

## Evaluation of Oil Remaining in the Intertidal from the Exxon Valdez Oil Spill

Project Number: 02543

Restoration Category: Research and Monitoring

Proposer: Jeffrey W. Short and Mandy Lindeberg  
NMFS, Auke Bay Laboratory  
ABL Program Manager: Dr. Stan Rice

Lead Trustee Agency: NOAA

Cooperating Agencies:

Alaska Sea Life Center: No

Duration: 2nd year of a 2 year project

FY02 92 K )closeout(

Geographic Area: Prince William Sound, Gulf of Alaska

Injured Resource/Service: Intertidal communities, Sediments

### ABSTRACT

This project will assess the amount of oil remaining from the *Exxon Valdez* oil spill on shorelines within Prince William Sound in FY01. A stratified random sample of shoreline will be intensively sampled for surface and subsurface oil to estimate length of oiled shoreline, area and volume of oiled sediment, and volume of oil. Approximately 8 km will

be sampled by digging about 8,000 pits to discover and quantify subsurface oil. In FY02, Phase III of this project which will be devoted to data and chemical analysis, preparation of a final report, and journal publications. No fieldwork is proposed for FY02.

## **INTRODUCTION**

Oil from the March 1989 *Exxon Valdez* oil spill (EVOS) has been surprisingly persistent on some beaches. At the end of the 1992 cleanup season, natural processes were expected to disperse most of the oil remaining on shorelines. However, relatively unweathered oil remains today at a number of locations that were heavily oiled initially, and protected from dispersion by storm-generated waves. The extent of the remaining oil is unknown, and this uncertainty engenders public and scientific concerns about the effects the oil may continue to have on humans and on fauna that may become exposed to the oil either directly or indirectly. This project was initiated in 2001 with extensive field work to address these concerns by providing a quantitative estimate of the amount of shoreline length, area, sediment and volume that remains contaminated. This estimate will inform any assessment of the significance of the amount of oil remaining, and be the basis for further management (e.g., do nothing, restrict access or harvest; etc.). For FY02, this project will complete chemical and data analyses, and provide a final report.

Estimating the oil remaining on beaches affected by the EVOS in a cost-effective manner presents a considerable challenge. Previous attempts to address this problem have mainly relied on Shoreline Contamination Assessment Teams (SCAT), consisting of field teams performing comprehensive foot-surveys of impacted beaches. Although this approach may be useful for directing cleanup efforts immediately after a spill, it is less appropriate for producing a quantitative estimate of remaining oil contamination, especially long after a spill when most remaining oil is obscured from casual view. Instead, a stratified random/adaptive sampling design will be used to focus sampling effort in areas where oil most likely persists, while allocating some effort to discovering oil in areas where persistence is uncertain. This approach will guarantee a credible minimum estimate of remaining oiled area, and will provide a confidence interval for the most likely amount remaining throughout the affected region. This information is needed to predict oil persistence into the future and to determine associated risks to vulnerable biota.

This project will focus on oil remaining on beaches inside Prince William Sound (PWS). At this time, areas outside of PWS are not part of the proposed assessment. Previous Trustee-

funded projects have examined oil persistence along the Kenai-Alaska Peninsula shoreline in 1999 )Project 99495( and in the vicinity of Kodiak Island in 1995 )Project 95027(.

In FY01, Phases I and II were initiated. Phase I is development of the sampling design to be applied to the study area. Phase I was funded, and the study design used for Phase II is the product. Design alternatives were developed during summer 2000 and presented at a workshop in November 2000 for consideration by peer-reviewers, trustee agency representatives, and other stakeholders. Phase II is execution of the adopted sampling design inside Prince William Sound during spring/summer 2001. Permitting is in progress, and the vessel and labor contracts are completed. Phase II of the project enters the field on May 7, 2001, and will have 80-100 charter days and 6 field personnel deployed. This detailed project description presents the specific objectives, sampling design, and methodology for Phase III in FY02.

## **NEED FOR THE PROJECT**

### **A. Statement of Problem**

Although the persistence of relatively unweathered oil is clearly established on some beaches 10 years after the EVOS, the cumulative extent of remaining oiled beach is controversial. One estimate places the area of beach that remains contaminated by oil at less than 450 m<sup>2</sup> )Page 1999(, but the basis for this claim has not been presented. Other studies suggest more extensive contamination )Brodersen et al. 1999; Hayes and Michel 1999; Irvine et al. 1999(. These latter studies have often found relatively unweathered oil in the upper intertidal zone of beaches that are armored by boulders and beneath mussel beds that were initially heavily oiled )Babcock et al. 1998; Carls et al. 2000(.

The extent of oil remaining on these beaches defines the lack of recovery for these sediments. The remaining oil may also impede recovery of injured species still exposed to it. This exposure includes direct contact with water contaminated by the remaining oil, or indirect contact through ingestion of prey contaminated by the oil. The fact that the remaining oil is often so unweathered indicates the oil is still a potent source of toxic

polycyclic aromatic hydrocarbons )PAH(, which elicit manifold adverse effects on biota exposed to them. These species may include black oystercatchers, clams, intertidal communities, mussels, Pacific herring, pink salmon, sea otters, subtidal communities, and harlequin ducks. In addition, subsistence uses, passive uses, recreation, and tourism may also be impaired because of speculation that the area remains contaminated.

## **B. Rationale**

The plausibility of oil-exposure linkages connecting fauna at higher trophic levels with oiled habitat, as well as the propriety of additional restoration options, depend on an assessment of the amount of oiled habitat remaining in the spill area. Conversely, without this assessment, the public will continue to wonder how much of the spill area remains contaminated, and may make inappropriate decisions regarding resource use based on misperceptions about the extent of remaining oil. Also, scientists evaluating biological linkages to oil exposure will be less able to assess geographic correlation, compromising those studies.

Assessment of the extent of remaining oil should be done now to maximize benefits that may derive from the expected reduction in uncertainty regarding the extent of this oil.

## **C. Location**

This project will be undertaken in PWS during 2001. Communities directly affected by this project include Cordova, Chenega, Tatitlek, Valdez, and Whittier. Benefits of the project will accrue especially to participants in subsistence and commercial fishing, scientists studying resource recovery in the region, and more generally to the public at large.

## **COMMUNITY INVOLVEMENT**

Community involvement has been a critical part of this project from public feedback meetings to local labor needs in Prince William Sound. In FY02, results of this project will be

summarized as a map depicting locations and extent of remaining oil discovered, together with a report summarizing the statistical estimate of the amount of oiled shoreline remaining. These materials will be accompanied by a press release announcing these findings to the media for general distribution. Public presentations will be given in Anchorage, Cordova, and Valdez to facilitate public review and commentary on the findings.

## **PROJECT DESIGN**

### **A. Objectives**

This project has four objectives:

1. Determine the amount of shoreline )length, surface area, sediment volume, and oil volume( that remains contaminated with oil in the *Exxon Valdez* oil spill area;
2. Determine the trend in the recovery of oiled shoreline in terms of oiled surface area and sediment volume;
3. Determine the trend in the recovery of subtidal sediments in terms of oil concentrations remaining at locations sampled in 1991; and
4. Verify the source of oil as the *Exxon Valdez* oil spill by “fingerprinting” and characterize the weathering state of the oil remaining in each of the strata sampled.

### **B. Methods**

#### **1. Phase I**

The goal of phase I was to produce a final sampling design to be implemented in the field the

following spring. A set of design alternatives was developed by Auke Bay Laboratory staff and presented at a workshop on November 2, 2000. Refinements to the design were selected at the end of the workshop.

## **2. Phase II**

Phase II consists of implementing the main sampling efforts of this project to determine the amount and recovery of contaminated shorelines and subtidal sediments in Prince William Sound. This requires an extensive field season during the summer of 2001 to survey the necessary shoreline. The methods for sampling design, power analysis, sampling effort, and recovery trends have been listed in detail in last years proposal )project 01543(.

## **3. Phase III**

Phase III will be carried out during FY01 and will primarily consist of updating the GIS oiled shoreline database, conducting chemical analyses, and completing estimates of contaminated shoreline and trend analyses.

### *GIS Mapping*

Data currently available in the EVOS GIS database )ADNR 1992( are not detailed enough to allow for stratification by shore type prior to sampling. Detailed information on shore type will be taken at each sampling unit so that relationships between oil retention and shore type can be examined. Maps will be generated depicting the survey areas.

### *Estimate of Contaminated Shoreline in Prince William Sound*

We will estimate the surface area and volume of contaminated shoreline based on a random sample of oiled shoreline identified in previous surveys from 1989 to 1993. We define three sampling strata: 1( shoreline having heavy impact in 1990, 1991, or 1993 )ADNR 1992; Gibeaut and Piper 1998a(; 2( shoreline with medium impact in 1990, 1991, or 1993; and 3( shoreline with heavy impact in 1989 but only light impact or less in later years.

For analysis, data may be stratified by shoreline type if doing so increases precision of the estimates of total oil. Shoreline type is based on the Environmental Sensitivity Index (ESI) and classifies shoreline locations according to geomorphology and exposure. Heavily impacted locations in 1990 were primarily of five shoreline types: 1( exposed rocky shores; 2( exposed wavecut platforms; 3( mixed sand and gravel beaches; 4( gravel, cobble, boulder beaches; and 5( sheltered rocky shores.

### *Recovery Trends*

The trend in recovery of oiled shoreline will be measured in two ways. First, we will resurvey at least 10 randomly selected sites from the 45 sites that were used in the 1993 shoreline assessment (Gibeaut and Piper 1998a,b). These sites have oiling and cleanup data from 1989 through 1993. At these sites, we will duplicate the sampling procedures of Gibeaut and Piper (1998a, b), as well as conduct the adaptive sampling design to compare results of the two designs.

A second means of determining recovery trend will be to resurvey some of the stations with permanent transects established in 1989 by NOAA and ADEC and resurveyed in 1993 by Gibeaut and Piper (1998a). These stations include high-energy boulder and cobble beaches; moderate-energy boulder, cobble, and pebble beaches; and sheltered set-aside stations. This type of survey entails measuring the profile along a line oriented perpendicular to the shoreline trend and visually estimating sediment and oiling conditions (Gibeaut and Piper 1998a). Resurveying 15 of these stations will provide quantitative data on erosional and depositional processes related to degradation and dispersal of oil.

Recovery trend of subtidal sediments will be evaluated by resampling 5 locations at 7 descending depths (0-100 m) for a total of 35 samples. These samples will be analyzed by GCMS and the data evaluated by the hydrocarbon source recognition methods developed by Short and Heintz (1997). Comparison of results with the 1991 data will permit assessment of oil persistence at these locations.

### *Oil Amount in Intertidal sediments*

Approximately 150 samples of oiled sediment from pits will be taken for gravimetric analysis to determine oil weight and to calibrate visual estimates of weighting categories. Oil in the collected material is extracted twice with dichloromethane, and the dichloromethane of the combined filtered aliquots is removed by distillation and re-used. The weight of the remaining residue is taken as the amount of oil present within the original sample.

The mean and variance of amount of oil recovered from each category of oil estimated visually by hydrocarbon vapor detection, or by UV-fluorescence will establish the basis for estimating the amount of oil present in each of the approximately 8,000 test pits dug during Phase II of this project, which in turn will establish the basis for extrapolation of results to un-sampled beaches in PWS.

### *Oil Presence in subtidal sediments*

Each of the 35 samples of subtidal sediments collected from the 1991 transects re-sampled during Phase II in 2001 will be analyzed for the same suite of alkane and PAH analytes as were analyzed during the 1991 studies (O'Clair et al. 1996), using the same methods summarized in Short et al. 1996. These analytes include 24 normal alkanes plus pristane and phytane, and 44 polycyclic aromatic compounds (PACs) ranging from naphthalene through indenoperylene, and including the alkylated isomers of naphthalene, fluorene, dibenzothiophene, phenanthrene, fluoranthene/pyrene, and chrysene. Results from these samples will be compared with corresponding results from the 1991 studies to evaluate trends in hydrocarbon concentrations in these subtidal sediments. These results will also be evaluated using a Bayesian statistical approach developed under EVOS Trustee Project 00598 to estimate the proportions of hydrocarbons from Exxon Valdez oil and from natural sources to these sediments.

### *Oil Source: Fingerprinting*

To determine condition of remaining oil and whether it still matches *Exxon Valdez* oil, 24 sediment samples with visible subsurface oil from pits at different sampling sites will be analyzed by GC-MS )summarized in Short et al. 1996( to determine whether PAH composition matches weathered *Exxon Valdez* oil. A weathering index )Short and Heintz 1997( will be determined for each sample.

**C. Contracts and Other Agency Assistance**

None

**SCHEDULE**

**A. Measurable Project Tasks for FY02 )October 1, 2000 – September 30, 2002(**

**FY02:** *Closeout year*

Oct 1 – April 15: Enter FY01 data into a GIS database, analyze FY01 gravimetric and fingerprinting GC-MS samples.

Jan. 14-23: Attend 2002 Trustee Council Annual Workshop.

April15 – Sep 30: Produce map depicting sampled locations and present to locals in Prince William Sound.

April15 – Sep 30: Submit final report and transform for journal publications.

**B. Project Milestones and Endpoints**

The project has evolved from the development of the sampling design )Phase I(, the collection of data from the summer survey crew )Phase II(, and now the analysis of samples and

synthesis of data will be compiled into a final report )Phase III(.

**C. Completion Date**

September 30, 2002

**PUBLICATIONS AND REPORTS**

We anticipate that three research papers will be submitted to peer-reviewed scientific journals in FY02. Probable titles of these papers will be "*Amount of oil contamination in Prince William Sound 11 years after the Exxon Valdez oil spill,*" "*Trend of recovery of subsurface oil after the Exxon Valdez oil spill,*" and "*Identification and weathered condition of remaining Exxon Valdez oil 11 years after the spill.*"

**PROFESSIONAL CONFERENCES**

None Planned for FY02.

**NORMAL AGENCY MANAGEMENT**

If the oil spill had not occurred, neither NOAA nor the cooperating agencies would be conducting this project.

**COORDINATION AND INTEGRATION OF RESTORATION EFFORT**

This project will be coordinated through participation of the cooperating agencies. Formal coordination commenced at the November workshop in Anchorage. All of the previous Trustee-funded studies on oil persistence in the spill region have been performed under the

auspices of these agencies, and it is presumed that local knowledge is the only significant source of additional information relevant to this project outside these agencies.

#### **EXPLANATION OF CHANGES IN CONTINUING PROJECTS**

None

#### **PROPOSED PRINCIPAL INVESTIGATOR**

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#### **PRINCIPAL INVESTIGATORS**

Jeffrey W. Short

Education: M.S. )Physical Chemistry(

#### *Relevant Experience:*

1989- Present: Established and managed the hydrocarbon analysis facility at ABL to analyze hydrocarbon samples generated by the *Exxon Valdez* NRDA effort )about 20% of these samples were analyzed at ABL(.

1989 - 1992: Principal Investigator, Exxon Valdez project Air/Water #3: Determination of petroleum hydrocarbons in seawater by direct chemical analysis and through the use of caged mussels deployed along the path of the oil spill.

1991 - 1996: Principal Investigator, Exxon Valdez project Subtidal #8: Development of computer-based statistical methods for global examination of sediment and mussel hydrocarbon data produced for the Exxon Valdez NRDA effort for systematic bias, and for identification of probable sources of hydrocarbons.

1996 - present: Principal Investigator, Restoration Project 290, Database Management.

#### **OTHER KEY PERSONNEL**

1. Patricia Harris, Zoologist, Auke Bay Laboratory, will assist in supervising field sampling, data analysis, and coordinate interactions with local communities.
2. Mandy Lindeberg, Fisheries Biologist, Auke Bay Laboratory, will assist in supervising field sampling, data analysis, and writing.
3. Jerome Pella, the senior biometrician at the Auke Bay Laboratory, will consult on sampling design and data analysis.

#### **LITERATURE CITED**

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O'Clair, C. E., J. W. Short, and S. D. Rice. 1996. Contamination of intertidal and subtidal sediments by oil from the Exxon Valdez in Prince William Sound. *Am. Fish. Soc. Symp.* 18:61-93.

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Short, J. W., and R. A. Heintz. 1997. Identification of *Exxon Valdez* oil in sediments and tissues from Prince William Sound and the northwestern Gulf of Alaska based on a PAH weathering model. *Environmental Science & Technology* 31:2375-2384.

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**FY 02 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>Budget Category:</b>	Authorized FY 2001	Proposed FY 2002					
Personnel	\$89.1	\$71.3					
Travel	\$30.0	\$3.7					
Contractual	\$284.9	\$17.9					
Commodities	\$9.0	\$8.3					
Equipment	\$10.0	\$0.0	LONG RANGE FUNDING REQUIREMENTS				
Subtotal	\$423.0	\$101.2	Estimated				
General Administration	\$31.6	\$11.9	FY 2003				
Project Total	\$454.6	\$113.1	\$0.0				
Full-time Equivalents (FTE)	1.0	1.0					
Dollar amounts are shown in thousands of dollars.							
Other Resources							
<p>Comments:</p> <p><b>Phase I</b> of this project (planning workshop) was completed in Nov. 2001 <b>Phase II</b> included the detailed costs of field sampling, labor, and vessel charters in FY01. This is the <b>Phase III</b> budget for FY02 which includes data and chemical analyses, and completion of a final report .</p> <p>NOAA Contribution: Jeff Short 2mo@ 20.6 K, Jeep Rice 1 mo @13K for a total NOAA contribution of 30 K</p>							

**FY02**

Prepared:4/13/01

Project Number: 02543 Phase III  
 Project Title: Evaluation of Oil in the Intertidal from the EVOS  
 Agency: NOAA- Auke Bay Laboratory

**FY 02 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>Personnel Costs:</b>		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime
Name	Position Description				
Jeff Short	Research Chemist	GS/14	0.5	10.6	
Mandy Lindeberg	Fisheries Research Biologist	GS/11	6.0	6.0	
Josie Lunasin	chemist	GS/9	2.0	6.0	
Larry Holland	chemist	GS/11	1.0	7.4	
Jacek Maselko	Programmer (GIS database)	GS/9	2.0	5.3	
<b>Subtotal</b>			11.5	35.3	0.0
<b>Personnel Total</b>					
<b>Travel Costs:</b>		Ticket Price	Round Trips	Total Days	Daily Per Diem
Description					
Juneau/Anchorage Trustee Annual Workshop		0.4	2	2	0.2
Juneau/Cordova		0.4	2	4	0.2
Air Charter \$300/hr		0.3	3		
Final Results outreach to Chenega, Valdez, Tatitlek					
<b>Travel Total</b>					

**FY02**

Prepared:4/13/01

Project Number: 02543  
 Project Title: Evaluation of Oil in the Intertidal from the EVOS  
 Agency: NOAA- Auke Bay Laboratory

**FY 02 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>Contractual Costs:</b>		
Description		
Temporary labor (NOAA) chem lab support		
Contract labor technical support		
When a non-trustee organization is used, the form 4A is required.		<b>Contractual Total</b>
<b>Commodities Costs:</b>		
Description		
150 Gravimetric Samples Chemicals lab supplies		
60 samples for GC/MS Analysis chemicals lab supplies		
		<b>Commodities Total</b>

**FY02**

Prepared:4/13/01

Project Number: 02543  
 Project Title: Evaluation of Oil in the Intertidal from the EVOS  
 Agency: NOAA - Auke Bay Laboratory

**FY 02 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>New Equipment Purchases:</b>		Number of Units	Unit Price	
Description				
Those purchases associated with replacement equipment should be indicated by placement of an R.		<b>New Equipment Total</b>		
<b>Existing Equipment Usage:</b>		Number of Units		
Description				
Computer Equipment HPLC GC/MS				

**FY02**

Prepared:4/13/01

Project Number: 02543  
 Project Title: Evaluation of Oil in the Intertidal from the EVOS  
 Agency: NOAA - Auke Bay Laboratory