FY 22-31 *PROJECT* PROPOSAL
LONG-TERM RESEARCH AND MONITORING PROGRAM

Does this proposal contain confidential information? ☐Yes ☒No

Project Number and Title

Gulf Watch Alaska Long-Term Research and Monitoring Program: Lingering Oil Component

22200114-P Long-term Monitoring of Lingering Oil in Prince William Sound

Primary Investigator(s) and Affiliation(s)

Dan Esler, U.S. Geological Survey, Alaska Science Center

Mandy Lindeberg, National Oceanic and Atmospheric Administration

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Project Abstract (maximum 300 words)

Of the nearly 11 million gallons of crude oil released during the 1989 *Exxon Valdez* oil spill (EVOS), a small proportion is thought to remain sequestered within sediments of beaches with distinct characteristics throughout the spill area. This lingering oil, as it is known, has been a source of concern for federal and state governments and the public for more than 30 years. Significant efforts have been applied by the EVOS Trustee Council (EVOSTC) to document the extent of this issue, determine effects of lingering oil on natural resources, and identify potential mitigation or restoration options and their pros and cons. The most recent studies have indicated that the sequestered oil is not declining significantly in volume or occurrence, nor is it weathering quickly. Lingering oil also does not appear to be bioavailable, as indicators of exposure of living resources to hydrocarbons are at background levels in areas where oil persists. However, it remains important to monitor the locations and status of lingering oil both for improved scientific understanding of the timeline of persistence of spilled oil, as well as to determine potential for detrimental effects in the event lingering oil is disturbed. The EVOSTC has indicated their commitment to continuing lingering oil monitoring and requested a plan to continue to document the occurrence and condition of lingering EVOS oil. This project proposes a low-cost presence/absence approach to intermittent monitoring, along with chemical analyses in FY25, that can be combined with previous EVOSTC-funded modeling efforts to provide managers with contemporary data on the status of lingering oil.

EVOSTC Funding Requested* (must include 9% GA)

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$0	$0	$0	$124,042	$0	$124,042
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$0	$0	$0	$45,453	$0	$45,453
				FY22-31 Total	*$169,495*

**If the amount requested here does not match the amount on the budget form, the request on the budget form will considered to be correct.*

Non-EVOSTC Funds to be used, please include source and amount per source:

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$0	$0	$25,500	$38,000	$0	$63,500
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$0	$0	$29,000	$42,500	$31,000	$102,500
				FY22-31 Total	*$166,000*

Non-EVOSTC funds are agency in-kind, representing salary contributions of permanent Primary Investigators and use of existing equipment including boats and other specialized gear.

1. EXECUTIVE SUMMARY (maximum ~1500 words, not including figures and tables)

Over the 10-year period between FY22-FY31, we propose to examine previously sampled beaches in Prince William Sound (PWS) known to have contained lingering *Exxon Valdez* oil (EVO). We will document whether subsurface oil persists at these beaches during FY25 and FY30, continuing the intermittent examination of this issue. In FY25, we also will collect oil samples for analysis of hydrocarbon composition to determine the degree of weathering of lingering oil. Finally, also in FY25, we will collect mussels (*Mytilus trossulus*) for evaluation of a wide suite of potential contaminants (Rider et al. 2020), including hydrocarbons, following NOAA's Mussel Watch protocols, continuing intermittent mussel sampling that has been conducted by the Nearshore component since the initiation of Gulf Watch Alaska (GWA). Together, these data will provide ongoing determination of the persistence, state, and bioavailability of lingering oil, with relevance to state and federal managers of natural resources.

The unanticipated duration of persistence of oil was one the most important findings by *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) scientists following the spill. When the *Exxon Valdez* ran aground on March 24, 1989, it released at least 10,800,000 gallons of crude oil (Wolfe et al. 1994). Western PWS beaches were hardest hit by spilled oil, affecting 783 km of shoreline (Short et al. 2004). Through a combination of large-scale clean-up efforts and natural processes, it was expected that remaining oil would be reduced to negligible amounts after the first several years of the spill (Neff et al. 1995). However, as the decades passed, studies funded by EVOSTC documented unanticipated long-term impacts of *Exxon Valdez* oil spill (EVOS), including persistence of oil in the environment and long-term effects of oil exposure on some wildlife (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. Continued monitoring of these beaches for the presence of oil provides the EVOSTC with up-to-date data on the spatial and temporal extents of EVOS effects.

The EVOSTC has had a long history of lingering oil studies focusing on quantifying distribution, quantity, loss rate, weathering state, and bioavailability of EVO through field studies and by developing empirical models. These findings are summarized in periodic reports on the status of lingering oil and effects on biota (Michel and Esler 2010, EVOSTC 2016, Michel et al. 2016), which are intended to inform sponsoring EVOSTC agencies, decision makers, and the public. The proposed work will continue this line of inquiry.

The first lingering oil survey 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). Additional 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).

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 was likely to persist. Most recent modeling by Nixon and Michel (2018) that included data ranging from 2001-2015 (14,000 pit excavations) supported previous estimates and even suggested slightly higher amounts of oil remaining. Model estimates changed from 0.25% to 0.6% of the originally spilled mass of oil remained and it is now estimated that lingering oil remains in 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 estimated to be 3-4% per year, but given the margin of error, loss rates could be closer to zero (Nixon and Michel 2018, Lindeberg et al. 2018).

Samples of oil collected during lingering oil surveys have been analyzed to verify that the oil is EVO and to evaluate its weathering state, based on composition of polycyclic aromatic hydrocarbons (PAH). 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 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 begun to weather (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.

Surveys have provided a clear idea of the location of sequestered oil in PWS (Michel et al. 2010, Nixon and Michel 2015) and the remaining amounts over time (Nixon and Michel 2018). Therefore, the strategy for addressing lingering oil is periodic monitoring conducted by EVOSTC-funded studies. We propose to follow this strategy and maintain the survey schedule (once every 5 years), sample oil to determine weathering state, and measure contaminants in mussels, a ubiquitous species in intertidal habitats of the spill-affected area.

2. RELEVANCE TO THE INVITATION (maximum 300 words)

This project proposal addresses the EVOSTC lingering oil topic under the Long-Term Research and Monitoring (LTRM) focus area in the FY22-31 Invitation for Proposals. The EVOSTC continues to be accountable for monitoring oil-contaminated beaches despite evidence that the sequestered oil is not bioavailable. Based on the

most recent surveys in 2015, oil sequestered on the beaches had not weathered substantially since it made landfall (Lindeberg et al. 2018) and therefore retained potential toxicity. So long as the oil remains on beaches, the EVOSTC needs to keep agencies and the public apprised of the status of lingering oil. Three decades 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 Deepwater Horizon court cases).

3. PROJECT HISTORY (maximum 400 words)

As described above, the EVOSTC has had a long history of lingering oil studies (summarized in EVOSTC 2016, Michel and Esler 2010, Michel et al. 2016, Lindeberg et al. 2018) (projects 02543, 040585, 050620, 070801, 12120117 and 12120114-S). The results of these have led to unprecedented understanding of the duration of consequences of oil spills, both in terms of the timeline over which oil remains in the environment (Lindeberg et al. 2018, and references therein), as well as the short- and long-term effects of oil on wildlife (Esler et al. 2018 and references therein). In turn, this information has led to important insights about the timing and causes of lack of recovery of injured resources and opportunities for restoration and mitigation. Further, these data have been used well beyond the EVOS, contributing to evaluations of damages from other spills and risk assessments of projects where hydrocarbon pollution is possible.

Lingering oil studies were integrated into the EVOSTC-funded GWA effort in 2012. In the FY22-31 Invitation for Proposals, the EVOSTC explicitly requested incorporation of lingering oil monitoring as part of the overall LTRM integrated program; this proposal is our response to that request.

4. PROJECT DESIGN

A. Objectives and Hypotheses

1. *Conduct regular surveillance of lingering oil*

The goal of the surveys proposed here is to determine if oil can be found in locations where lingering oil has been previously found. Sampling procedures will follow methods established during previous lingering oil surveys; these are designed to provide estimates of oil incidence and visual classification on oil intensity using standard categories of light, moderate, or heavy oil residue: LOR, MOR, HOR (Short et al. 2004). We note that these surveys are explicitly not intended to provide estimates of the probability of encountering oil, nor the area or mass of retained oil. We hypothesize that, under a scenario of minimal oil degradation and high sequestration, incidence of oil presence will be similar to previous surveys. If incidence is lower than previous surveys, either weathering has degraded the oil (see Objective 2) or it has been disturbed and released, potentially exposing nearshore biota (see Objective 3).

2. *Conduct PAH composition analysis of lingering oil*

Forensic analysis has been an important component of previous lingering oil surveys. Collection of samples to determine the oil's chemical composition is critical for identifying its weathering state and verifying its identity as EVO. Weathering refers to the process by which compounds are lost from the surface of deposits to surrounding matrices. The weathering state of an oil deposit can be quantified because compounds are lost predictably, e.g., naphthalenes are lost more rapidly from oil residues than chrysenes (Venosa et al. 1996, Short

and Heintz 1997). These processes for EVO have been well quantified and we can use this understanding to evaluate the degree of weather in oil discovered during 2025. This is important because the degree of weathering is related to the rate at which oil will degrade and the toxicity threat that it could pose to marine biota.

The PAH compounds in crude oil degrade in a predictable pattern, facilitating identification of the source of an unknown sample (Short and Heintz 1997). This approach has been used in previous surveys in western PWS 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 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.

3. Document contaminant levels in mussels

A central issue in understanding natural resource injuries from the EVOS was the occurrence and consequence of exposure of various marine biota to lingering oil (e.g., Esler et al. 2016, Esler et al. 2018). Filter feeding mussels (*Mytilus trossulus* in the north Pacific) have been used widely to evaluate incidence and relative concentrations of a wide variety of contaminants in marine environments, including PAH. Because of that, mussels have been collected and analyzed intermittently as part of GWA, as reported by Rider et al. (2020). We propose to continue this, with mussels sampled during 2025 and sent to NOAA's Project Mussel Watch for analysis of concentrations of PAHs, polychlorinated biphenyls (PCBs), pesticides, and metals. Mussels will be collected by the LTRM nearshore component at intertidal sampling sites across the spill affected region of the northern Gulf of Alaska. This broad spatial extent of sampling will provide perspective on samples from PWS, the study block with a history of lingering oil and where Objectives 1 and 2 will be conducted. The are many methods for evaluating PAH exposure in biota, including measurement of tissue concentrations, expression of cytochrome P4501A, and gene transcription. We have chosen the former to be consistent with previous GWA sampling, other studies dating back to the EVOS, and the continental scale NOAA Mussel Watch program.

B. Procedural and Scientific Methods

Objective 1. Conduct regular surveillance of lingering oil.

We propose a "presence/absence" approach to monitoring known patches of lingering oil (Lindeberg et al. 2018). 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 lowers potential for mobilizing lingering oil deposits or changing its natural state. If a large number of pits across sites are devoid of oil residues, then a more detailed approach will be warranted on future surveys.

Surveys will be conducted during summers of 2025 and 2030 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. These 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.

Location of pits for assessing 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 into 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 (MVD 5). 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 is encountered (e.g., bedrock).

Objective 2. Conduct PAH composition analysis of lingering oil.

At lingering oil monitoring sites, samples of oiled sediment will be collected in 2025 from pits when oil contamination is encountered during lingering oil surveys described above. Hydrocarbon-free spoons will be used to scrape contaminated sediments into 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. If oiled sediments are not observed, additional samples will be collected from locations where oil is known to exist. Oiled sediment samples will be shipped to NOAA's NOS NCCOS - Monitoring & Assessment Branch, Stressor Detection & Impacts Division and a contract with TDI Brooks. Samples and analyses will have oversight by Dr. Dennis Apeti, a senior chemist and manager of the national program Mussel Watch (see letter of commitment attached). Analyses will determine oil source, total PAH, and weathering state. From the five lingering oil monitoring sites, 24 oiled sediment samples will be analyzed providing a sufficient number for monitoring results and continuing the long-term time series.

Objective 3. Document contaminant levels in mussels.

The concentration of contaminants will be measured in mussels collected in 2025 from rocky intertidal sites continuing to be monitored by the GWA-LTRM Nearshore Component, separate from the lingering oil monitoring sites. These sites include several regions across the spill-affected area, including western PWS, Kenai Fjord National Park, Kachemak Bay, and Katmai National Park and Preserve. Mussels will be handled following the Nearshore Component standard operating procedures (Dean and Bodkin 2011) and the protocols of NOAA Mussel Watch Program (Apeti et al. 2012). Analyses will also be conducted through NOS NCCOS and Dr. Apeti who has analyzed and reported on mussels throughout the Gulf of Alaska over the last 10 years (Rider et al. 2020). We are pleased that mussel and oiled sediment samples will be analyzed from the same laboratory applying the same protocols and quality control standards for the time-series. A breakdown of analytical costs are summarized in the budget section (Section 8.A).

C. Data Analysis and Statistical Methods

Data analysis will consist of comparing the probability of encountering oil in 2025 and 2030 relative to 2015 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 $\alpha = 0.05$.

Data on concentrations of contaminants in mussels will be summarized and presented following Rider et al. (2020). This is largely descriptive, although any suggestion that certain compounds or locations are showing unexpected patterns can be evaluated statistically. These data are primarily intended to serve as benchmarks for contamination levels through time, with the expectation that contaminant concentrations will not change markedly in our relatively pristine study areas. In the event that expectation is not realized, additional detailed evaluations will follow.

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

Table 1. A list of sites re-surveyed during summer 2015 in Prince William Sound (PWS), Alaska (Lindeberg et al. 2018). These sites were selected based on heavy or moderate initial oiling, a history of being surveyed, subsurface oil (SSO) observed in 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). Sampling in 2025 and 2030 will focus on a subset of sites (SM006, EL056C, EL058B, GR103B, and KN114A), which had high incidences of oil in the most recent sampling (Lindeberg 2018). The additional sites will serve as alternates in case of access issues due to weather.

	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.

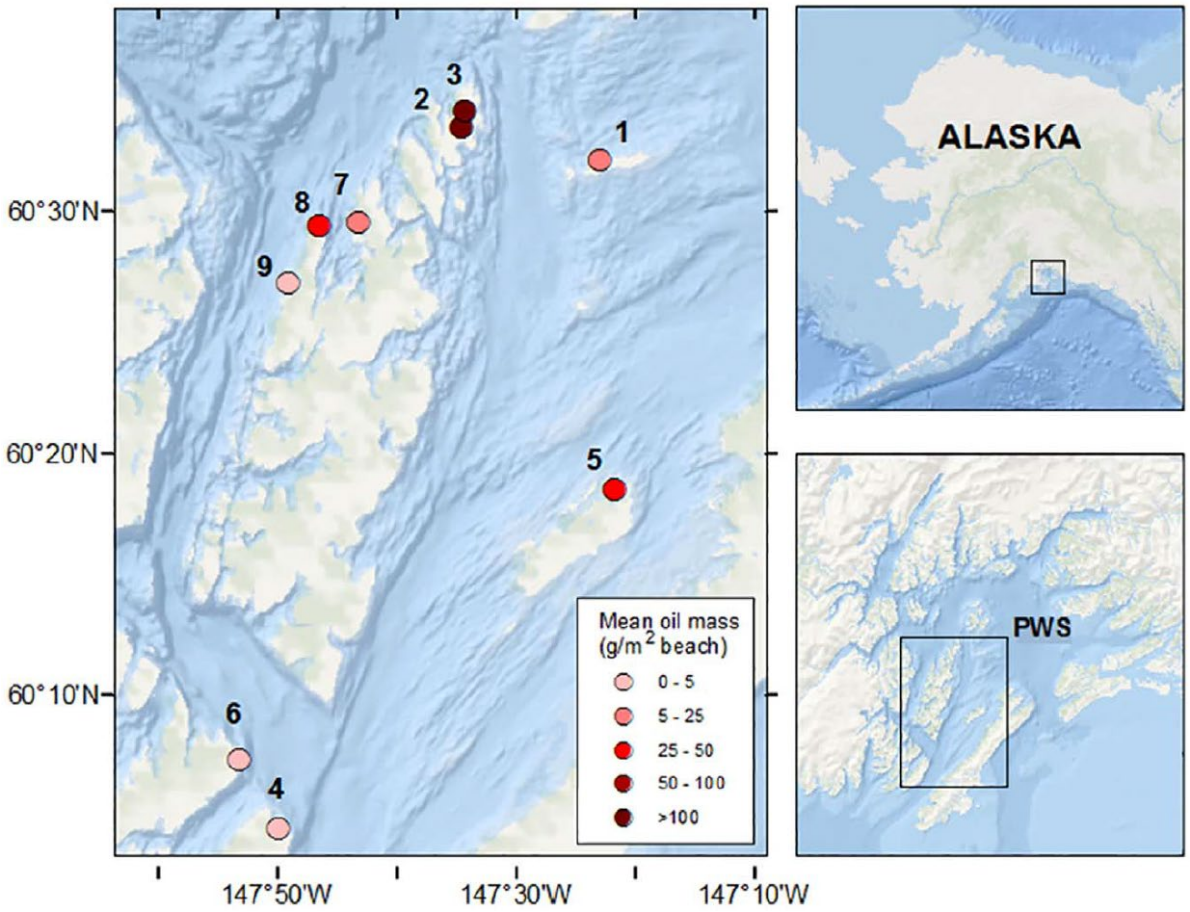

Figure 1. Sites to be surveyed for subsurface Exxon Valdez oil in Prince William Sound (PWS), Alaska, during summers of 2025 and 2030. Light red to darker brown colored icons indicate progressively greater oil discovered on beach segments during previous lingering oil surveys. Numbers adjacent to icons correspond to prioritized shore segments listed in Table 1 (Lindeberg et al. 2018).

5. COORDINATION AND COLLABORATION

A. With the Alaska SeaLife Center or Prince William Sound Science Center

The lingering oil component does not have any direct collaboration with the Alaska SeaLife Center or Prince William Sound Science Center.

B. Within the EVOSTC LTRM Program

Environmental Drivers Component

The Lingering Oil Component does not have any direct collaboration with the Environmental Drivers Component.

Pelagic Monitoring Component

The Lingering Oil Component does not have any direct collaboration with the Pelagic Component.

Nearshore Monitoring Component

The lingering oil issue has always been tightly linked to the nearshore component, as stranded oil and the biota affected by that oil are largely found within the nearshore biome. Understanding of the status and weathering of lingering oil will provide context on the status and potential for contamination of nearshore habitats, plants, and animals, which constitute the majority of resources injured by the EVOS. Logistically, personnel from the nearshore component are uniquely qualified for intertidal work and bring efficiencies for conducting lingering oil surveys. In addition, mussels collected at all Nearshore Component sites will be used to evaluate contaminant concentrations (Objective 3). This collaboration is essential for sampling mussels across a broad swatch of nearshore locations within the spill-affected area of the northern Gulf of Alaska.

Herring Research and Monitoring component

The Lingering Oil Component does not have any direct collaboration with the Herring Research and Monitoring Component.

Synthesis and Modeling Component

Lingering oil data may be incorporated into synthesis and modeling efforts, depending on the nature of the questions posed during the 10-year duration of this work. For example, one potential Synthesis and Modeling Component analysis is comparing the magnitude of response and duration of recovery for species with known effects of EVO and subsequent environmental perturbations, both cyclical (e.g., El Niño) and longitudinal (e.g., climate warming).

Data Management Project

As with other components, data from the Lingering Oil Component will be compiled, QA/QC'ed, and made public through publication in a timely manner, with guidance and assistance from the data management project.

C. With Other EVOSTC-funded Projects (not within the LTRM Focus Area)

Current EVOSTC-funded projects not within the LTRM focus area have not intersected with this project so far. As the EVOSTC funds future projects outside the GWA-LTRM program we will evaluate their applicability to our project and coordinate as appropriate. Status of lingering oil may provide some context in the ongoing evaluation of injured resources, including some that are being studied outside of the LTRM (e.g., pigeon guillemots and Kittlitz's murrelets).

D. With Proposed EVOSTC Mariculture Focus Area Projects

The Lingering Oil Component does not have planned collaborations with Mariculture projects. However, the data from this project could have implications when evaluating plans for mariculture site selection and potential risks of PAH contamination of mariculture products.

E. With Proposed EVOSTC Education and Outreach Focus Area Projects

The GWA-LTRM program will develop an outreach plan that includes coordination and collaboration with the Trustee's Education and Outreach Program and projects. We look forward to participating in education and outreach opportunities where our project findings can contribute to a better understanding of the Gulf of Alaska ecosystem by the general public. The Lingering Oil Component will be involved in overall LTRM engagement with

any relevant Education and Outreach projects funded during the FY22-31 cycle. As in previous cycles, we expect to regularly generate outreach materials in a number of formats.

F. With Trustee or Management Agencies

Lingering oil presence and status are important for state and federal agencies with habitat or species management mandates. There are no other current efforts by any agencies or other organizations to document lingering oil, so these data are particularly valuable to those agencies needing this information.

G. With Native and Local Communities

The GWA-LTRM program and this project are committed to involvement with local and Alaska Native communities. Our vision for this involvement will include active engagement with the Education and Outreach Focus Area, program-directed engagement through the Program Management project (2222LTRM), and project-level engagement. During the first year of the funding cycle (FY22), the GWA-LTRM program will reach out to local communities and Alaska Native organizations in the spill affected area to ask what engagement they would like from us and develop an approach that invites involvement of PIs from each project, including this one. Our intent as a program is to provide effective and meaningful community involvement that complements the work of the Education and Outreach Focus Area and allows communities to engage directly with scientists based on local interests.

The Lingering Oil Component will continue to participate in these outreach activities, especially engaging with local communities as we have during the first 10 years of the program, including listening sessions throughout spill-effected communities and contributing newsletter articles targeted for public understanding.

6. DELIVERABLES

We will produce annual reports in the years following field activities and a final report at the end of the 10-year cycle describing activities and findings of this lingering oil work. We anticipate at least one peer-reviewed publication describing the persistence and weathering of EVOS lingering oil, which will be of high interest to the scientific community. We also anticipate at least one presentation following each period of field sampling, highlighting the findings of the preceding sampling. Data and metadata will be delivered following each sampling event, with publication within a year of data collection or generation.

7. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

Project milestones and tasks by fiscal year and quarter, beginning February 1, 2022. Fiscal Year Quarters: 1= Feb. 1-April 30; 2= May 1-July 31; 3= Aug. 1-Oct. 31; 4= Nov. 1-Jan 31.

	FY22				FY23				FY24				FY25				FY26			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Field Prep and Logistics																				
Contracting and gear prep												X	X							
Field Work																				
Oil surveys and collection of oil and mussel samples														X						
Lab Analyses																				
Oil composition and mussel contaminant analyses															X	X				

Milestone/Task	FY22				FY23				FY24				FY25				FY26			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Reporting																				
Annual reports																	X			
Deliverables																				
Data posted online																		X		

Milestone/Task	FY27				FY28				FY29				FY30				FY31			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Field Prep and Logistics																				
Contracting and gear prep												X	X							
Field Work																				
Oil surveys														X						
Reporting																				
Annual reports																X				
Final report																				X
Deliverables																				
Peer reviewed paper																				X
Data posted online																		X		

8. BUDGET

A. Budget Forms (Attach)

Please see Gulf Watch Alaska Long-Term Research and Monitoring workbook.

Budget Category:	Proposed FY 22	Proposed FY 23	Proposed FY 24	Proposed FY 25	Proposed FY 26	5-YR TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$0	$0	$0	$16,800	$0	$16,800	
Travel	$0	$0	$0	$5,000	$0	$5,000	
Contractual	$0	$0	$0	$75,000	$0	$75,000	
Commodities	$0	$0	$0	$17,000	$0	$17,000	
Equipment	$0	$0	$0	$0	$0	$0	
Indirect Costs (varies by proposer)	$0	$0	$0	$0	$0	$0	
SUBTOTAL	$0	$0	$0	$113,800	$0	$113,800	
General Administration (9% of subtotal)	$0	$0	$0	$10,242	$0	$10,242	N/A
PROGRAM TOTAL	**$0**	**$0**	**$0**	**$124,042**	**$0**	**$124,042**	
Other Resources (In-Kind Funds)	**$0**	**$0**	**$25,500**	**$38,000**	**$0**	**$63,500**	

Budget Category:	Proposed FY 27	Proposed FY 28	Proposed FY 29	Proposed FY 30	Proposed FY 31	5-YR TOTAL PROPOSED	ACTUAL CUMULATIVE	TEN YEAR TOTAL
Personnel	$0	$0	$0	$19,200	$0	$19,200		$36,000
Travel	$0	$0	$0	$5,500	$0	$5,500		$10,500
Contractual	$0	$0	$0	$0	$0	$0		$75,000
Commodities	$0	$0	$0	$17,000	$0	$17,000		$34,000
Equipment	$0	$0	$0	$0	$0	$0		$0
Indirect Costs (report rate here)	$0	$0	$0	$0	$0	$0		$0
SUBTOTAL	$0	$0	$0	$41,700	$0	$41,700		$155,500
General Administration (9% of subtotal)	$0	$0	$0	$3,753	$0	$3,753	N/A	$13,995
PROGRAM TOTAL	**$0**	**$0**	**$0**	**$45,453**	**$0**	**$45,453**		**$169,495**
Other Resources (In-Kind Funds)	**$0**	**$0**	**$29,000**	**$42,500**	**$31,000**	**$102,500**		**$166,000**

This is a multi-agency project between USGS and NOAA. USGS will be conducting the fieldwork and collecting samples for a total of $87.8K (with 9% GA). NOAA will be providing chemical analyses of the Nearshore Component's Mussel Watch samples and the Lingering Oil project's oiled sediment samples for a total of $81.8K (with 9% GA). Analyses will be facilitated through NOS NCCOS - Monitoring & Assessment Branch, Stressor Detection & Impacts Division and a contract with TDI Brooks. Analyses will cost $2.5K/sample for mussels (20 samples for $50K) and $1K for oiled sediment samples (~24 samples for $25K).

B. Sources of Additional Funding

Non-EVOSTC Funds to be used, please include source and amount per source:

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$0	$0	$25,500	$38,000	$0	$63,500
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$0	$0	$29,000	$42,500	$31,000	$102,500
				FY22-31 Total	*$166,000*

Non-EVOSTC funds are agency in-kind, representing salary contributions of permanent Primary Investigators and use of existing equipment including boats and other specialized gear. Over the 10-year period, U.S. Geological Survey (USGS) in-kind is $82,000 (salary: $58,000 and equipment: $24,000) and NOAA in-kind is $84,000 (salary). USGS and NOAA funds included as in-kind or as contributions are included for planning purposes only and nothing contained in this proposal shall be construed as binding the USGS nor NOAA to expend in any one fiscal year any sum in excess of its appropriations or funding in excess or what it has received for the collaborative work outlined in this proposal or involving the Federal government in any obligation to pay money before funds have been appropriated for that purpose unless otherwise allowed by law.

9. LITERATURE CITED

Apeti, D.A., W.E. Johnson, K.L. Kimbrough, and G.G. Lauenstein. 2012. National Status and Trends Mussel Watch Program: Sampling Methods 2012 Update. NOAA Technical Memorandum NOS NCCOS 134. Silver Spring, MD. 39 pp.

Carls, M.G., L. Holland, G.V. Irvine, D.H. Mann, and M. Lindeberg. 2016. Biomarkers as tracers of *Exxon Valdez* oil. Report to the *Exxon Valdez* Oil Spill Trustee Council, National Oceanic and Atmospheric Administration, Juneau, AK.

Dean, T.A., and J.L. Bodkin. 2011. SOP for sampling of intertidal invertebrates and algae on sheltered rocky shores - Version 4.6: Southwest Alaska Inventory and Monitoring Network. Natural Resource Report NPS/SWAN/NRR—2011/397. National Park Service, Fort Collins, Colorado.

Esler, D., B.E. Ballachey, L. Bowen, A.K. Miles, R.D. Dickson, and J.D. Henderson. 2016. Cessation of oil exposure in harlequin ducks after the *Exxon Valdez* oil spill: cytochrome P4501A biomarker evidence. Environmental Toxicology and Chemistry 36:1294-1300.

Esler, D., B.E. Ballachey, C. Matkin, D. Cushing, R. Kaler, J. Bodkin, D. Monson, G. Esslinger, and K. Kloecker. 2018. Timelines and mechanisms of wildlife population recovery following the *Exxon Valdez* oil spill. Deep-Sea Research Part II 147:36-42.

EVOSTC. 2016. An Evaluation of Remedial Options for Lingering Oil from the *Exxon Valdez* Oil Spill. Prepared by the Alaska Department of Environmental Conservation Division of Spill Prevention and Response for the Exxon Valdez Oil Spill Trustee Council.

Hayes, M.O., and J. Michel. 1999. Factors determining the long-term persistence of *Exxon Valdez* oil in gravel beaches. Marine Pollution Bulletin 38:92-101.

Hayes, M.O., J. Michel, D.V. Betenbaugh. 2010. The intermittently exposed, coarse-grained gravel beaches of Prince William Sound, Alaska: Comparison with open-ocean gravel beaches. Journal of Coastal Research 26:4-30.

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

Michel, J., and D. Esler. 2010. Summary of lingering oil studies funded by the *Exxon Valdez* Oil Spill Trustee Council. *Exxon Valdez* Oil Spill Trustee Council, 41 pp.

Michel, J., D. Esler, and Z. Nixon. 2016. Studies on *Exxon Valdez* Lingering Oil: Review and Update on Recent Findings – February 2016. Prepared for the *Exxon Valdez* Oil Spill Trustee Council. 48p.

Michel, J., Z. Nixon, M.O. Hayes, J. Short, G. Irvine, D. Betenbaugh, C. Boring, and D. Mann. 2010. Distribution of subsurface oil from the *Exxon Valdez* oil spill. *Exxon Valdez* Oil Spill Restoration Project Final Report (Project 070801), National Oceanic and Atmospheric Administration, Juneau, AK, 121pp.

Neff, J.M., E.H. Owens, S.W. Stoker, D.M. McCormick DM. 1995. Shoreline oiling conditions in Prince William Sound following the *Exxon Valdez* oil spill. *Exxon Valdez* Oil Spill: Fate and Effects in Alaskan Waters. p 312-346.

Nixon, Z., and J. Michel. 2015. Predictive Modeling of Subsurface Shoreline Oil Encounter Probability from the *Exxon Valdez* Oil Spill in Prince William Sound, Alaska. Environmental Science and Technology 49:4354–4361.

Nixon, Z., and J. Michel. 2018. A review of distribution and quantity of lingering subsurface oil from the *Exxon Valdez* oil spill. Deep-Sea Research Part II 147:20-26.

Pella, J., and J. Maselko. 2007. Probability Sampling and Estimation of the Oil Remaining in 2001 from the *Exxon Valdez* Oil Spill in Prince William Sound, Alaska. NOAA Technical Memorandum NMFS-AFSC- 169:60. Seattle.

Rider, M., D.A. Apeti, A. Jacob, K. Kimbrough, E. Davenport, M. Bower, H. Coletti, and D. Esler. 2020. A Synthesis of Ten Years of Chemical Contaminants Monitoring in National Park Service - Southeast and Southwest Alaska Networks. A collaboration with the NOAA National Mussel Watch Program. NOAA Technical Memorandum NOS NCCOS 277. Silver Spring, MD. 110 pp. DOI 10.25923/dbyq-7z17 https://repository.library.noaa.gov/view/noaa/25520.

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 and Technology 31:2375–2384.

Short, J.W., M.R. Lindeberg, P.M. Harris, J.M. Maselko, J.J. Pella, and S.D. Rice. 2004. Estimate of oil persisting on the beaches of Prince William Sound 12 years after the *Exxon Valdez* oil spill. Environmental Science & Technology 38:19-25.

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. Environmental Science & Technology 40:3723-3729.

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. Environmental Science & Technology 41:1245-1250.

Venosa, A.D., P. Campo, and M.T. Suidan MT. 2010. Biodegradability of lingering crude oil 19 years after the *Exxon Valdez* oil spill. Environmental Science & Technology, 44:7613-7621.

Wolfe, D.A., M.J. Hameedi, J.A. Galt, G. Watabayashi, J. Short, C. Oclaire, S.D. Rice, J. Michel, J.R. Payne, J. Braddock, and others. 1994. The fate of the oil spilled from the *Exxon Valdez*. Environmental Science & Technology 28(13):A560-A568.

10. PROJECT PERSONNEL

DAN ESLER

Project Leader and Research Wildlife Biologist
Nearshore Marine Ecosystem Research Program, Alaska Science Center-U.S. Geological Survey
4210 University Drive, Anchorage, Alaska 99508
(907) 331-8115; desler@usgs.gov

RELEVANT PROFESSIONAL EXPERIENCE

Leader, Nearshore Marine Ecosystems Research Program (NMERP) of the Alaska Science Center, USGS. My program conducts studies to document and understand underlying causes of change in nearshore marine systems (August 2013 – present).

University Research Associate and Adjunct Professor, Centre for Wildlife Ecology, Department of Biological Sciences, Simon Fraser University, British Columbia (February 2001 – May 2013).

MOST RELEVANT PUBLICATIONS

Konar, B., T.J. Mitchell, K. Iken, H. Coletti, T. Dean, **D. Esler**, M. Lindeberg, B. Pister, and B. Weitzman. 2019. Wasting disease and static environmental variables drive sea star assemblages in the northern Gulf of Alaska. Journal of Experimental Marine Biology and Ecology 520.

Esler, D., B.E. Ballachey, C.O. Matkin, D. Cushing, R. Kaler, J. Bodkin, D. Monson, G.G. Esslinger, and K. Kloecker. 2018. Timelines and mechanisms of wildlife population recovery following the *Exxon Valdez* oil spill. Deep Sea Research II 147:36-42.

Bowen, L., A.K. Miles, B.E. Ballachey, S. Waters, J.L. Bodkin, M. Lindeberg, and **D. Esler**. 2018. Gene transcription patterns in response to low level petroleum contaminants in *Mytilus trossulus* from field sites and harbors in southcentral Alaska. Deep Sea Research II 147:27-35.

Bodkin, J.L., H.A. Coletti, B.E. Ballachey, D. Monson, **D. Esler**, and T.A. Dean. 2018. Spatial and temporal variation in Pacific blue mussel, *Mytilus trossulus*, abundance in the northern Gulf of Alaska, 2006-2015. Deep Sea Research II 147:87-97.

Willie, M., **D. Esler**, W.S. Boyd, P. Molloy, and R.C. Ydenberg. 2017. Spatial variation in polycyclic aromatic hydrocarbon exposure in Barrow's goldeneye (*Bucephala islandica*) in coastal British Columbia. Marine Pollution Bulletin 118:167-179.

Esler, D., B.E. Ballachey, L. Bowen, A.K. Miles, R.D. Dickson, and J.D. Henderson. 2016. Cessation of oil exposure in harlequin ducks after the *Exxon Valdez* oil spill: cytochrome P4501A biomarker evidence. Environmental Toxicology and Chemistry 36:1294-1300.

Bodkin, J. L., **D. Esler**, S. D. Rice, C. O. Matkin, and B. E. Ballachey. 2014. The effects of spilled oil on coastal ecosystems: lessons from the *Exxon Valdez* spill. Pp. 311-346 in B. Maslo and J. L. Lockwood, eds. Coastal Conservation. Cambridge University Press.

Esler, D., B. E. Ballachey, K. A. Trust, S. A. Iverson, J. A. Reed, A. K. Miles, J. D. Henderson, B. W. Wilson, B. R. Woodin, J. R. Stegeman, M. McAdie, and D. M. Mulcahy. 2011. Cytochrome P4501A biomarker indication of the timeline of chronic exposure of Barrow's goldeneye to residual *Exxon Valdez* oil. Marine Pollution Bulletin 62:609-614.

Esler, D., K. A. Trust, B. E. Ballachey, S. A. Iverson, T. L. Lewis, D. J. Rizzolo, D. M. Mulcahy, A. K. Miles, B. R. Woodin, J. J. Stegeman, J. D. Henderson, and B. W. Wilson. 2010. Cytochrome P4501A biomarker indication of oil exposure in harlequin ducks up to 20 years after the *Exxon Valdez* oil spill. Environmental Toxicology and Chemistry 29:1138-1145.

Iverson, S. A., and **D. Esler**. 2010. Harlequin duck population dynamics following the 1989 *Exxon Valdez* oil spill: assessing injury and projecting a timeline to recovery. Ecological Applications 20:1993-2006.

OTHER SIGNIFICANT PUBLICATIONS

Esler, D., and S. A. Iverson. 2010. Female harlequin duck winter survival 11 to 14 years after the *Exxon Valdez* oil spill. Journal of Wildlife Management 74:471-478.

Peterson, C. H., S. D. Rice, J. W. Short, **D. Esler**, J. L. Bodkin, B. A. Ballachey, and D. B. Irons. 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302:2082-2086.

Esler, D., T. D. Bowman, K. Trust, B. E. Ballachey, T. A. Dean, S. C. Jewett, and C. E. O'Clair. 2002. Harlequin duck population recovery following the *Exxon Valdez* oil spill: progress, process, and constraints. Marine Ecology Progress Series 241:271-286.

EDUCATION

2000 Ph.D. Wildlife Science. Oregon State University, Corvallis, Oregon, USA.
1988 M.Sc. Wildlife Ecology. Texas A&M University, College Station, Texas, USA.
1985 B.Sc. Biology/Outdoor Education. Northland College, Ashland, Wisconsin, USA.

COLLABORATIONS

Anderson, Eric (British Columbia Institute of Technology), Ballachey, Brenda (USGS-retired), Bodkin, James (USGS-retired), Bowen, Liz (USGS), Bowman, Tim (USFWS), Boyd, W. Sean (Environment Canada), Coletti, Heather (NPS), Green, David (Simon Fraser University), Hogan, Danica (Environment Canada), Iken, Katrin (UAF), Konar, Brenda (UAF), Kurtz, Deborah (NPS), Lok, Erika (Environment Canada), Lindeberg, Mandy (NOAA), Schmutz, Joel (USGS), Thompson, Jonathan (Alberta Provincial Government), Weitzman, Ben (USFWS), Willie, Megan (Environment Canada), Ydenberg, Ron (Simon Fraser University)

MANDY R. LINDEBERG

Fisheries Research Biologist IV
NOAA NMFS Alaska Fisheries Science Center, Auke Bay Laboratories
17109 Pt. Lena Loop Rd, Juneau, Alaska 99801
Phone: (907) 789-6616; FAX: (907) 789-6094
mandy.lindeberg@noaa.gov

RELEVANT PROFESSIONAL EXPERIENCE

Long-Term Marine Ecosystem Monitoring (2011 - Present): Currently providing leadership to the Gulf Watch Alaska (GWA) Program as Program Lead to 28 principal investigators (2017-21). Previous roles included GWA Pelagic Component Lead (2013-16), GWA co-Principal Investigator for the Nearshore component (2011-21), and GWA co-Principal Investigator for the Lingering Oil component (2011-21). In leading the Gulf Watch Alaska program during the past four years, the program has thrived producing: 24 key ecosystem indicators to resource managers (NPFMC) on an annual basis, 63 peer reviewed journal publications, 45 published datasets, 81 scientific reports, over 250 presentations at professional conferences, and a diversity of outreach efforts (e.g., website, newsletters, agency social media, and traditional ecological knowledge exchange with remote spill-affected communities).

Oil Spill Research in the marine environment (1990 - Present): Extensive experience with oil spill research for over 30 years. Research includes investigations of damage assessment, recovery of injured resources, long-term ecosystem monitoring of nearshore flora and fauna, and lingering *Exxon Valdez* oil in the marine environment. Also participated in the injury assessment of the Deepwater Horizon oil spill under NRDA's Submerged Aquatic Vegetation TWIG. Recently, a collaborator in a four-year assessment for BOEM in a NEPA analysis associated with the Oil & Gas Leasing Program in Cook Inlet (2015-18).

Coastal Habitat Mapping (2004 - Present): A core steering committee member for over 17 years and lead biologist for the successful Alaska *ShoreZone* coastal habitat mapping project and online tools for agencies, educators, and the public.

Essential Fish Habitat (2005 - Present): Conducting research on essential fish habitat under the Magnuson-Stevens Act, focusing on nearshore marine forage fish and promoting the development of online tools for a statewide catch database (Alaska Nearshore Fish Atlas).

Specialized Expertise (1990 - present): Scientific expertise lies with coastal ecology, specializing in the taxonomy and ecology of seaweeds throughout Alaska's coastal regions. Author of two popular books: *A Field Guide to Seaweeds of Alaska* and co-author of *A Handy Field Guide to Nearshore Fishes of Alaska*.

MOST RELEVANT PUBLICATIONS

Aderhold, D. G. R, M. R. **Lindeberg**, K. Holderied, and S.W. Pegau. 2018. 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 Special Issue. doi:10.1016/j.dsr2.2017.11.015.

Bowen, L., B. Ballachey, A. K.Miles, J. Bodkin, M. **Lindeberg**, and D. Esler. 2018. Mussels and Oil: Gene transcription patterns as a new approach for evaluation of injury and recovery following the *Exxon Valdez* oil spill. Deep Sea Research II Special Issue. http://www.sciencedirect.com/science/article/pii/S0967064516302855.

Konar, B., T. J. Mitchell, K. Iken, H. Coletti, T. Dean, D. Esler, M. **Lindeberg**, B. Pister, B. Weitzman. 2019. Wasting disease and static environmental variables drive sea star assemblages in the Northern Gulf of Alaska. JEMBE. Vol. 520. ISSN 0022-0981. https://doi.org/10.1016/j.jembe.2019.151209.

Lindeberg, M. R., J. Maselko, C. Fugate, L. Holland, and M. G. Carls. 2017. Persistent *Exxon Valdez* oil on beaches in Prince William Sound 26 years later. Deep Sea Research II Special Issue. http://www.sciencedirect.com/science/article/pii/S0967064516304234.

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**, P. M. Harris, J. Maselko, J. 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.

Suryan, R. M., M. Arimitsu, H. Coletti, R. R. Hopcroft, M. R. **Lindeberg**, S. Batten, M. A. Bishop, R. Brenner, R. Campbell, D. Cushing, S. Danielson, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J.M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, J. Straley, K. Seeeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. *In review*. Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. Scientific Reports.

Weitzman, B., B. Konar, K. Iken, H. Coletti, D. Monson, R.M. Suryan, T. Dean, D. Hondolero, and M.R. **Lindeberg**. *In review*. Changes in rocky intertidal community structure during a marine heatwave in the northern Gulf of Alaska. Frontiers in Marine Science.

OTHER SIGNIFICANT PUBLICATIONS

Johnson, S. W., A. D. Neff, and M. R. **Lindeberg**. 2015. A handy field guide to the nearshore fishes of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-293, 211 p.

Kawai, H., T. Hanyuda, M. R. **Lindeberg**, and S. C. Lindstrom. 2008. Morphology and molecular phylogeny of *Aureophycus aleuticus* gen. et sp. Nov. (Laminariales, Phaeophyceae) from the Aleutian Islands. J. of Phycol. 44:1013-1021. http://onlinelibrary.wiley.com/doi/10.1111/j.1529- 8817.2008.00548.x/epdf.

Lindeberg, M. R. and S. C. Lindstrom. 2019. Assessment and Catalog of Benthic Marine Algae from the Alaska Peninsula, May 2016. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-389, 501p.

Lindeberg, M. R. and S. C. Lindstrom. 2015. Field Guide to Seaweeds of Alaska. *Updated and reprinted*. Fairbanks, Alaska: Alaska Sea Grant College Program. University of Alaska Fairbanks. 188 p. ISBN 978-1-56612-156-9. doi.10.4027.fgsa.2010.

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. doi: 10.1021/es100176k.

EDUCATION

B.S. 1989, Marine Biology, Western Washington University, Bellingham, Washington.

COLLABORATIONS

Apeti, Dennis (NOAA NOS); Coletti, Heather (NPS); Coon, Catherine (BOEM); Iken, Katrin (UAF); Jones, Tahzay (NPS); Konar, Brenda (UAF); Lewis, Steve (Alaska Regional Office, NMFS); Lindstrom, Sandra (UBC); Pister, Benjamin (NPS); Saupe, Sue (Cook Inlet RCAC); Stickle, William (LSU); Weitzman, Ben (NOAA NOS).

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Alaska Fisheries Science Center
7600 Sand Point Way N.E.
Seattle, Washington 98115-0070
Tel: 907.789.6617 Fax: 206.526.4004

July 7, 2021

Shiway Wang
Exxon Valdez Oil Spill Trustee Council
4230 University Drive, Ste. 220
Anchorage, AK 99508-4650

Dear Ms. Wang,

We are pleased to provide this letter of commitment for the Gulf Watch Alaska – Long-Term Research and Monitoring (GWA-LTRM) program proposal and two embedded project proposals to the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC). These proposals were drafted in response to the EVOSTC's FY22-31 Invitation in March and subsequent request for final submission by August 13, 2021. AFSC will provide support for Mandy Lindeberg as the GWA Program Lead and Rob Suryan as Science Lead. AFSC also supports John Moran as a principal investigator (PI) for the humpback whale monitoring project and Mandy Lindeberg as a co-PI for the periodic lingering oil project. We support AFSC's role in leading and conducting research for this long-term program with in-kind contributions by our agency.

If these proposals are funded over the next 10 years, in-kind support is estimated to be:

- GWA-LTRM Program proposal 2222LTRM: $100K/year = salaries (6 mos/year combined salary for Lindeberg and Suryan).
- Humpback Whale project #22120114-O: $140K/year = $90K/year for salary (7 mos/year for PI Moran); and all field and laboratory equipment required ($50 K/year).
- Lingering Oil project # 22220114-P: $84K = salary (5 mos/10 years) for PI Lindeberg.

Sincerely,

Robert J. Foy, Ph.D.
Science and Research Director

United States Department of the Interior
U.S. GEOLOGICAL SURVEY
ALASKA SCIENCE CENTER
4210 University Dr.
Anchorage, Alaska 99508

July 23, 2021

To: Mandy Lindeberg - NOAA, GWA-LTRM Program Lead
Shiway Wang, EVOSTC Executive Director

Re: Letter of Commitment

We are pleased to provide this letter of commitment for the proposed project "22200114-P Long-term Monitoring of Lingering Oil in Prince William Sound", which is a collaborative study with NOAA that includes USGS principal investigator Dan Esler. This proposal was prepared in response to the EVOSTC's FY22-31 Invitation for Proposals and subsequent request for final submission on August 13, 2021. The funding request for this project over a ten-year period is $169.5 K (including EVOSTC GA), of which $87.8 K will come to USGS. Support for the program includes some non-EVOSTC funds that are in-kind contributions totaling $166.0 K for the life of the project (e.g., salaries of permanent staff, laboratory facilities, and equipment use), of which $82.0 K will come from USGS.

This project proposal is part of the larger multi-agency Gulf Watch Alaska Long-Term Research and Monitoring (GWA-LTRM) program proposal package. This package represents a continued commitment of the successful long-term research and monitoring projects supported by the EVOSTC and various agencies and organizational investments since 2012.

However, USGS funds included as in-kind or as contributions are included for planning purposes only and nothing contained in this proposal shall be construed as binding the USGS to expend in any one fiscal year any sum in excess of its appropriations or funding in excess or what it has received for the collaborative work outlined in this proposal or involving the federal government in any obligation to pay money before funds have been appropriated for that purpose unless otherwise allowed by law.

Sincerely,

Digitally signed by member: 720CC750-FB79-4BCC-8333-30E70ED4311F C059F91D-241C-4DFA-B845-A2FEE3F297A8
Date: 2021.07.29 16:15:42 -08'00'

Christian E. Zimmerman
Director, USGS Alaska Science Center
czimmerman@ugsgs.gov, 907-786-7071

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NOS-NCCOS-CCMA
Silver Spring, Maryland 20910

June 29, 2021

From: NOAA National Mussel Watch Program

To: Exxon Valdez Oil Spill Trustee Council

Subject: National Mussel Watch Program Commitment to Collaborate with the Gulf of Alaska GulfWatch Program

The National Oceanic and Atmospheric Administration (NOAA) Mussel Watch Program (MWP) is a contaminant monitoring program that monitors the status and trends of chemical contaminants and biological stressors in the nation's coastal waters. Since 1986, the MWP remains the longest running continuous contaminant-monitoring program of its kind in the United States. The program utilizes a sentinel-based approach to monitoring, by collecting and analyzing sediment and bivalves (oysters and mussels) as surrogates for water pollution and bioaccumulation. Contaminants monitored include a suite of organic and inorganic chemicals, such as pesticides (e.g., DDT), antifouling agents (e.g., butyltin), industrial contaminants (e.g., PCB), oil and fossil fuel related contaminants (e.g., PAH) and heavy metals (e.g., mercury). Recently, more than 280 contaminants of emerging concern (CEC) are being measured for place-based monitoring consideration; these include pharmaceuticals and personal care products, flame-retardants, current-use pesticides, surfactants, and stain repellant compounds. Along with other ancillary data, including sediment grain size and bivalve lipid content, the program has also historically measured biological indicators of water quality. The quality of the analytical data generated by the MWP is overseen by the performance-based Quality Assurance (QA) Project. The QA Project, in operation since 1985, assures the highest data quality. End-users of the MWP data include federal, state and local coastal resource managers for management decision making processes.

As part of NOAA and with funding provided by the Exxon Valdez Oil Spill Trustee Council, we will provide chemical analyses, and interpretation of mussel and oiled sediment samples as needed for the Gulf Watch Alaska Long-Term Research and Monitoring program during FY22-31.

For additional information, please contact me at the address below.

Sincerely,

APETI.DENNIS.AYAOVI.1365825587 Digitally signed by APETI.DENNIS.AYAOVI.1365825587 Date: 2021.06.29 16:11:33 -04'00'

Dennis Apeti, Ph.D.
National Centers for Coastal Ocean Science
National Ocean Service
Phone: (240) 533-0337
dennis.apeti@noaa.gov

ARZAYUS.LUIS.FELIPE.1178262340 Digitally signed by ARZAYUS.LUIS.FELIPE.1178262340 Date: 2021.06.29 14:05:08 -04'00'

Felipe Arzayus
National Centers for Coastal Ocean Science
National Ocean Service
Phone: (240) 533-0335
felipe.arzayus@noaa.gov