EVOSTC FY17-FY21 INVITATION FOR PROPOSALS
FY20 NEW PROJECT PROPOSAL SUMMARY PAGE

Project Number and Title

Gulf Watch Alaska: Lingering Oil Component Project

20200114-P Long-term Monitoring of Lingering Oil in Prince William Sound

Primary Investigator(s) and Affiliation(s)

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Date Proposal Submitted

August 23, 2019 *revised September 25,2019*

Project Abstract

Oil from the *Exxon Valdez* remains sequestered under beaches throughout the spill area. This lingering oil, as it is known, has been a source of concern for the federal and state government and the public for over 30 years. In 2015 the United States and State of Alaska governments advised the federal district court they would not be filing for additional damages based on the presence of lingering oil and the "reopener claim." In their joint status report, the Governments noted that, although the Governments would not pursue the additional claim, "[the *Exxon Valdez* Oil Spill Trustee] Council (EVOSTC) and its member agencies have discretion to consider and proceed with actions to reduce residual oil in the Spill area. . . ." In subsequent Council meetings, the Trustees noted their commitment to continuing lingering oil monitoring to ensure that the oil is not bioavailable or creating damage to the spill area habitat and its resources. Subsequent Councils requested EVOSTC staff develop a lingering oil monitoring project to address targeted areas to effectively monitor the presence and condition of lingering EVOS oil.

This project was developed in coordination with EVOSTC staff to provide a sensible monitoring program that continues past efforts. Past monitoring projects began with an initial assessment in 2001 where over 9,000 pits were excavated to estimate how much oil remained on beaches in Prince William Sound. Results from this survey showed oil was lingering in the environment longer than expected and not changing in its chemical composition or "weathering". Additional surveys were conducted from 2003-2015 to determine the oil's extent and to refine model estimates. Recommendations from these surveys were to continue monitoring these known sites periodically on a 5 year cycle to maintain the oil chemistry time series and evaluate any change. This project fulfills those recommendations.

In recent years the *Exxon Valdez* oil spill has become an important case study in the long-term impacts of oil spills and there are few agencies capable of producing the long-term data that the EVOSTC-funded studies provide. This project proposes a low-cost presence/absence approach to monitoring that can be combined with previously Council-funded modeling efforts to provide managers with up to date information on where oil is located and its potential to cause injury.

EVOSTC Funding Requested* *(must include 9% GA)*

FY17	FY18	FY19	FY20	FY21	TOTAL
N/A	N/A	N/A	$52,200	$13,100	$65,200

Non-EVOSTC Funds to be used, please include source and amount per source: (see Section 6C for details)

FY17	FY18	FY19	FY20	FY21	TOTAL
N/A	N/A	N/A	$11,200	$11,200	$22,400

1. PROJECT EXECUTIVE SUMMARY

We propose in FY20 to examine established lingering oil beaches in Prince William Sound (PWS) for the presence of oil spilled by the *Exxon Valdez* as recommended by the last lingering oil project, 16120114-S (Lindeberg et al. 2017). The presence of lingering oil was one the most important findings by the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) scientists following the *Exxon Valdez* oil spill (EVOS). On March 24, 1989 when the tanker ran aground on Bligh Reef in PWS it released at least 10,800,000 gallons of crude oil (Wolfe et al. 1994). Western PWS beaches were the hardest hit by spilled oil, affecting 783 km of shoreline (Short et al. 2004). With a combination of large-scale clean-up efforts and natural processes it was expected that remaining oil would be reduced to negligible amounts soon after the first several years of the spill (Neff et al. 1995). As the decades passed, studies funded by EVOSTC documented unanticipated long-term impacts of EVOS, one of which was the persistence of oil in the environment (Lindeberg et al. 2018, Esler et al. 2018). Lingering oil residues are patchily distributed across geologically complex shorelines, largely found in finer-grained sand and gravel beach sediments, often under an armor of cobble and boulders (Hayes and Michel 1999, Hayes et al. 2010, Nixon and Michel 2018). Estimates of oil loss-rates from these sites indicate a prolonged presence. Monitoring these beaches for the presence of oil provides the EVOSTC with up-to-date data on the extent of injury at minimal cost.

Past Lingering Oil Findings

The EVOSTC has had a comprehensive legacy regarding lingering oil studies focusing on the distribution, quantity, loss rate, weathering state, and bioavailability of *Exxon Valdez* oil (EVO) through field studies and by developing empirical models. EVOSTC has periodically solicited reports on the status of lingering oil (EVOSTC 2016; Michel and Esler 2010, Michel et al. 2016) to help inform sponsoring EVOSTC agencies, decision makers, and the public. Results from these studies also helped guide future focus areas for research invitations (e.g., http://www.evostc.state.ak.us/Universal/Documents/Publications/Invitations/2018Invitation.pdf). A brief review of findings for the lingering oil focus area follows.

Lingering oil surveys - The first of these surveys was conducted 12 years after the spill in 2001 by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service's (NMFS's) Auke Bay Laboratories, which estimated a cumulative area of 11.3 ha of EVO and 55,600 kg of subsurface oil remaining in PWS (Short et al. 2004, Pella and Maselko 2007). Additional surveys conducted in 2003 and 2005 focused on determining the distribution of subsurface oil with respect to tidal elevation and the probability of encountering oil in a heavily oiled region of PWS (Short et al. 2006, 2007). Several other surveys were conducted in 2007-08 (Michel et al. 2010) and many of these sites were revisited in 2015. In 2015, lingering EVO was present at 8 of the 9 sites and surveys revealed little evidence of change in oil mass, area, and distribution since 2001 (Lindeberg et al. 2018). If left undisturbed by natural processes or human activities, lingering oil will likely persist in the environment on a decadal or longer scale.

Lingering oil modeling - A comparison of survey results between 2001 and 2005 showed the likely rate of decline of oiled beach area within PWS was 3-4%/year (Short et al. 2006, 2007). Using quantitative data from past surveys, a geomorphic spatial model was developed (Michel et al. 2010, Nixon and Michel 2015) to predict where oil is likely to occur, in addition to known locations identified by field surveys. Most recent testing by Nixon and Michel (2018) that included data ranging from 2001-2015 (14,000 pit excavations), continues to support estimates and even suggests previous estimates of the initial amount of oil remaining were slightly underestimated. Model estimates changed from 0.25% to 0.6% of the originally spilled mass of oil and it is now

estimated that lingering oil remains over 30 ha of intertidal area along 11.4 km of shoreline (Nixon and Michel 2018). A refined projection for the rate of decline made in 2015 found that loss rates are still 3-4% per year, but given the margin of error, loss rates could be closer to zero and undetectable (Nixon and Michel 2017, Lindeberg et al. 2018).

Composition of EVO – Samples of oil, collected during lingering oil surveys, have been analyzed to verify the oil is EVO and evaluate its weathering state. Polycyclic aromatic hydrocarbons (PAH) are used to identify the oil and determine its weathering state. Weathering is important to monitor because it provides an indication of the potential toxicity of the stranded oil. Subsurface oil over the decades has varied from extremely weathered to no different than 11-day old EVO, which has been the standard oil to compare the rate of weathering once the oil stranded on the shoreline (Short et al. 2007, Venosa et al. 2010). Analysis of EVO sampled in 2015 indicated that the oil has not appreciably weathered since 2001 and still resembles the 11-day old EVO (Lindeberg et al. 2018). As the oil eventually weathers, polycyclic aromatic hydrocarbons (PAHs) will be lost and attempts to identify and assess the weathering state of the oil will need to rely on biomarkers. Biomarkers, including hopanes, steranes, and disteranes, are compounds believed to be most resistant to weathering. However, samples collected in 2015 indicate some of these compounds may have also slightly weathered (Carls et al. 2016, Lindeberg et al. 2018). Consequently, it is important to maintain samples of stranded EVO over time to better understand how biomarker concentrations change over time in situ.

Future Monitoring of Lingering Oil

Recent surveys have provided a clear idea of the location of sequestered oil in PWS (Michele et al. 2010, Nixon and Michele 2015) and the amount (Nixon et al. 2017). The former study relied on a geomorphic model and historic oil distribution to predict locations where oil is likely to be sequestered. Field studies conducted in 2015 (EVOSTC project 16120114-S) found the distribution model accurately predicted the probability of encountering oil residues on contaminated beaches (Lindeberg et al. 2018). Predictions of the amount of oil remaining in PWS by both EVOSTC and industry scientists (Short et al. 2004, Taylor and Reimer 2008, Nixon and Michele 2018) have estimated the remaining oil to represent between 0.25 % to 0.6% of the initial spilled mass. The field study conducted in 2015 revisited previously surveyed sites and was unable to detect any loss in either the area contaminated by oil or the oil's mass (Lindeberg et al. 2018). Thus, the EVOSTC currently has a comprehensive understanding of where the oil is located, how much is there, and how long it will be there. In the near term the EVOSTC needs only to monitor contaminated locations to verify the presence of the oil.

Forensic analysis has been an important component to these previous surveys. Collection of oil samples to determine the oil's chemical composition was critical to identifying its weathering state and verifying its identity as EVO. The PAH compounds in crude oil degrade in a predictable pattern facilitating the identification of the source of an unknown sample (Short and Heintz 1997). This approach has been used in previous surveys to verify that sequestered oil is EVO and that it has retained its toxic potential. Ultimately, PAH will be lost from the oil sequestered on PWS beaches along with the potential for verifying the source of the oil. More recent developments in oil forensics have developed the use of petroleum biomarkers including triterpene, hopane, and sterane isomers to identify source oils (Wang et al. 2016). These biomarkers are highly refractory and are the result of geologic processes that formed the oil from original biological materials. Analysis of oil samples collected from locations in PWS over a 25-year period demonstrated their persistence and utility for source identification (Carls et al. 2016). That study represents one of the longest time series for monitoring biomarker persistence in the scientific record. Continued monitoring of biomarkers in PWS will be of significant value to the community of scientists studying spilled petroleum hydrocarbons.

Currently, the primary process for addressing lingering oil is the periodic monitoring conducted by EVOSTC-funded studies. During these surveys numerous pits are dug on contaminated beaches in order to assess the area covered by the oil, estimate the mass remaining, and collect oil samples. These estimates are expensive because they require that a large number of pits be dug. Moreover, there is the danger of mobilizing excavated oil and altering the natural weathering process during excavation. For these reasons, surveys that have a high density of pit excavations or a high frequency of visitation are not recommended, maintaining minimal impacts to the oiled beaches. We propose to maintain the current survey schedule (once every 5 years) but minimize survey objectives so that the EVOSTC can maintain a current inventory of contaminated beaches, while minimizing the potential for disturbance. This project would become part of the Gulf Watch Alaska (GWA) lingering oil component as it has been in the past (FY12-16) and allow for future related projects in the long-term. We anticipate acquiring partners in the near future to carry out biomarker analyses and soliciting funds from EVOSTC in FY21.

Relevance to the invitation for proposals - This project proposal addresses the EVOSTC lingering oil focus area. The EVOSTC continues to be accountable for monitoring oil-contaminated beaches despite evidence that the sequestered oil is not bioavailable. Oil sequestered on the beaches has not weathered substantially since it made landfall (Lindeberg et al. 2018) and therefore retains potential toxicity. So long as the oil remains on the beaches the EVOSTC needs to keep the public apprised of the status of lingering oil. Twenty-five plus years of knowledge gained by funding lingering oil studies has established the EVOSTC as a leading authority and resource for oil spill research. The long-term time series datasets accumulated by EVOSTC-funded projects have proven to be important for oil spills around the world (e.g., citations in environmental impact statements, Hebei Spirit reports, and Deep Water Horizon court cases).

2. PROJECT HISTORY

This is a new project but builds on previous lingering oil projects funded by the EVOSTC. GWA project 16120114-S was a 5-year project initiated in 2012 and culminated in 2016. The overall goal of this lingering oil project was to extend previous efforts to track EVO occurrence and chemical composition in PWS. Previous EVOSTC-funded studies (projects 02543, 040585, 050620, 070801, and 12120117) had demonstrated that, on some beaches, subsurface oil persisted in a relatively unweathered state longer than expected with an unknown long-term fate.

3. PROJECT DESIGN

A. Objectives

1. Maintain surveillance of lingering oil

We propose a “presence/absence” approach to monitoring known patches of lingering oil. Beaches with moderately and heavily oiled residues will be sampled to determine if oil continues to persist by re-digging pits on beaches known to be contaminated in 2015. This approach minimizes costs and any potential for mobilizing lingering oil deposits or changing its natural state. If a large number of re-dug pits across sites are devoid of oil residues, then a more detailed approach will be warranted on future surveys. The goal of the surveys proposed here is to determine if oil can be found in locations where oil has been previously found. Therefore, sampling procedures are not intended to provide estimates of the probability of encountering oil, nor the area or mass of retained oil.

2. *Collect and archive biomarkers for future analysis*

   Samples of oiled residues will be collected from each site targeting the heaviest oil from visual classification. A control sample, no visible oil, will also be taken from each site.

B. Procedural and Scientific Methods

A survey will be conducted during the summer of 2020 to assess the presence of oil on beaches sampled by Lindeberg et al. (2018) (Table 1 and Fig. 1). The five most contaminated beach segments surveyed in 2015 will be re-examined for the presence of subsurface oiling during low tide. The segments include Smith Island (SM006), Eleanor Island (EL058B, EL056C), Knight Island (KN114A), and Green Island (GR103B). Residues will be scored as lightly, moderately, heavily, or not oiled following protocols used in 2015. Pits will be refilled after scoring. Results of the survey will allow for comparison of current oil encounter rate with rates observed in 2015.

Pits for assessing the presence of oil will be randomly selected by using methods adapted from Lindeberg et al. (2018). Briefly, surveying equipment will be used to divide shoreline segments in contiguous 20 m wide columns. Shorelines less than 100 m will be divided into correspondingly fewer 20 m sampling columns. Each column will be further partitioned into 5 rectangular blocks designated MVD 1 to MVD 5 and defined by 1-m vertical drops or tidal elevation intervals, beginning at + 4.8 m tide height (MVD 1) and extending to down to −0.2 m (MVD5). Ten blocks will be randomly selected, and a pit will be randomly located within the block, resulting in 10 pits for each 100 m of shoreline. Each pit will be excavated to a depth of 0.5 m or less if an impenetrable substrate was encountered (e.g., bedrock).

Samples of oiled sediment will be collected from contaminated pits when practical. Hydrocarbon-free spoons will be used to scrape contaminated sediments in hydrocarbon-free jars. Sediment samples will be labeled, sealed and transferred with chain of custody to an archive of collected samples from EVOSTC-funded projects maintained at NOAA NMFS's Auke Bay Laboratory. Samples will be collected from all pits in which oiling is visible. In the event that our random selections fail to encounter contaminated sediments, we will re-open pits in known locations to obtain samples for archiving. NOAA maintains records of the specific locations where oil has previously been found. Should this approach be necessary we will collect no more than five total samples for archiving within the time we have available for sample collection.

C. Data Analysis and Statistical Methods

We hypothesize that if oil is sequestered in place then the proportion of oiled pits should remain constant between 2015 and 2020.

Data analysis will consist of comparing the probability of encountering oil in 2015 with the probability in 2020 using a chi square test. Based on the probability of encountering oil reported for 2015 our sample size of 10 pits on each segment should result in detecting oil in at least 1 pit on each of the 5 sampled segments. A power analysis reveals that we will be at least 80% certain of detecting a difference in the proportion of oiled pits at an $\alpha = 0.05$.

D. Description of Study Area

The beaches selected for this survey were among the most heavily oiled in 1989 and the most contaminated of those surveyed in 2015. The beaches selected for that study were prioritized based on oiling history, survey history, and geomorphology (Table 1 and Fig. 1). Each of these beaches has been surveyed multiple times and they represent a variety of substrates. The five beaches selected for this study have an average oil

encounter rate of 25%. In addition, each beach had multiple pits with oil residues in 2015 and each of these beaches retains an average of 472 kg of oil.

Table 1. A prioritized list of sites selected for re-surveying during summer 2015 in Prince William Sound (PWS), Alaska (Lindeberg et al. 2018). Priority has been given to sites with heavy or moderate initial oiling, a history of being surveyed, subsurface oil (SSO) observed in more recent years (heavy, moderate and light oil residue: HOR, MOR, LOR), shore types prone to oil retention, and a high probability of finding SSO based on the predictive model (Nixon and Michel 2015).

	Location Name	Shore Segment	Initial Oiling	Oil Surveys Excavation History	Most Recent Oil Class	Shore Type Prone to Persistent Oil
1	Smith Is.	SM006B	Heavy 1990-93	1989-92[1], 2001[3], 2008[4]	HOR	armored
2	Eleanor Is.	EL056C	Medium 1990-93	2001[3], 2007[4]	MOR	rubble accumulation
3	Eleanor Is.	EL058B	Heavy 1989	2001[3], 2005[3]	MOR	breakwater
4	Latouche Is.	LA018A-1	Heavy 1990-93	1989-92[1], 2001[3], 2005[3]	HOR	rubble, slope
5	Green Is.	GR103B	Heavy 1990-93	2001[3], 2005[3], 2007[4]	HOR	armored, slope
6	Evans Is.	EV039A	Heavy 1990-93	1993[2], 2005[3]	MOR	edge effect
7	Knight Is.	KN0114A	Heavy 1990-93	2003[3]	HOR	breakwater
8	Knight Is.	KN0300A-2	Medium 1990-93	1993[2], 2005[3]	MOR	breakwater
9	Knight Is.	KN0506A	Heavy 1990-93	2001[3], 2005[3]	LOR	edge effect

Excavation history: 1. NOAA Hazmat surveys (now Office of Response & Restoration); 2. EVOSTC Gibeaut surveys; 3. NOAA Auke Bay Laboratory surveys; 4. Nixon and Michel surveys.

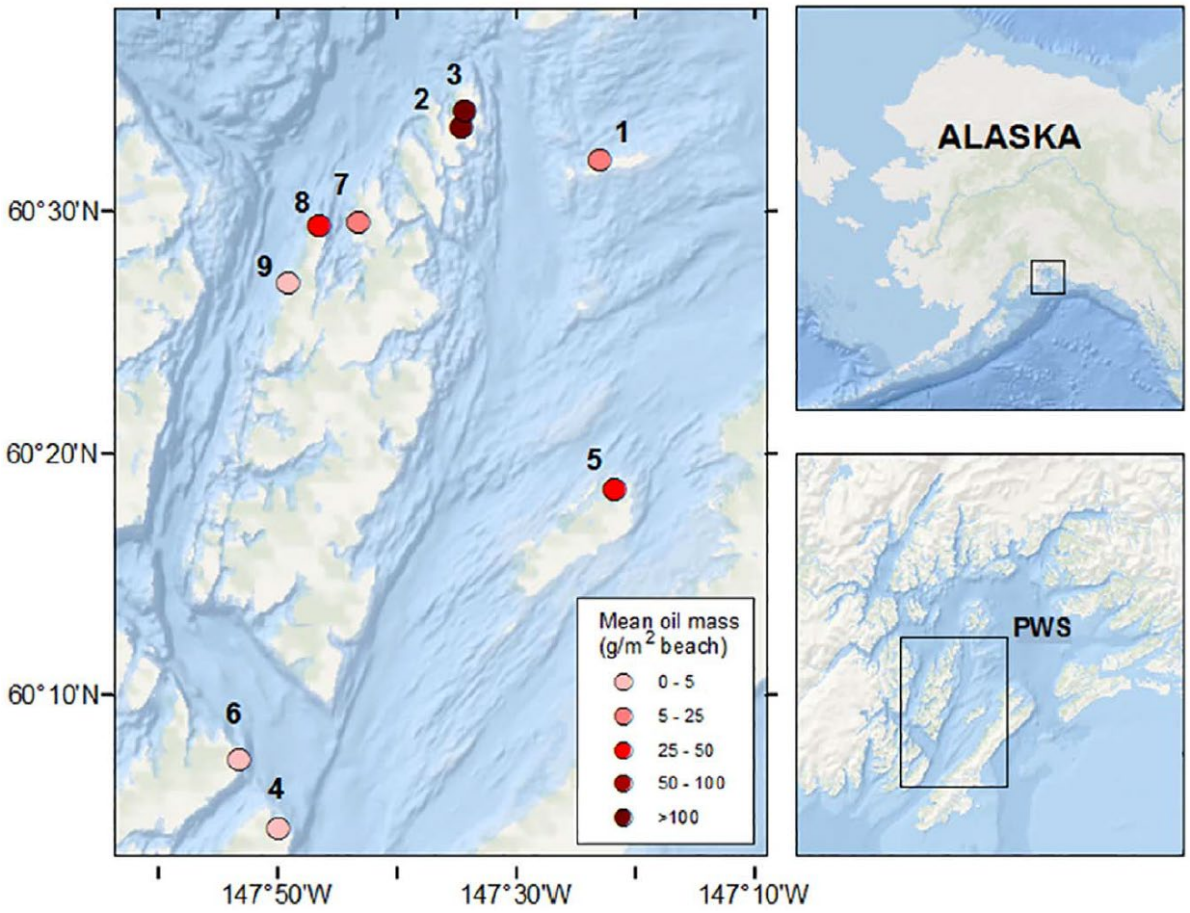

Figure 1. Sites surveyed for subsurface *Exxon Valdez* oil in Prince William Sound, Alaska, during the summer of 2015. Light red to darker brown colored icons indicate greater oil discovered on beach segments. Numbers adjacent to icons correspond to prioritized shore segments listed in Table 1 (Lindeberg et al. 2018).

4. COORDINATION AND COLLABORATION

A. Within an EVOSTC Funded Program

This project would fall under a Lingering Oil component of the GWA program (originally in FY12-16) and continues monitoring conducted by project 16120114-S. Results from the lingering oil survey would be presented at the joint GWA/Herring Research and Monitoring (HRM) annual principal investigator (PI) meetings. The Nearshore component of GWA historically has been closely linked with the Lingering Oil component, given that lingering oil occurs in nearshore habitats and affects nearshore species. Data collected by the Nearshore component are relevant for understanding ecosystem recovery with respect to the presence of lingering oil. In particular, the Nearshore component monitors mussels for the presence of a broad suite of contaminants including PAH.

Currently there is one other project associated with lingering oil research that has recently moved under the HRM program. The project titled Immunological Expressions of PAH Exposure in Fish (EVOSTC project 19170115) and the PI is Andrew Whitehead. This project is looking to interrogate the genome structure and genome function of PWS fish to test hypotheses about the causes and consequences of the PWS herring population collapse, by revealing ecological, evolutionary, and genetic mechanisms governing the demographic trajectory of PWS fish over the past ~30 years. These results coupled with previous survey results have the potential to be highly valuable for assessing long-term impacts of persistent EVO.

This project will coordinate with the Data Management Program preparing metadata and data for publication on the Gulf of Alaska Data Portal and DataONE within the required timeframes.

B. With Other EVOSTC-funded Projects

This project will coordinate with other EVOSTC-funded projects as appropriate by providing data, discussing the relevance and interpretation of data, and collaborating on reports and publications.

C. With Trustee or Management Agencies

Interested state, federal, and non-governmental organizations (NGOs) would benefit from the information provided by continued monitoring. Lingering EVO persisting in the spill area has ramifications for agencies and NGOs related to their mandates (e.g., National Park Service, Regional Citizens' Advisory Councils, Oil Spill Recovery Institute, Alaska Department of Health and Human Services, and Alaska State Parks). The report would bring awareness about the long-term outcomes of the EVOS and the lessons learned that could be incorporated into their operational plans in the region and wherever oil spills may occur.

D. With Native and Local Communities

The purpose of this survey is to maintain surveillance on beaches known to be contaminated with lingering oil. This offers EVOSTC the ability to answer questions from the public on the fate and location of oil remaining on beaches in PWS. The last survey was conducted in 2015. The persistent nature of the oil requires EVOSTC to periodically evaluate contaminated beaches so they can apprise communities with contemporary data.

5. DELIVERABLES

Deliverables for this project will be archived oiled sediment samples ready for chemical analyses with chain of custody and securely locked in the hydrocarbon freezer at NOAA/NMFS Auke Bay Laboratories. Survey data will be provided to the public through the Research Workspace and Gulf of Alaska Data Portal. PIs will present survey findings at the GWA annual PI meetings and the 2021 Alaska Marine Science Symposium. The Lingering Oil component will be added to the GWA website and updated with findings from this project. A news brief will be presented in *Delta Sound Connections* and a possible NOAA web story if warranted. Finally, in FY21 a final report will be drafted, reviewed and submitted to the EVOSTC with recommendations for moving forward with a long-term lingering oil monitoring project.

6. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

Table 2. This table breaks down project deliverables and their status into milestones and tasks by fiscal year and quarter, beginning February 1, 2017. Yellow highlight indicates proposed fiscal year workplan. C = completed, X = not completed or planned. Fiscal year quarters: 1 = Feb 1 – April 30; 2 = May 1 – July 31; 3 = Aug. 1 – Oct. 31; 4 = Nov. 1 – Jan. 31.

	FY20				FY21			
Milestone/Task	1	2	3	4	1	2	3	4
1: Field Work								
Secure funding	X							
Contracts/Supplies		X						
Travel arrangements			X					
Survey cruise			X					
2: Data Analysis								

	FY20				FY21			
Data analysis				X	X			
Data publicly available							X	
3: Deliverables								
Attend/brief GWA PI meeting			X					
Annual report					NA			
FY21 workplan			X					
2021 AMMS presentation				X				
GWA website –LO project					X			
New article						X		
Draft final report						X		
Reviews							X	
Submit final draft report								X

7. PROJECT BUDGET

A. Budget Forms (See GWA FY20 Budget Workbook)

Please see project budget forms compiled for the GWA program.

Table 3. Copy of budget summary page for this project.

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Travel	$0.0	$0.0	$0.0	$1.4	$0.0	$1.4	
Contractual	$0.0	$0.0	$0.0	$46.5	$12.0	$58.5	
Commodities	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	
SUBTOTAL	$0.0	$0.0	$0.0	$47.9	$12.0	$59.9	$0.0
General Administration (9% of subtotal)	$0.0	$0.0	$0.0	$4.3	$1.1	$5.4	N/A
PROJECT TOTAL	$0.0	$0.0	$0.0	$52.2	$13.1	$65.2	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

COMMENTS: NOAA will contribute 1 month of Lindeberg's FTE ($11.2K) during FY20 and FY21. Project total = $22.4K. Requesting 1 trip for Lindeberg ($1.4K). Remaining funds for this project will go to a NOAA Grant.

The PWS Science Center helps administer the GWA program (PM II Project #20120114-B) through a NOAA Grant and will facilitate project funding to the Sitka Sound Science Center for co-PI Ron Heintz.
FY20 breakdown under NOAA grant [$46.5K w/o GA]:
Heintz 1 mo ($7.5K), travel ($4K), charter ($15.5K), field labor ($17.5K), field/sampling gear ($2K)
FY21 breakdown under NOAA grant [$12K w/o GA]:
Heintz 1.5 mo ($9.75K), Heintz travel PI meeting and AMSS ($2.25K)

FY17-21	**Project Number: 20200114-P** **Project Title: Lingering Oil** **Primary Investigator: Mandy Lindeberg** **Agency: NOAA**	**TRUSTEE AGENCY SUMMARY PAGE**

B. Sources of Additional Project Funding

NOAA will provide in-kind funding for 1 month of Mandy Lindeberg's time ($11.2K) for FY20 and FY21 for a project total of $22.4K.

8. LITERATURE CITED

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9. PROJECT PERSONNEL

Project personnel would be Mandy Lindeberg (NOAA NMFS) and Ron Heintz (Sitka Sound Science Center). Lindeberg will provide overall leadership for the project serving as the point of contact and taking custody of all field samples to ensure chain of custody. Heintz will oversee the field component and analyze field data. Lindeberg and Heintz will jointly produce the final report.

MANDY R. LINDEBERG
Fisheries Research Biologist (1996-present)
Auke Bay Laboratories, Alaska Fisheries Science Center, NMFS
17109 Pt. Lena Loop Rd, Juneau, Alaska 99801
Phone: (907) 789-6616; mandy.lindeberg@noaa.gov

Professional Experience

- GWA Program Lead (2017-present); Pelagic Component Lead (2013-16).
- Researcher for Recruitment, Energetics, and Coastal Assessment Program (2011-current) - NMFS Auke Bay Laboratories (ABL)
- Core team member of Habitat and Ecological Processes Program, Alaska Fisheries Science Center (AFSC) - developing RFPs, reviewing proposals for scientific merit, and recommendation for funding
- Chair for Auke Bay Laboratories Data Coordination Committee and member of AFSC Public Access and Research Results (PARR) workgroup
- Acting Deputy Director for NMFS Auke Bay Laboratories (two tours of duty)
- Coordinator for Division FOIA responses – NMFS, Auke Bay Laboratories.

Research

1990 - Present: Mandy has been involved in oil spill research and nearshore habitat studies throughout Alaska's coastline, particularly Prince William Sound, for over 25 years. Her research includes damage assessment and long term monitoring of nearshore flora, fauna, and persistence of oil in the EVOS spill region. Mandy has been an integral part of the Gulf Watch Alaska Program serving as Program Lead (2017-current), Pelagic Component Lead (2013-16), co-Principle Investigator for the Nearshore component (2011-16), and co-Principle Investigator for the Lingering oil component (2011-16). She has been a core steering committee member and a participant in the Alaska *ShoreZone* habitat mapping project for over 12 years. Mandy has also conducted research on essential fish habitat under the Magnuson-Stevens Act, focusing on nearshore forage fish throughout the state. Her specific scientific expertise lies with coastal ecology and specializes in the taxonomy and ecology of seaweeds. All of these studies have enabled her to not only develop a unique knowledge of Alaskan marine ecosystems but also manage all activities associated with a diverse array of research projects and collaborators.

Publications: *(selected)*

EVOS Research Highlights:

Aderhold, D.G.R, **Lindeberg**, M.R., Holderied, K., Pegau, S.W., 2017. Introduction: Spatial and temporal ecological variability in the northern Gulf of Alaska: What have we learned since the *Exxon Valdez* oil spill? Deep-Sea Research Part II. DOI:10.1016/j.dsr2.2017.11.015

Carls MG, Holland L, Irvine GV, Mann DH, **Lindeberg** M. 2016. Biomarkers as tracers of *Exxon Valdez* oil. Environmental Toxicology and Chemistry 35(11):2683-2690.

Bowen, L., Miles, A.K., Ballachey, B., Waters, S., Bodkin, J., **Lindeberg**, M., Esler, D., 2017. Gene transcription patterns in response to low level petroleum contaminants in *Mytilus trossulus* from field sites and harbors in southcentral Alaska. Deep-Sea Research Part II. DOI:10.1016/j.dsr2.2017.08.007.

Lindeberg, M.R., Maselko, J., Heintz, R.A., Fugate, C.J., Holland, L., 2018. Conditions of persistent oil on beaches in Prince William Sound 26 years after the *Exxon Valdez* spill. Deep-Sea Research Part II. DOI:10.1016/j.dsr2.2017.07.011.

Lindeberg, M. R., M. G. Carls, and J. Maselko. 2017. Lingering Oil: Extending the Tracking of Oil Levels and Weathering (PAH Composition) in PWS through Time. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 12120014-S), NOAA/NMFS Auke Bay Laboratories, Juneau, Alaska.

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O'Clair, Charles E., M. R. **Lindeberg**, and Joshua Millstein. 2001. "Mesoscale differences in mussel, *Mytilus trossulus*, population structure in Prince William Sound, Alaska in relation to oiling history and predation intensity." Journal of Experimental Marine Biology and Ecology. 262:155-176.

Short, J. W., K. R. Springman, M. R. **Lindeberg**, L. G. Holland, M. L. Larsen, C. A. Sloan, C. Khan, P. V. Hodson, and S. D. Rice. 2008. Semipermeable membrane devices link site-specific contaminants to effects: Part II – A comparison of lingering *Exxon Valdez* oil with other potential sources of CYP1A inducers in Prince William Sound, Alaska. Mar. Environ. Res. 66:487-498.

Short J.W., G. V. Irvine, D. H. Mann, J. M. Maselko, J. J. Pella, M. R. **Lindeberg**, J. R. Payne, W. B. Driskell, and S. D. Rice. 2007. Slightly weathered *Exxon Valdez* oil persists in Gulf of Alaska beach sediments after 16 years. Environ. Sci. Technol. 41:1245-1250.

Short, J.W., J.M. Maselko, M.R. **Lindeberg**, P.M Harris, and S.D. Rice. 2006. Vertical distribution and probability of encountering intertidal *Exxon Valdez* oil on shorelines of three embayments within Prince William Sound, Alaska. Environ. Sci. and Technol. Vol. 40, 3723-3729.

Short, J.W., M. R. **Lindeberg**, Patricia M. Harris, J. Maselko, Jerome J. Pella, and S.D. Rice. 2004. An estimate of oil persisting on beaches of Prince William Sound, 12 years after the *Exxon Valdez* oil spill. Environ. Sci. and Technol. Vol 38: 19-25.

Springman, K. R., J. W. Short, M. **Lindeberg**, and S. D. Rice. 2008. Evaluation of bioavailable hydrocarbon sources and their induction potential in Prince William Sound, Alaska. Mar. Environ. Res. 66:218-220.

Springman, K. R., J. W. Short, M. R. **Lindeberg**, J. M. Maselko, C. Khan, P. V. Hodson, and S. D. Rice. 2008. Semipermeable membrane devices link site-specific contaminants to effects: Part 1 – Induction of CYP1A in rainbow trout from contaminants in Prince William Sound, Alaska. Mar. Environ. Res. 66:477-486.

Thomas, R.E., M. R. **Lindeberg**, Patricia M. Harris, and Stanley D. Rice. 2007. Induction of DNA Strand Breaks in the Mussel (*Mytilus trossulus*) and Clam (*Protothaca staminea*) Following Chronic Field Exposure to Polycyclic Aromatic Hydrocarbons from the *Exxon Valdez* Spill. Marine Pollution Bulletin. 54: 726-732.

Education: BS 1989, Marine Biology, Western Washington University, Bellingham, Washington.

Collaborators (no particular order, last 4 years):
Coon, Catherine (BOEM); Coletti, Heather (NPS); Dan Esler (USGS), Ballachey, Brenda (USGS); Bowen, Lizabeth (USGS, UC Davis); Iken, Katrin (UAF); Hoffman, Christopher (USACOE); Jones, Tahzay (NPS); Konar, Brenda (UAF); Lewis, Steve (Alaska Regional Office, NMFS); Lindstrom, Sandra (UBC); Lauenstein, Gunnar (NOAA, NOS); Saupe, Sue (Cook Inlet RCAC); Stickle, William (LSU).

Ron Heintz - Research Director

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Education

University of Illinois, Urbana IL	Ecology Ethology and Evolution	B.Sc. 1979
University of Alaska, Fairbanks AK	Fisheries Biology	M.Sc. 1985
University of Alaska, Fairbanks AK	Fisheries Biology	Ph.D. 2010

Work History

Present: *Research Director* Sitka Sound Science Center – Oversee research portfolio for the Sitka Sound Science Center, plan and develop research programs, identify and develop research partnerships, ensure completion of existing programs.

2019- 2013: *Program Manager* NOAA Alaska Fisheries Science Center (AFSC)– Lead and supervise 24 scientists and contractors in the Recruitment Energetics and Coastal Assessment Program. The program conducted original research into the trophic ecology of forage fish in the Gulf of Alaska, Bering Sea and U.S. Arctic, monitored Prince William Sound for the presence of lingering *Exxon Valdez* oil, conducted surveys to evaluate the abundance and distribution of fish in near shore habitats and developed indicators of ecosystem status for large marine ecosystems in Alaska in conjunction with fishery oceanographic surveys.

2013 – 2000: *Research Biologist* Nutritional Ecology Laboratory, NOAA, Alaska Fisheries Science Center – Developed a bioenergetics research group ultimately consisting of 7 scientists and contractors. Research focused on cataloging the nutritional quality of Steller Sea Lion prey in the Gulf of Alaska, understanding the lipid phenology in forage species, and characterizing the nutritional subsidies to freshwater habitats offered by salmon returning to spawn.

1992 to 2000 - *Research Biolo*gist NOAA Alaska Fisheries Science Center - Conducted original research establishing the teratogenic effects of crude oil on fish embryos following the *Exxon Valdez* oil spill. Managed a database cataloging hydrocarbon concentrations in sediments, water and biota collected by Trustee scientists following the spill, helped to develop an algorithm for fingerprinting *Exxon Valdez* oil in sediments, water and biota.

1985 to 1995 - *Research Biologist* NOAA Alaska Fisheries Science Center – Conducted original research into the culture of Chinook Salmon at a remote research hatchery in southeastern Alaska. Developed methods for rearing fish to maturity in captivity and researched the optimal size at release for hatchery reared Chinook salmon.

Products related to this proposal

2018 – Invited by the Korean National Park Service to speak at the 10th Anniversary of the Hebei Spirit Symposium, Incheon S Korea

2018 – Guest Editor for Deep Sea Research II Special Issue on Lessons Learned from the *Exxon Valdez* Oil Spill

2015 – Gold Medal for Scientific/Engineering Achievement awarded by Secretary of Commerce for work conducted on the Bering Sea Integrated Ecosystem Research Project

Representative Publications

Lindeberg, M.R., Maselko, J., **Heintz, R.A**., Fugate, C.J. and Holland, L., 2018. Conditions of persistent oil on beaches in Prince William Sound 26 years after the *Exxon Valdez* spill. *Deep Sea Research Part II: Topical Studies in Oceanography*, *147*, pp.9-19.

Heintz, R. **A.** 2007. Chronic exposure to polynuclear aromatic hydrocarbons in natal habitats leads to decreased equilibrium size, growth and stability of pink salmon populations. Integrated Environmental Assessment and Management. 3(3):351-363.

Barron, M. G., M. G. Carls, **R. Heintz** and S. D. Rice. 2004. Evaluation of fish early life-stage toxicity models of chronic embryonic exposures to complex polycyclic aromatic hydrocarbon mixtures. Toxicological Sciences **78**(1): 60-67.

Heintz, R. A., S. D. Rice, et al. 2000. Delayed effects on growth and marine survival of pink salmon *Oncorhynchus gorbuscha* after exposure to crude oil during embryonic development. Marine Ecology Progress Series 208: 205-216.

Heintz, R. A., J. W. Short, et al. 1999. Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered *Exxon Valdez* crude oil. Environmental Toxicology and Chemistry 18(3): 494-503.

Marty, G. D., J. W. Short, D. M. Dambach, N. H. Willits, **R. A. Heintz**, S. D. Rice, J. J. Stegeman and D. E. Hinton. 1997. Ascites, premature emergence, increased gonadal cell apoptosis, and cytochrome P4501A induction in pink salmon larvae continuously exposed to oil-contaminated gravel during development. Canadian Journal of Zoology **75**(6): 989-1007.

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(8): 2375-2384.

Collaborators last 4 years (no particular order):

University of Alaska: Kristen Gorman, Jan Straley, Brenda Norcross, Seth Danielson, Alexei Pinchuk, Anne Beaudreau

NOAA Alaska Fisheries Science Center: Fletcher Sewall, Johanna Vollenweider Thomas Hurst, Ben Laurel, John Moran, Mandy Lindeberg, Janet Duffy-Anderson, Jamal Moss, Mike Sigler, Ed Farley, Elizabeth Siddon, Ashwin Sreenivasan, Katharine Miller, Matt Rogers, Todd Miller, Rob Suryan

University of California: Ben Martin, Kristy Kroeker

Oregon State University: Louise Copeman

Florida International University: Kevin Boswell