivalve recovery on treated mixed-soft beaches in western Prince William Sound. Presented at 2006 Marine Science in Alaska Symposium, January 11-25 2006, Anchorage AK.

National Marine Fisheries Service (NMFS). 1997. Fisheries of the United States, 1996. Website address http://remora.ssp.nmfs.gov/fus/fus96/index.html. Current Fishery Statistics No. 9600.

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 CH (2001) The "*Exxon Valdez*" oil spill in Alaska: acute, indirect and chronic effects on the ecosystem. Adv Mar Biol 39:1-103

Peterson CH, Rice SD, Short JW, Esler D, Bodkin JL, Ballachey BE, Irons DB (2003) Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302:2082-2086

Roberts, P.O., C.B. Henry Jr., G. Shigenaka, and A.K. Fukuyama. 1999. Weathered petroleum "bioavailability" to intertidal bivalve species after the T/V *Exxon Valdez* incident. 1999 Oil Spill Conference Proc., Seattle, WA. Pp. 1002-1005.

Shigenaka G, Coats DA, Fukuyama AK, Roberts PO (1999) Effects and trends in littleneck clams (*Protothaca staminea*) impacted by the *Exxon Valdez* oil spill. Paper ID #326, Proc of the 1999 International Oil Spill Conference, Seattle, American Petroleum Institute, Washington DC, p 349-356

Stratton, L. and E.B. Chisum. 1986. Resource use patterns in Chenega, western Prince William Sound: Chenega in the 1960s and Chenega Bay 1984-1986. Technical Paper No. 139. Anchorage: Alaska Department of Fish and Game, Division of Subsistence, 161 pp.

RESUMES OF PRINCIPAL INVESTIGATORS - COATS

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MARINE RESEARCH SPECIALISTS
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EDUCATION

Ph.D.	Oceanography, Scripps Institution of Oceanography	1982
M.S.	Oceanography, Scripps Institution of Oceanography	1979
B.S.	Physics, California State Polytechnic University at Pomona	1975

SUMMARY OF EXPERIENCE

Over the past 25 years, Dr. Coats has applied quantitative interdisciplinary field sampling and analyses to resolve a wide variety of complex marine environmental issues. He specializes in the application of multivariate statistical techniques to interrelate biological, physical, and chemical measurements of the marine environment. Most of his studies have culminated in peer-reviewed scientific publications. Graduate-level training at Scripps Institution of Oceanography focused on field sampling and quantitative data analysis founded on formal coursework in all aspects of biological, chemical, physical, and geological oceanography. As part of his dissertation, Dr. Coats collected and analyzed data from a two-month trans-Pacific oceanographic expedition. His resulting description of new aspects of the Pacific flow field were published as part of a Master's Thesis, Ph.D. Dissertation, and two peer-reviewed publications. Dr. Coats has prepared numerous marine environmental assessments dealing with controversial projects such as oil-spill remediation activities, coastal development, point-source discharges, offshore fiber-optic cable installation, and the development of offshore oil fields. All required definitive analysis of available biological and water-quality data in order to support conclusions as to the significance of potential impacts. In a many cases, he conducted offshore surveys to fill-in data gaps.

Principal Investigator and Program Manager for Assessing the Long-Term Recovery Intertidal Organisms after the *Exxon Valdez* Oil Spill. Dr. Coats was one of the principal investigators for NOAA's study of the recovery of intertidal environment after the *Exxon Valdez* oil spill in Prince William Sound Alaska. In addition to his responsibilities for managing the overall program, Dr. Coats was responsible for applying innovative statistical techniques to the vast amount of field biological data collected over the course of the study. This led to explicit determinations of the recovery of the biological and physical environment, and to statistical power analyses that guide the rigorous design of intertidal sampling programs in general. In addition to his lead authorship of widely distributed NOAA reports, his efforts have culminated in the publication of several peer-reviewed scientific publications. He continues to be the program manager for intertidal clearing experiments that have been conducted in Prince William Sound and Kasitsna Bay between 2000 and 2006. The investigative field experiments were motivated by unresolved questions about intertidal recovery that arose from the analysis of the spill monitoring data. He also conducted statistical power analysis on the extensive intertidal dataset to establish strategies and guidelines for sampling size when conducting intertidal monitoring.

SELECTED PUBLICATIONS AND REPORTS

Fukuyama, A.K., D. Coats, and G. Shigenaka. (in preparation). **Impacts and Long-Term Recovery of Infaunal Intertidal Organisms after the Exxon Valdez Oil Spill.**

Skalski, J.R., J.J. Millspaugh, C. Cooper, and D.A. Coats. 2006. **A Statistical Test and Sample Size Calculations for Differences in Ecological Community Composition Based on Analysis of Distance (ANODIS).** Submitted to the Journal of Agricultural, Biological and Environmental Statistics.

Coats, D.A., and G. Shigenaka. 2005. **Sampling Needed to Assess Intertidal Impacts: Lessons Learned from 11 Years of Monitoring in Prince William Sound.** Proceedings of the International Oil-Spill Conference, Miami, Florida. A75:3.

Coats, D.A., E. Imamura, A.K. Fukuyama, J.R. Skalski, S. Kimura and J. Steinbeck. 2003. **Monitoring of Biological Recovery of Prince William Sound Intertidal Sites Impacted by the *Exxon Valdez* Oil Spill: Sampling Effort in Assessments of Oil-Spill Impacts to Intertidal Organisms.** Edited By: G. Shigenaka and R. Hoff. NOAA Technical Memorandum NOS OR&R 12, August 2003.

Skalski, J.R., D.A. Coats, and A.K. Fukuyama. 2001. **Criteria for Oil Spill Recovery: A Case Study of the Intertidal Community of Prince William Sound, Alaska, following the *Exxon Valdez* Oil Spill**. Environmental Management, Vol. 28, No. 1, pp 9-18.

Shigenaka, G., D.A. Coats, A.K. Fukuyama, P.O. Roberts. 1999. **Effects and trends in littleneck clams (*Protothaca staminea*) impacted by the *Exxon Valdez* oil spill**. Proceedings of the 1999 International Oil Spill Conference. Paper ID #326.

Coats, D. A., E. Imamura, A. K. Fukuyama, J. R. Skalski, S. Kimura, and J. Steinbeck. 1999. **Monitoring of biological recovery of Prince William Sound intertidal sites impacted by the *Exxon Valdez* oil spill.** NOAA Technical Memorandum NOS OR&R 1, Final report. Prepared for Hazardous Materials Response and Assessment Division, Seattle: NOAA. 73 pp. + Appendices

Coats, D.A. 1994. **Deposition of Drilling Particulates Offshore Point Conception California,** Marine Environmental Research. Vol. 37(1994): 95-127.

Hyland, J., D. Hardin, M. Steinhauer, D. Coats, R. Green, and J. Neff, 1994. *Environmental Impact of* **Offshore Oil Development on the Outer Continental Shelf and Slope off Point Arguello, California,** Marine Environmental Research. Vol. 37(1994): 195-229.

RECENT COLLABORATIONS

Cooper, Cynthia at Quantitative Ecology and Resource Management, University of Washington
Fukuyama, Allan at Fukuyama/Hironaka Taxonomic & Environmental Services
Hoff, Rebecca at NOAA, OR&R
Imamura, Eiji at Marine Research Specialists
Kimura, Scott at Tenera, Inc.
Klinger, Terrie at School of Marine Affairs, University of Washington
Luke, Bonnie at Marine Research Specialists
Millspaugh, Joshua at Department of Fisheries and Wildlife Sciences, University of Missouri
Shigenaka, Gary at NOAA, OR&R
Skalski, John at School of Aquatic and Fishery Sciences, University of Washington
Steinbeck, John at Tenera, Inc.
Word, Jack at Weston Solutions, Inc.

RESUMES OF PRINCIPAL INVESTIGATORS – FUKUYAMA

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EDUCATION

Ph.D. 2000. University of Washington, School of Aquatic and Fishery Science. Dissertation title: "The Ecology of Bivalve Communities in Prince William Sound, Alaska: Influence of the *Exxon Valdez* Oil Spill and Predation by Sea Otters." 360 pp.

M.A. 1985. Biological Sciences, San Francisco State University and Moss Landing Marine Laboratories. Thesis title: " The Effects of Sea Star and Walrus Predation on Bivalves in Norton Sound, Alaska." 68 pp.

B.S. 1973. Zoology, University of California, Davis.

EXPERIENCE

1993-present. Co-owner Fukuyama/Hironaka Taxonomic & Environmental Services. Marine Biologist and Marine Invertebrate Taxonomist. Sole proprietorship providing invertebrate taxonomy and environmental monitoring and assessment services.

2002 to 2004. Research Associate, University of Washington. Field sampling, preparation for field sampling, and data analyses for EMAP Alaska Program. Currently investigating effects of geoduck harvesting on benthic communities of Puget Sound using benthic corers and transects.

1991-1993. Pentec Environmental Services, Marine Biologist and Laboratory Manager. Responsible for daily management of laboratory samples including benthic, epifaunal, planktonic, and stomach samples.

1985-1991 Marine Biologist, Subtask Leader, TENERA Environmental Services project for Pacific Gas and Electric Company, Diablo Canyon Power Plant to assess thermal impacts on marine communities. Specialized in intertidal and subtidal invertebrate taxonomy of molluscan species.

1980-1985. Graduate Student, Moss Landing Marine Laboratories and San Francisco State University. Thesis: Sea star and walrus predation on bivalves in Norton Sound, Bering Sea, Alaska; funded by the National Science Foundation for three years.

1978-1980. Fishery Biologist, National Marine Fisheries Service, Kodiak, Alaska. Research on population dynamics of king crabs and pandalid shrimps.

1977-1978. Biological Technician, U.S. Fish and Wildlife Service, Anchorage, Alaska. Identification of prey from seabird and shorebird guts from south central Alaska.

1974-1976. Research Associate, Oregon State University, School of Oceanography, Corvallis, Oregon. Identification of benthic animals and fishes from grab samples at the mouth of the Columbia River, Oregon.

PUBLICATIONS

J.L. Bodkin, B.E. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L. McDonald,

D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Sea otter population status and the process of recovery from the 1989 *Exxon Valdez* oil spill. Mar. Ecol. Progr. Ser. 241:237-253.

Dean, T.A., J.L. Bodkin, A.K. Fukuyama, S.C. Jewett, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Food limitation and the recovery of sea otters following the *Exxon Valdez* oil spill. Mar. Ecol. Progr. Ser. 241:255-270.

Skalski, J.R., D.A. Coats, and A.K. Fukuyama. 2001 Criteria for oil spill recovery: a case study of the intertidal community of Prince William Sound, Alaska following the *Exxon Valdez* oil spill. J. Environ. Mgmt. 28(1):9-18.

Fukuyama, A.K., G. Shigenaka, and R.Z. Hoff. 2000. Effects of residual *Exxon Valdez* oil on intertidal *Protothaca staminea*: mortality, growth, and bioaccumulation of hydrocarbons in transplanted clams. Marine Pollution Bulletin 40(11):1042-1050.

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

PUBLICATIONS (non-refereed)

Shigenaka, G., D.A. Coats, A.K. Fukuyama, and P.O. Roberts. 1999. Effects and trends in littleneck clams (*Protothaca staminea*) impacted by the *Exxon Valdez* oil spill. 1999 Oil Spill Conference Proc., Seattle, WA. Pp. 349-356.

Roberts, P.O., C.B. Henry Jr., G. Shigenaka, and A.K. Fukuyama. 1999. Weathered petroleum "bioavailability" to intertidal bivalve species after the T/V *Exxon Valdez* incident. 1999 Oil Spill Conference Proc., Seattle, WA. Pp. 1002-1005.

Coats, D.A., E. Imamura, A.K. Fukuyama, J.R. Skalski, S. Kimura, and J. Steinbeck. 1998. Monitoring of biological recovery of Prince William Sound intertidal sites impacted by the *Exxon Valdez* oil spill. NOAA Tech. Memo. NOS OR&R 1, NOAA HazMat, Seattle, WA. 73 pp.

Fukuyama, A.K., G. Shigenaka and G.R. VanBlaricom. 1998. Oil spill impacts and the biological basis for response guidance: an applied synthesis of research on three subarctic intertidal communities. NOAA Tech. Memorandum NOS ORCA 125; NOAA HazMat, Seattle, WA. 73 pp.

Fukuyama, A.K. and G.R. VanBlaricom. 1996. Literature review of the effects of oil and oil spills on Arctic and North temperate intertidal and shallow subtidal ecosystems. NOAA Tech. Memorandum NOS ORCA 103. NOAA HazMat, Seattle, WA. 124 pp.

COLLABORATORS

Mr. James Bodkin	US Geological Survey; Anchorage, AK.
Dr. Douglas Coats	Marine Research Specialists; Ventura, WA.
Dr. Terrie Klinger	University of Washington; Seattle, WA.
Mr. Gary Shigenaka	NOAA HazMat; Seattle, WA.
Dr. Glenn VanBlaricom	University of Washington; Seattle, WA.

RESUMES OF PRINCIPAL INVESTIGATORS – SHIGENAKA

GARY SHIGENAKA
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• SUMMARY •

Graduate of the University of Washington with degrees in marine policy and biological oceanography. Professional interests and experience include marine ecology, effects of marine pollution and hazardous waste in coastal environments, and related decision-making processes. Knowledgeable about assessment of aquatic and marine habitats and the effects of acute and chronic contamination. Extensive field research experience. Supervisory and administrative expertise, with contract and program management skills. Skilled in technical writing, teaching and educational outreach, and communication of scientific information. Oddball sense of humor, eclectic tastes in food, beverage, art and music.

• EDUCATION •

Master of Marine Affairs, Marine Environmental Policy
Institute for Marine Studies, University of Washington, 1987

Thesis title: *Implementation Analysis and Nonpoint Source Pollution: An Application in Puget Sound*
Donald L. McKernan Award for Outstanding Marine Affairs Thesis, 1988

Bachelor of Science, Biological Oceanography
Department of Oceanography, University of Washington, 1976

• PROFESSIONAL EXPERIENCE •

Marine Biologist - 2/90 to present
NOAA, Office of Response and Restoration, Hazardous Materials Response Division. Senior biologist, providing biological fate and effects guidance for oil spill response. Evaluate effectiveness and environmental effects of spill countermeasures. Contract manager for long-term shoreline recovery monitoring & research program, 1991-present. Domestic responses: *Exxon Valdez* (Alaska, 1989-91); *Tenyo Maru* (Washington, 1991); *Morris J. Berman* (Puerto Rico, 1994); Roosevelt Roads Naval Air Station (Puerto Rico, 1999); *New Carissa* (Oregon, 1999); *Athos 1* (Pennsylvania, 2004); *Selendang Ayu* (Alaska, 2005-6); Hurricanes Katrina/Rita (2005-6). International responses: *Nakhodka* (Japan, 1997); *Prestige* (Spain, 2002). Spill monitoring & research in Newfoundland & Chile. Dept. of Commerce representative to Northwest Regional Response Team, 2005-. Instructor in oil spill-related classes. Certification in Helicopter Emergency Egress Device survival training (2005), first aid, CPR, small boat safety.

Oceanographer - 8/87 to 2/90
NOAA, Ocean Assessments Division, Coastal and Estuarine Assessments Branch, Pacific Office. Scientific team responsible for documenting and interpreting status and recent trends of U.S. marine environmental quality. Prepared assessments and technical publications focusing on specific coastal regions and on specific contaminants of concern. Synthesized relevant data from multiple sources, published literature, analyzed and interpreted data to provide insights into marine environmental quality. Presented and published papers at professional meetings and peer-reviewed literature. Field party chief aboard research cruises.

Physical Scientist - 1/86 to 8/87
NOAA, Ocean Assessments Division, National Status and Trends Program. Multidisciplinary team of scientists responsible for documenting current status and recent trends in U.S. marine environmental quality. Interpreted results of chemical and biological analyses for audiences ranging from lay to technical. Designed, implemented, and maintained computer databases of national analytical data. Assisted in coordination of sediment biological effects study in San Francisco Bay. Reviewed research proposals for interagency environmental assessments. Written products included technical reports with production of associated graphics; briefing materials for congressional hearings; press releases detailing program activities.

Chief Biological Survey Technician - 3/79 to 12/84
NOAA Ship *Miller Freeman*, National Ocean Service research vessel. Shipboard support for field sampling activities in coastal and deep water research projects. Department supervisor. Technical: instrument deployment, data processing, graphics support, computer program development. Administrative: personnel actions, departmental budget preparation and oversight, interdepartmental coordination, and report production. Certified and served as medical technician.

Biological Technician - 10/78 to 3/79
National Marine Fisheries Service, Resource Ecology & Fisheries Management Division; and Resource Assessment & Conservation Engineering Division. Field data collection and processing in Gulf of Alaska icthyoplankton and groundfish surveys. Deployment of remote sampling equipment and collection of basic population data on groundfish stocks. Laboratory taxonomic work with X-ray identification of juvenile fish.

• PROFESSIONAL EXPERIENCE - continued •

Fisheries Biologist/Foreign Fisheries Observer - 2/78 to 10/78; 2/77 to 9/77
National Marine Fisheries Service, Foreign Fisheries Observer Program. U.S. Government representative during two field seasons aboard M.V. *Keiko Maru*, Japanese (Nippon Suisan Corporation) tanner crab factoryship in U.S. Bering Sea working grounds. Observed mothership operations, verified daily fleet catch totals, and collected biological information on resource. Independent research on commensal turbellarian in crab population.

Scientific Aide - 8/76 to 12/76
Washington Department of Fisheries, Research & Development Division. Constructed and tested experimental salmon trap in Budd Inlet, Puget Sound. Conducted stream surveys for spawning salmon. Operated Deschutes River fish ladder, Tumwater, WA, to monitor movements of tagged salmon. Worked with U.S. Army Corps of Engineers at Wynoochee Dam Project to facilitate return migration of coho salmon. Laboratory work removing coded wire tags from sport- and commercially-caught salmon.

Oceanographic Technician - 7/75 to 12/75
University of Washington, Department of Oceanography. Field data collection and processing for U.S. Navy contract study of zooplankton and myctophid fish component of Deep Scattering Layer in north Pacific Ocean, aboard R.V. *Thomas G. Thompson*. Laboratory work identifying and sorting decapod shrimp in plankton samples.

• RECOGNITION AND AWARDS •

- U.S. Department of Commerce, NOAA, recognition and awards:
  - Special Service Award, Hurricanes Katrina & Rita response (2006)
  - Bronze Medal group award, *Athos 1* response (2005)
  - Individual Award, *Selendang Ayu* response (2005)
  - NOAA Spectrum Diversity Award (2005)
  - (10 NOAA awards & commendations, 1979-1994, details available upon request)
- U.S. Coast Guard, recognition and awards:
  - Meritorious Team Commendation, 2005 (*Athos 1* response); 2001a (International Oil Spill Conference Program Team); 2001b (Tankship *Jessica* International Response Coordination Team)

• REFERENCES (RELATED TO PROPOSAL) •

Downs, C.A., G. Shigenaka, J.E. Fauth, C.E. Robinson, and A. Huang A. 2002. Cellular physiological assessment of bivalves after chronic exposure to spilled *Exxon Valdez* crude oil using a novel molecular diagnostic biotechnology. Environ Sci Technol 36:2987-2993.

Fukuyama, A.K., D.A. Coats, and G. Shigenaka. In progress. Recovery of intertidal infaunal communities from the *Exxon Valdez* oil spill in Prince William Sound, Alaska

Fukuyama, A.K., G. Shigenaka, and G.R. Van Blaricom. 1998. Oil spill impacts and the biological basis for response guidance: An applied synthesis of research on three subarctic intertidal communities. NOAA Technical Memorandum NOS ORCA 125, 73 pp.

Fukuyama A.K., G. Shigenaka, and R.Z. Hoff. 2000. Effects of residual *Exxon Valdez* oil on intertidal *Protothaca staminea*: mortality, growth, and bioaccumulation of hydrocarbons in transplanted clams. Mar Poll Bull 40:1042-1050.

Shigenaka, G., D.A. Coats, A.K. Fukuyama, and P.O. Roberts. 1999. Effects and trends in littleneck clams (*Protothaca staminea*) impacted by the *Exxon Valdez* oil spill. Paper ID #326, Proc of the 1999 International Oil Spill Conference, Seattle, American Petroleum Institute, Washington DC, p 349-356

• REFERENCES (OTHER) •

Driskell, W.B., J.R. Payne, and G. Shigenaka. 2005. Revisiting source identification, weathering models, and phase discrimination for Exxon Valdez oil. In Proceedings of the Twenty-Eighth Arctic and Marine Oilspill Program (AMOP) technical Seminar, June 7-9 2005, Calgary (Alberta) Canada, 33-58.

Shigenaka, G. (ed.). 1997. Integrating physical and biological studies of recovery from the *Exxon Valdez* oil spill. NOAA Technical Memorandum NOS ORCA 114, 206 pp. + appendix.

Shigenaka, G.. 2001. Toxicity of oil to reef-building corals: A spill response perspective. NOAA Technical Memorandum NOS OR&R 8, 100 pp..

Shigenaka, G. (Technical Ed.). 2003. Oil and Sea Turtles: Biology, Planning, and Response. Seattle, WA: National Oceanic and Atmospheric Administration, 111 pp.

Shigenaka, G. and A.J. Mearns. 2005. Thoughts and retrospection from 16 years in the wake of the *Exxon Valdez*. In Proceedings of the 2005 International Oil Spill Conference, May 15-19 2005, Miami FL.

• C O L L A B O R A T I O N S •

Beegle-Krause, C.J., NOAA
Coats, D., Marine Research Specialists
DiPinto, L., NOAA
Downs, C., Haereticus Environmental Laboratory
Fonseca, M., NOAA/NCCOS
Fukuyama, A., University of Washington
Khelifa, A., Environment Canada
Klinger, T., University of Washington
Lutz, P., Florida Atlantic University
Mearns, A., NOAA
Merten, A., UNH/NOAA Coastal Response Research Center
Owens, E., Polaris Environmental
Payne, J., Payne Environmental Consultants, Inc.

BUDGET JUSTIFICATION: PJ 070829 - FY 07 Funding: **$239.9K**

Personnel - $58.4K Total
NOAA employees of the Office of Response and Restoration are addressed under this budget category. Other PIs are considered and covered under the Contractual portion of the budget proposal.

Shigenaka is projected at 3.3 months time dedicated to the project, inclusive of field sampling, planning, oversight, and analysis. As he is lead PI for this proposal, his time allocation reflects this oversight role and will be the largest on the team. Two other NOAA personnel are projected participants at lower time allocations in the field or for analytical purposes, or both.

Travel - $10.8K
Travel is expected to be a relatively small part of our overall budget, constituting about four and a half percent of the total. However, some travel costs are included under the Contractual category as part of the project participation by MRS. The travel budget, therefore, reflects travel by NOAA personnel only. We anticipate traveling for two purposes only: for the field sampling in Prince William Sound, and for the Anchorage Alaska Science Symposium in January 2008.

Contractual - $146.5K Total
The largest portion of the project budget falls under this category, and costs associated with two members of the team reside here. The lead contractor for the work, MRS, will subcontract vessel costs (estimated at approximately $16K) under their total of $120.5K.

Marine Research Specialists – field logistics, sampling, and analysis; statistical and database support - $120.5K

The project support provided under this contractor ranges from field planning and implementation to data processing, analysis, and reporting. MRS will work with the lead PI to plan the field visits, oversee the collection and processing of in situ clams to measure abundance, size, and age, process clam population information and add it to the long-term trend analysis, manage and format project data for transfer to the Trustees, and provide statistical consulting services to the entire team. MRS will be the designated lead for reporting in FY2008.

Louisiana State University – sediment and tissue chemistry - $20K

Chemistry support is considered to be a critical part of this project, in order to assess the biological availability of lingering oil to the littleneck clams. We anticipate the need to analyze 10 sediments samples and 10 composited clam tissue samples to characterize habitat and uptake. Louisiana State University is a NOAA/OR&R contractor that has the demonstrated capability to process and analyze the analytes of concern, and the existing contracting mechanism simplifies the fee-for-service approach we require for the project. We use a per sample cost of $.85K per sediment and $1.1K per tissue as our working estimates.

Payne Environmental Consulting, Inc. – field and laboratory chemistry protocols – $6K

Jim Payne and his colleague Bill Driskell have recently completed an extensive review of the chemistry data collected during the NOAA Long-Term Monitoring Program in Prince William Sound. They identified field and lab issues in the NOAA effort, and we will ask PECI to prepare a set of applied lessons-learned in the form of protocols developed specifically for this proposed project. In this way, we hope to maximize the quality and the utility of the data generated for the project.

Commodities - $2.9K Total
Many of the commodities costs for this project are covered in estimated contract expenses. A total of $2.9K is included under this budget heading to cover expendables such as sampling jars and other field sampling supplies, field notebooks, and office supplies not provided as in-kind materials by agencies.

Equipment - $1.5K
The only piece of equipment we will purchase to support this project is a YSI-type field device for measuring in situ conductivity, temperature, salinity, and dissolved oxygen.

Trustee Agency 9% G&A: $19.9K

POPULATION RECOVERY STATUS OF LITTLENECK CLAMS (*Protothaca staminea*) IN PRINCE WILLIAM SOUND AND BIOAVAILABILITY OF LINGERING OIL

DATA MANAGEMENT AND QUALITY ASSURANCE/QUALITY CONTROL STATEMENT

Data for this project will originate from two general locations and represent two different study components. Prince William Sound field sampling will be targeted on defining the current recovery status of clam populations at oiled and cleaned sites. Exposure and bioeffects endpoints will also be surveyed at these sites. Tentative sampling sites include:

Outside Bay:	60°38'17"N 147°27'02"W
Sheep Bay:	60°41'06"N 145°56'22"W
Bainbridge Bight:	60°06'59"N 148°14'48"W
Snug Harbor:	60°15'43"N 147°45'57"W
Herring Bay:	60°27'25"N 147°42'30"W
Mussel Beach:	60°32'10"N 147°36'56"W
Northwest Bay West Arm:	60°32'38"N 147°36'09"W
Shelter Bay:	60°07'06"N 147°57'24"W
Sleepy Bay:	60°03'56"N 147°50'08"W
Block Island:	60°31'48"N 147°36'24"W

Procedures for collection of these clam samples have been discussed in Coats et al. (1999). Collection of clam samples will be accomplished by hand-held corers and also by excavating 0.25 m^2 quadrats in which sediment will be sieved and all clams carefully reserved for potential age/size and chemistry analyses.

Preservation of samples will be either in 10 percent buffered formalin, 70 percent ethanol, or (for chemistry) by freezing. Samples will be transported either by airfreight or surface shipment, dependent upon method of preservation.

PROJECT DATA CHARACTERISTICS

Metadata features are described in the attached MetaLite files. Characteristics of quantitative data are summarized below.

Physical Measurements. Measurements of sediment properties are classified as "Physical Measurements" because they describe the physicochemical properties of the sediment samples collected in the field and in the laboratory. The fields are as follows:

Sample ID
Names of Individuals Involved in Sampling
Site ID
Site Name
Sample Type (Core, Quadrat, or Laboratory)
Core, Quadrat, or Laboratory Chamber Number
Core or Quadrat Latitude

Core or Quadrat Longitude
Collection Date
Collection Time
Tidal Height
Sediment PAH Concentration
Sediment Moisture Content
Porewater Salinity
Porewater Temperature
Notes

Species-Specific Measurements. Measurements of biological properties are classified as "Species-Specific Measurements" because they describe the properties of clam tissue samples and the enumeration, sizing, and aging of clams collected in the field. The biological fields are as follows:

Sample ID
Names of Individuals Involved in Sampling
Site ID
Site Name
Sample Type (Core, Quadrat, or Laboratory)
Core, Quadrat, or Laboratory Chamber Number
Core or Quadrat Latitude
Core or Quadrat Longitude
Collection Date
Collection Time
Sieve Size
Taxon ID
Taxon
Count
Tissue PAH concentration
Sediment Source Area (Lab/Field)
Clam Size
Clam Age
Fluorescence signal
Notes

METADATA

Population Recovery Status of Littleneck Clams
Metadata:

- Identification_Information
- Spatial_Data_Organization_Information
- Distribution_Information
- Metadata_Reference_Information

Identification_Information:
Citation:
Citation_Information:
Originator:
National Oceanic and Atmospheric Administration (NOAA), ORR, 7600 Sand Point Way N.E., Seattle WA 98115 USA (gary.shigenaka@noaa.gov)
Publication_Date: 20060813
Title: Effects of Lingering Oil on Littleneck Clams
Edition: 1.1
Geospatial_Data_Presentation_Form: atlas
Publication_Information:
Publication_Place: 3140 Telegraph Rd. Ste A, Ventura, CA 93003
Publisher:
Dr. Douglas A. Coats, Marine Research Specialists (marine@rain.org)
Online_Linkage: <http://www.mrsenv.com/>
Description:
Abstract:
Littleneck clams (Protothaca staminea) were enumerated and extracted from sediment core samples collected at ten lower-intertidal intertidal sites (beaches) within Prince William Sound Alaska. The ten sites correspond to sites sampled as part of NOAA"s long-term intertidal monitoring program between 1990 and 2000. Four 0.25 m^2 quadrats were excavated at each site. Excavated clams were analyzed for size, age analysis, and tissue metrics. Five additional randomly located cores were also collected at each sited using a modified hand-held cylindrical clam gun. The corer, 10.5 cm in diameter by 15 cm in length, samples an area of 0.009 m^2. These cores were sieved through a 1.0 mm screen in the field and clams were enumerated, sized , and aged.

Sediments and littleneck clams from oiled and unoiled intertidal locations in Prince William Sound were also collected for laboratory determination of sediment and tissue hydrocarbon levels.

Purpose:
Prince William Sound field sampling was conducted to define the current recovery status of clam populations at oiled and cleaned sites. Exposure and bioeffects endpoints were also surveyed at these sites to characterize the biological consequences of lingering oil

exposure. Manipulative exposure studies within the NOAA Kasitsna Bay Laboratory determined whether currently extant oiling conditions within Prince William Sound result in biological uptake in clams, and whether they invoke a biological response from clams placed in them.
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Address: 3140 Telegraph Rd., Ste A
City: Ventura
State_or_Province: CA
Postal_Code: 93003
Country: USA
Contact_Voice_Telephone: (805)644-1180
Contact_Electronic_Mail_Address: marine@rain.org
Resource_Description:

NOAA/EVOS: POPULATION RECOVERY STATUS OF LITTLENECK CLAMS (*Protothaca staminea*) IN PRINCE WILLIAM SOUND AND BIOAVAILABILITY OF LINGERING OIL

Distribution_Liability:

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State_or_Province: CA
Postal_Code: 93003
Country: USA
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Contact_Electronic_Mail_Address: marine@rain.org
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

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Citation:
Citation_Information:
Originator: National Oceanic and Atmospheric Administration (NOAA), ORR, 7600 Sand Point Way N.E., Seattle WA 98115 USA (gary.shigenaka@noaa.gov)
Publication_Date: 20060813
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Edition: 1.1

Geospatial_Data_Presentation_Form: atlas
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Description:
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Littleneck clams (Protothaca staminea) were enumerated and extracted from sediment core samples collected at ten lower-intertidal intertidal sites (beaches) within Prince William Sound Alaska. The ten sites correspond to sites sampled as part of NOAA's long-term intertidal monitoring program between 1990 and 2000. Four 0.25 m^2 quadrats were excavated at each site. Excavated clams were analyzed for size, age analysis, and tissue metrics. Five additional randomly located cores were also collected at each sited using a modified hand-held cylindrical clam gun. The corer, 10.5 cm in diameter by 15 cm in length, samples an area of 0.009 m^2. These cores were sieved through a 1.0 mm screen in the field and clams were enumerated, sized, and aged.

Sediments and littleneck clams from oiled and unoiled intertidal locations in Prince William Sound were also collected for laboratory determination of hydrocarbon levels and composition.

Purpose: Prince William Sound field sampling was conducted to define the current recovery status of clam populations at oiled and cleaned sites. Exposure endpoints were also surveyed at these sites to characterize the biological consequences of lingering oil exposure.
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Contact_Organization: Marine Research Specialists
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City: Ventura
State_or_Province: CA
Postal_Code: 93003
Country: USA
Contact_Voice_Telephone: (805)644-1180
Contact_Electronic_Mail_Address: marine@rain.org
Resource_Description: NOAA/EVOS: POPULATION RECOVERY STATUS OF LITTLENECK CLAMS (*Protothaca staminea*) IN PRINCE WILLIAM SOUND AND BIOAVAILABILITY OF LINGERING OIL
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Contact_Organization: Marine Research Specialists
Contact_Address:
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Address: 3140 Telegraph Rd., Ste A
City: Ventura
State_or_Province: CA
Postal_Code: 93003
Country: USA
Contact_Voice_Telephone: (805)644-1180
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correspond to sites sampled as part of NOAA's long-term intertidal monitoring
program between 1990 and 2000. Four 0.25 m2 quadrats were excavated at each
site.  Excavated clams were analyzed for size, age analysis, and tissue
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diameter by 15 cm in length, samples an area of 0.009 m2.  These cores were
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and aged.

Sediments and littleneck clams from oiled and unoiled intertidal locations in
Prince William Sound were also collected for laboratory determination of
sediment and tissue hydrocarbon levels, molecular biomarkers, and
histological condition. From the sediment samples collected at each site, 10
clams were analyzed at each site for biomarkers, and four were analyzed for
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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2006	Proposed FY 2007
Personnel		$58.4
Travel		$10.8
Contractual		$146.5
Commodities		$2.9
Equipment		$1.5
Subtotal	$0.0	$220.1
General Administration		$19.8
Project Total	$0.0	$239.9
Full-time Equivalents (FTE)		0.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
			Estimated FY 2008		

Dollar amounts are shown in thousands of dollars.

Comments:
This is projected as a two-year project, although all of the field work and laboratory analysis will take place in FY2007. Data analysis, interpretation, and report writing will take place in FY2008.

FY07

Prepared:

Project Number: 070829
Project Title: Bioavailability and Effects of Lingering Oil to Littleneck Clams (*Protothaca staminea*) and Population Recovery Status in Prince William Sound
Agency: U.S. Department of Commerce/NOAA/NOS/OR&R

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 2007
Gary Shigenaka	Marine Biologist	GS/13/8	3.3	11.2	3.0	40.0
New NOAA hire	Biologist	GS/12/1	1.0	8.7	1.9	10.6
New NOAA hire	Biologist	GS/11/1	1.0	7.8	0.0	7.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
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						0.0
	Subtotal		5.3	27.7	4.9	
					Personnel Total	$58.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2007
Prince William Sound field collections, July 2007 (Shigenaka)	2.0	1	2	0.2	2.4
Prince William Sound field collections, July 2007 (new NOAA hires)	2.0	2	2	0.2	4.4
					0.0
Marine Science Symposium, January 2008 (NOAA biologists)	1.5	2	5	0.2	4.0
					0.0
					0.0
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				Travel Total	$10.8

FY07

Prepared:

Project Number: 070829
Project Title: Bioavailability and Effects of Lingering Oil to Littleneck Clams (*Protothaca staminea*) and Population Recovery Status in Prince William Sound
Agency: U.S. Department of Commerce/NOAA/NOS/OR&R

FORM 3B
Personnel
& Travel
DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2007
Marine Research Specialists (Fukuyama & Coats)	120.5
Louisiana State University, sediment & tissue chemistry analysis	20.0
Payne Environmental Consultants, Inc.	6.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$146.5

Commodities Costs:	Proposed
Description	FY 2007
Field sampling supplies (e.g., chemistry-grade sampling jars, sampling gloves, 5-gal. buckets + lids, field notebooks, etc.)	2.5
Miscellaneous laboratory expendables	0.4
Commodities Total	$2.9

FY07

Prepared:

Project Number: 070829
Project Title: Bioavailability and Effects of Lingering Oil to Littleneck Clams (*Protothaca staminea*) and Population Recovery Status in Prince William Sound
Agency: U.S. Department of Commerce/NOAA/NOS/OR&R

FORM 3B
Contractual & Commodities DETAIL

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2007
YSI field meter	1	1.5	1.5
			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**		$1.5

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

FY07

Prepared:

Project Number: 070829
Project Title: Bioavailability and Effects of Lingering Oil to Littleneck Clams (*Protothaca staminea*) and Population Recovery Status in Prince William Sound
Agency: U.S. Department of Commerce/NOAA/NOS/OR&R

FORM 3B
Equipment
DETAIL