Draft Damage Assessment and Restoration Plan and Environmental Assessment for the Tug *Powhatan* Oil Spill Sitka, Alaska

Public Review Draft

July 1, 2019

Prepared by:

U.S. Department of Commerce

National Oceanic and Atmospheric Administration

NOAA wishes to acknowledge the contributions made to the development of this Damage Assessment and Restoration Plan by Industrial Economics, Incorporated.

TABLE OF CONTENTS

LIST OF EXHIBITS IV

ACRONYMS V

EXECUTIVE SUMMARY VII

CHAPTER 1 | INTRODUCTION 1

Summary and Purpose ... 1

Incident Overview ... 1

Natural Resource Trustees and Authority ... 5

Overview of the Oil Pollution Act ... 5

Restoration Planning ... 6

Summary of Injury Assessment ... 7

Summary of Restoration Alternatives Analysis and Identification of Preferred Restoration Alternatives ... 7

Trustee Coordination with the Responsible Party ... 7

Trustee Oversight of Proposed Restoration ... 8

Public Involvement ... 8

Administrative Record ... 9

Organization of DARP/EA ... 9

CHAPTER 2 | AFFECTED ENVIRONMENT AND NATURAL RESOURCES OF CONCERN 10

Physical Environment ... 10

The Biological Resources ... 10

Fish and Marine Invertebrates ... 10

Birds and Marine Mammals ... 11

Human Use ... 11

Recreation ... 11

Commercial Fishing ... 11

Non-Commercial Harvest ... 12

Threatened and Endangered Species and Essential Fish Habitat ... 12

Focus of the Assessment ... 12

Pacific Herring ... 13

Shellfish Harvesting ... 14

CHAPTER 3 | SUMMARY OF PRE-ASSESSMENT ACTIVITIES 15

Initiation of Pre-Assessment Activities ... 15

Aerial Imagery 16
Field Sampling for Chemical Analysis 18
Source Oil Sampling for Chemical Analysis 20
Water Sampling for Chemical Analysis 20
Sheen Sampling for Chemical Analysis 20
Shellfish Tissue Sampling for Chemical Analysis 21
Fish Field Sampling for Presence, Lifestage, and Density Estimates 21
Diver Surveys for Pacific Herring Spawn Deposition 21
Ichthyoplankton Surveys for Pacific Herring Larvae 23
Beach Seine Sampling for Salmon Smolt 25
Shellfish Alert 25
CHAPTER 4 | INJURED RESOURCES 27
Exposure of Trust Resources and Pathway 27
Injury Determination and Quantification for Ecological Resources 27
Injury Determination to Pacific Herring 27
Injury Quantification for Pacific Herring 29
Injury Quantification Steps 33
Injury Quantification Results for Pacific Herring 34
Injury Determination and Quantification for Human Use Resources 34
Injury Determination for Shellfishing 34
Injury Quantification for Shellfishing 35
Lost Human Use Results 37
Injury Determination to Other Resources 38
CHAPTER 5 | RESTORATION PLANNING 39
Restoration Strategy 39
Project Evaluation Criteria Development 40
Project Identification and Alternative Evaluation 40
Alternative 1: No Action Alternative/Natural Recovery 42
Alternative 2: Pacific Herring Research 42
Alternative 3: Open- and Closed-Pound ‘Spawn-on-Kelp’ Activities 43
Alternative 4: Marine Debris Removal (Preferred Alternative) 43
Alternative 5: Enhance Access, Accessibility, and Amenities for Shellfish Harvesting at Starrigavan Beach 44
Alternative 6: Shellfish Monitoring (Preferred Alternative) 45
Preferred Restoration Alternatives Scaling 45

Marine debris removal (Alternative 4) Scaling 45
Shellfish Monitoring (Alternative 6) Scaling 49
Performance Measures, Monitoring, and Adaptive Management 50
CHAPTER 6 | ENVIRONMENTAL IMPACTS OF RESTORATION ALTERNATIVES 51
Restoration Alternative Evaluation Criteria 51
NEPA Analysis 52
Alternative 1: No Action Alternative/Natural Recovery 53
Alternative 2: Pacific Herring Research 54
Alternative 3: Open- and Closed-Pound 'Spawn-on-Kelp' Activities 54
Alternative 4: Marine Debris Removal (Preferred Alternative) 54
Alternative 5: Enhance Access, Accessibility, and Amenities for Shellfish Harvesting at Starrigavan Beach 55
Alternative 6: Shellfish Monitoring (Preferred Alternative) 55
CHAPTER 7 | COORDINATION WITH APPLICABLE REGULATIONS AND AUTHORITIES 56
Key Statutes, Regulations, and Policies 56
Oil Pollution Act of 1990 (OPA) 56
National Environmental Policy Act (NEPA) 56
Federal Water Pollution Control Act (Clean Water Act/CWA) 56
Magnuson-Stevens Fishery Conservation and Management Act 57
Fish and Wildlife Coordination Act 57
Rivers and Harbors Act of 1899 57
Executive Order 12898 - Environmental Justice 57
Executive Order 11514 - Protection and Enhancement of Environmental Quality 57
Executive Order 13112 – Invasive Species 58
Marine Mammal Protection Act (MMPA) 58
National Historic Preservation Act 58
CHAPTER 8 | PREPARERS, AGENCIES, AND PERSONS CONSULTED 59
REFERENCES 60
APPENDIX A: NEWFIELDS CHEMICAL FINGERPRINTING A
APPENDIX B: ICHTHYOPLANKTON SURVEYS B
APPENDIX C: MATERIAL DENSITY VALUES C
APPENDIX D: POROSITY FACTOR DERIVATION D

LIST OF EXHIBITS

Exhibit 1.1 Final Location of Tug *Powhatan* in Sitka Sound………………………..... 2
Exhibit 1.2 Examples of Response Operations and Natural Resource Impacts……..... 3
Exhibit 1.3 Shoreline Assessment Segments………………………………… 4
Exhibit 3.1 Select Aerial Images of Sheen…. 16
Exhibit 3.2 Select Digitized Areas of Sheen…... 17
Exhibit 3.3 Daily Estimates of Sheen Area 18
Exhibit 3.4 Field Sampling Locations for Chemical Analysis 19
Exhibit 3.5 Forensic Classification for Six Environmental Samples........................... 21
Exhibit 3.6 Approximate Pacific Herring Egg Dive Transect Locations 23
Exhibit 3.7 Start locations for Ichthyoplankton Net Tows 24
Exhibit 3.8 Approximate Seine Locations 25
Exhibit 3.9 Shellfish Alert Sign.. 26
Exhibit 4.1 Sitka Sound April 21, 2017 Oil Sheens and Egg Locations...................... 31
Exhibit 4.2 Starrigavan Beach Shellfishing Closure Dates 35
Exhibit 4.3 Baseline Monthly Shellfishing Trips at Starrigavan Beach 36
Exhibit 4.4 Lost Shellfishing Trips at Starrigavan Beach... 37
Exhibit 5.1 Evaluation of Restoration Projects... 42
Exhibit 5.2 Marine Debris Removal Benefits Quantification and Scaling.................. 49

ACRONYMS

ACD	Alaska Commercial Divers
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AS	Alaska Statute
CAA	Clean Air Act
C.F.R.	Code of Federal Regulations
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FONSI	Finding of No Significant Impact
FWS	U.S. Fish and Wildlife Service
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPFC	National Pollution Funds Center
NRDA	Natural Resource Damage Assessment
OPA	Oil Pollution Act
OSLTF	Oil Spill Liability Trust Fund

PAH	Polycyclic aromatic hydrocarbons
PSP	Paralytic shellfish poisoning
RP	Responsible Party
SAV	Submerged aquatic vegetation
SCAT	Shoreline Cleanup Assessment Technique
SDB	NOAA Spatial Data Branch
SEAPRO	Southeast Petroleum Response Organization
SEATOR	Southeast Alaska Tribal Ocean Research
SSSC	Sitka Sound Science Center
STAERL	Sitka Tribe of Alaska Environmental Research Lab
TPAH	Total polycyclic aromatic hydrocarbons
TPH	Total petroleum hydrocarbons
USACE	United States Army Corp of Engineers
U.S.C.	United States Code
USCG	United States Coast Guard
UV	Ultraviolet

EXECUTIVE SUMMARY

On April 19, 2017, the Tug *Powhatan* sank in approximately 15 meters of water in Starrigavan Bay, Alaska and migrated downslope approximately 330 meters to the north. Shortly after sinking, visible oil sheens were observed on the water's surface and subsequent underwater inspections by divers confirmed an ongoing oil release. Released oil was transported by currents, wind, and other natural processes, resulting in impacts to fish and shellfish harvesting activities on impacted shorelines. Under the Federal Oil Pollution Act of 1990 (33 U.S.C. §§ 2701 *et seq.*), the National Oceanic and Atmospheric Administration (NOAA), acting as the Natural Resource Trustee on the Public's behalf, is responsible for restoring natural resources injured by the oil spill.

Following the spill, NOAA conducted pre-assessment activities to document injuries to Trust resources. Efforts included, but were not limited to, collecting sheen, water, and biota samples, compiling available aerial photography depicting the extent of the spill, and gathering information on shellfish harvest alerts. NOAA gathered and analyzed information for the purposes of conducting injury assessment activities and evaluating whether feasible restoration actions can address the scale of potential injuries.

This draft Damage Assessment and Restoration Plan/Environmental Assessment was prepared by NOAA to inform the public about the Natural Resource Damage Assessment (NRDA) and restoration planning efforts conducted following the incident. NOAA estimated 25.5 billion Pacific herring egg-equivalents were killed in 2017 due to the spill and an estimated 444 shellfish harvesting trips were lost.

To restore lost resources and services, NOAA identified two preferred restoration projects. To restore lost Pacific herring, NOAA identified and scaled a marine debris removal project that would benefit Pacific herring by reducing egg loss. To restore lost shellfish harvesting days, NOAA identified as a preferred project an increased effort to monitor paralytic shellfish poisoning (PSP).

CHAPTER 1 | INTRODUCTION

Summary and Purpose

The purpose of this draft Damage Assessment and Restoration Plan and Environmental Assessment (DARP/EA) is to address restoration of natural resources injured by the Tug *Powhatan* (the Tug) oil spill in Sitka Sound (the incident), Alaska. The Oil Pollution Act of 1990 (OPA; 33 U.S.C. §§ 2701 *et seq.*) assigns certain state and federal government natural resource agencies, known as Natural Resource Trustees (Trustees), the responsibility for restoring natural resources and resource services injured or harmed by an oil spill.[1] As a designated Trustee, NOAA is authorized to act on behalf of the public to assess and recover natural resource damages and to plan and implement actions to restore, rehabilitate, replace, or acquire the equivalent of the natural resources or services injured as a result of an unpermitted discharge of oil. The purpose of natural resource restoration is to make the environment and the public whole for natural resource injuries resulting from an oil spill by implementing restoration actions that offset the harm caused by the spill.

This document is also intended to address the requirements of the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4370d. NEPA requires that federal agencies analyze the potential direct, indirect, and cumulative effects/impacts of proposed major federal actions and alternatives and involve the public in the process. NOAA is the lead federal agency responsible for NEPA compliance for this draft DARP/EA. This draft DARP/EA describes the affected environment and illustrates restoration alternatives, while proposing preferred projects for public consideration. The document was developed in accordance with OPA and its implementing regulations, 15 C.F.R. Part 990; as well as NEPA and its implementing regulations, 40 C.F.R. Parts 1500-1508. NOA now invites the public to comment on this draft DARP/EA.

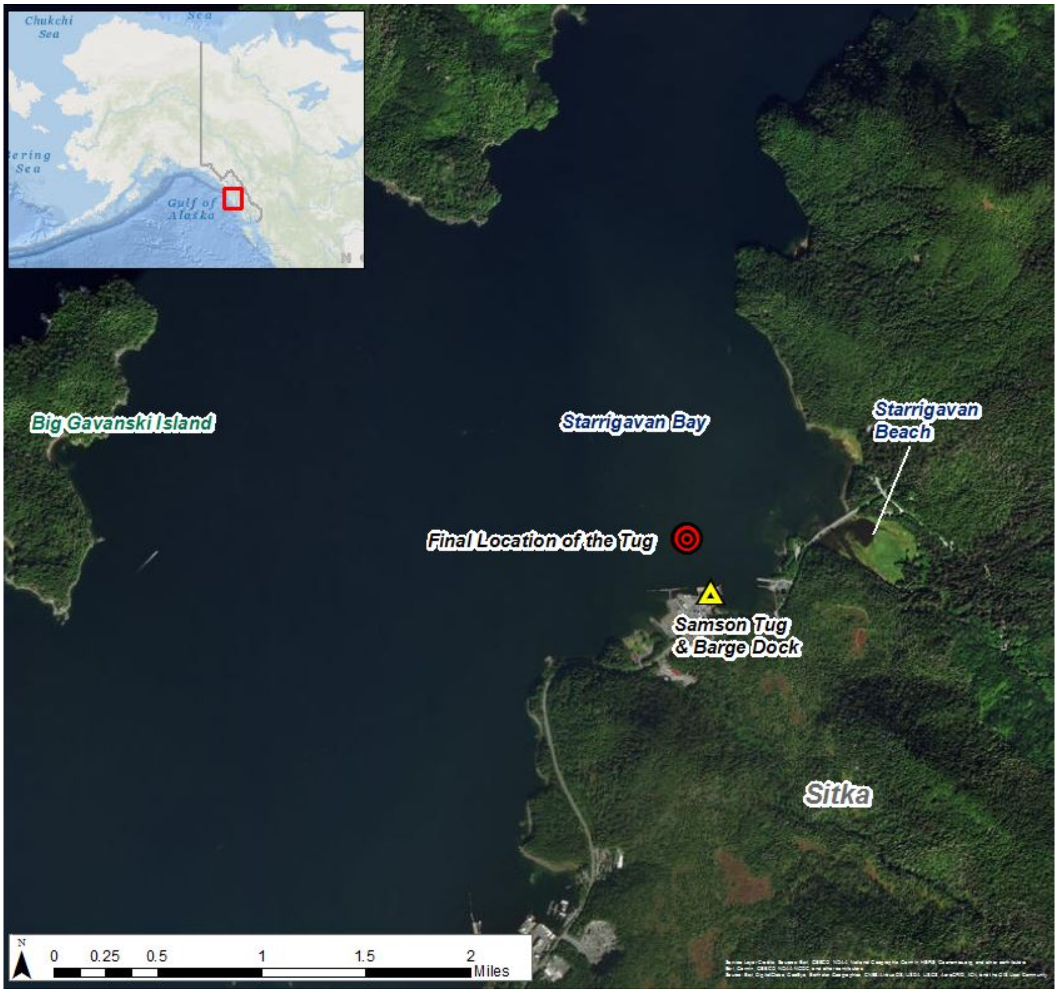
Incident Overview

On April 19, 2017, the Tug sank in approximately 15 meters of water in Starrigavan Bay, Alaska. The Tug is owned and operated by Samson Tug & Barge (hereinafter the Responsible Party, or RP) and sank while docked at the Samson Tug & Barge dock located approximately seven miles north of Sitka, Alaska (Exhibit 1.1). Shortly after sinking, visible oil sheens were observed on the water's surface and subsequent underwater inspections by divers confirmed an ongoing oil release. Based on available information at the time, an unknown volume of diesel fuel, fuel residues, and lubricating oil were on board. Subsequent laboratory analysis confirmed the released oils as diesel fuel #2 and a mixture of diesel fuel #2 and lubricating oil. After sinking and continuing to release oil, the Tug migrated downslope approximately 330 meters offshore to the north-northwest. The eventual resting place of the Tug was in approximately 60 meters of water at the mouth of Starrigavan Bay. Released oil was transported by wind, currents, and other natural processes, resulting in impacts to water column biota and recreational

[1] Natural resource trusteeship and authority is discussed further below.

shellfish harvesting activities. During response and salvage operations, approximately 6,830 gallons of oil-water mixture was recovered from the Tug.

Exhibit 1.1 Final Location of Tug Powhatan in Sitka Sound



Initial response efforts included deployment of containment and sorbent boom to contain released oil. Additional response efforts included using boom to prevent oil from being transported into sensitive habitats and aid in oil recovery, conducting Shoreline Cleanup Assessment Technique (SCAT) surveys to identify shoreline oiling, publishing shellfish/beach alerts to prevent shellfish harvesting, and managing dive operations to cap fuel tanks and recover the Tug. After the Tug migrated downslope to the north-northwest, response actions included expanding the area of boom coverage and placing boom at the entrance of select creeks in Starrigavan Bay. SCAT surveys reported sheen and oiling in sand, soil, grass, kelp, and tidal pools within all survey segments except the segment identified as No Name Creek. Exhibit 1.2 presents examples of response operations and spill impacts and Exhibit 1.3 presents SCAT survey segments.

Exhibit 1.2 Examples of Response Operations and Natural Resource Impacts

A. Oil sheen and boom observed from above the Samson Tug and Barge dock (photo credit: DOI). B. Oil sheen observed from the north of the initial sinking location (photo credit: USCG). C. Shellfish harvest and consumption alert (photo credit: Bob Mattson).

Exhibit 1.3 Shoreline Assessment Segments

Shoreline Assessment segments are listed south to north as follows: No Name Creek (green line), Samson dock (red), Samson dock to Old Sitka Historic Site (blue), and Mosquito Cove to the north of the trailhead (yellow).

Alaska Commercial Divers (ACD) arrived on April 25 to assess the vessel for salvage and cap oil release sites. They successfully capped the two main fuel tank vents, which were the primary release sites. Within the next month, additional oil release sites on the vessel were identified and sealed. Though the release rate was reduced by these response efforts, continued releases and surface sheens were observed during the entire time the vessel was submerged. Ongoing oil-water mixture removal efforts were conducted and on June 12, ACD and Pacific Pile & Marine (contracted by the RP), raised, dewatered, and removed the Tug. During the removal process, boom deployment was maintained to mitigate potential further release.

Acting as the Natural Resource Trustee on the public’s behalf, NOAA conducted pre-assessment activities to document injuries to Trust resources. Efforts included, but were not limited to, collecting sheen, water, and biota samples, compiling available aerial photography depicting the extent of the spill, gathering information on shellfish harvest alerts, and determining if restoration actions exist to address the scale of potential injuries. The results of pre-assessment efforts documented injury to Pacific herring eggs and larvae exposed to oil sheen based on literature-derived toxicity thresholds and impacts to shellfish harvesting activities due to harvest and consumption alerts posted at Starrigavan Beach and on the Southeast Alaska Tribal Ocean Research shellfish advisory webpage.

Natural Resource Trustees and Authority

Both federal and state laws establish liability for natural resource damages to compensate the public for injury, destruction, and loss of such resources and services resulting from oil spills. Natural Resource Trustees are authorized to act on behalf of the public to assess these injuries to natural resources. Potential Trustees for this incident include NOAA of the U.S. Department of Commerce, the U.S. Fish and Wildlife Service (FWS) of the Department of the Interior, the U.S. Forest Service (USFS) of the Department of Agriculture, Alaska Department of Fish and Game (ADF&G), Alaska Department of Natural Resources (ADNR), Alaska Department of Law, and Alaska Department of Environmental Conservation (ADEC). Following initial response actions and pre-assessment activities, other Federal agencies and the State of Alaska decided not participate further in the NRDA and allow NOAA to independently conduct NRDA assessment activities and pursue damages. However, due to involvement in initial pre-assessment activities, other Federal agencies and the State of Alaska may seek reimbursement for pre-assessment costs.

Thus, the Federal Lead Administrative Trustee (FLAT) and the overall NRDA coordinator for this incident is NOAA. This agency is a designated Natural Resource Trustee pursuant to OPA (33 U.S.C. § 2706), and the National Oil and Hazardous Substances Pollution Contingency Plan (40 C.F.R. §§ 300.600 and 300.605). As a designated Trustee, NOAA is authorized to act on behalf of the public to assess and recover natural resource damages and to develop and implement actions to restore natural resources and resource services injured or lost as the result of a discharge of oil.

Overview of the Oil Pollution Act

OPA provides the statutory authority for natural resource Trustees to assess and restore injuries resulting from oil spill incidents. OPA defines injury as "*an observable or measurable adverse change in a natural resource or impairment of a natural resource service*." Restoration, under the OPA regulations, means "*restoring, rehabilitating, replacing, or acquiring the equivalent of injured natural resources and services*" and includes both primary restoration and compensatory restoration (15 C.F.R. § 990.30).

A NRDA, as described under Section 1006 of OPA (33 U.S.C. § 2706), and its implementing regulations (15 C.F.R. Part 990), consists of three phases: (1) pre-assessment; (2) restoration planning; and (3) restoration implementation. The Trustees may initiate a damage assessment provided that an incident has occurred; the incident is not from a public vessel or an onshore facility subject to the Trans-Alaska Pipeline Authority Act; the incident is not permitted under federal, state or local law; and Trustee natural resources may have been injured as a result of the incident.

Based on information collected during the pre-assessment phase, the Trustees make an initial determination as to whether natural resources or services have been injured, or are likely to be injured, by the release. Through coordination with other responding agencies (e.g., the United States Coast Guard (USCG) and the State of Alaska), the Trustees next determine whether oil spill response actions will eliminate the injury or the threat of injury to natural resources. If injuries are expected to continue, and feasible restoration alternatives exist to address such injuries, the Trustees may proceed with the restoration planning phase. Even if degradation from injuries is not expected to continue, restoration planning may be necessary if injuries resulted in interim losses requiring compensatory restoration.

Restoration Planning

The purpose of the restoration planning phase is to evaluate the potential injuries to natural resources and services, and to use that information to determine the need for, type of, and scale of restoration actions. OPA defines natural resources as: "*land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States, any state or local government or Indian tribe, or any foreign government* (33 U.S.C. § 2701(20))." Services (or natural resource services) are functions performed by a natural resource for the benefit of another natural resource and/or the public.

Restoration planning under OPA has two components: injury assessment and restoration selection. The goal of injury assessment is to determine the nature and extent of injuries to natural resources and services, thus providing a factual basis for evaluating the need for, type of, and scale of restoration actions. Restoration selection involves identifying a reasonable range of restoration alternatives; evaluating and selecting the preferred alternative(s); developing a draft DARP/EA; presenting the alternative(s) to the public; soliciting public comment on the draft DARP/EA; and considering those comments before issuing a final DARP/EA.

During the restoration implementation phase, the final Restoration Plan is presented to the RPs to implement or to fund the Trustees' cost of implementing the Plan, thus providing an opportunity for settlement of damage claims without litigation. Should the RPs decline to settle a claim, OPA authorizes Trustees to bring a civil action against RPs for damages. If a viable RP does not exist, or where an RP has exceeded its limit of liability, Trustees can seek damages from the National Pollution Funds Center's (NPFC) Oil Spill Liability Trust Fund (OSLTF) for the assessment and restoration costs. Components of damages are specified in sections 1001(5) and 1002(b) of OPA and include the cost of conducting damage assessments.

OPA requires that the Trustees develop a Restoration Plan and provide the public with an opportunity to review and comment on these plans. NOAA prepared this draft DARP/EA in accordance with OPA requirements and applicable regulations, as well as with guidance concerning restoration planning and implementation. (*See*, 33 U.S.C. §§ 2706 *et seq.*; 15 C.F.R. Part 990). This draft DARP/EA documents the information and analyses that support NOAA's evaluation of:

- Injuries to natural resources and natural resource services caused by the incident;

- Proposed restoration alternatives; and
- Rationale for NOAA's preferred restoration alternative, including NEPA compliance.

Summary of Injury Assessment

NOAA gathered and analyzed information for the purposes of conducting injury assessment activities and evaluating if feasible restoration actions exist to address the scale of potential injuries. Injury determination and quantification for Pacific herring larvae is based on available site-specific exposure data, how exposure relates to literature-based adverse effects levels, biological densities, and corresponding mortality due to exposure. Based on available information reviewed by NOAA, an estimated 25.5 billion Pacific herring egg-equivalents were killed due to the spill. Injury determination and quantification for lost shellfish harvesting trips are based on the timing and duration of a shellfish alert at Starrigavan Beach, state and site-specific data on baseline shellfishing rates/trips, and shellfishing values from the economics literature. Based on available information reviewed by NOAA, they estimated approximately 444 shellfishing trips were lost.

Summary of Restoration Alternatives Analysis and Identification of Preferred Restoration Alternatives

To restore lost resources and services, NOAA evaluated six restoration alternatives, including a no action alternative, and identified two preferred restoration projects. To restore lost Pacific herring, NOAA identified and scaled a marine debris removal project that would benefit Pacific herring by reducing egg loss as the preferred alternative. To restore lost shellfish harvesting days, NOAA identified as a preferred alternative, an increased effort to monitor for paralytic shellfish poisoning (PSP).

Trustee Coordination with the Responsible Party

The OPA regulations require the Trustees to invite the RP to participate in the damage assessment process (15 C.F.R. § 990.14). Accordingly, immediately following the spill, the Trustees offered the RP the opportunity to cooperatively conduct assessment activities. Initial cooperative efforts focused on the identification of an analytical laboratory to conduct forensic hydrocarbon analyses and the collection of source oil and shellfish tissue samples. The RP and its contractor shared information gathered on scene, as well as source samples and tissue chemistry data with the Trustees. However, the RP declined the opportunity to cooperatively fund and participate in study planning and implementation of field collection efforts targeting ephemeral data. As such, immediately following the release, the Trustees independently initiated collection of ephemeral data utilizing initiate funding for pre-assessment activities provided by the NPFC (Interagency Agreement number NOAA 15 NRD 01-0002- 000). Further, on May 25, the RP's legal counsel indicated that while they would continue to work with the NRDA Trustees, they would not provide funding for NRDA activities, asserting that they had reached their limitation of liability during the response and removal operations. As such, NOAA will present the Final DARP/EA to the RP, but should the RP be found to have reached their limit of liability or decline to participate, NOAA will request past assessment and restoration costs and restoration implementation funding from the NPFC's Oil Spill Liability Trust Fund (OSLTF).

Trustee Oversight of Proposed Restoration

For the purposes of implementing restoration alternatives, NOAA intends to work collaboratively with local non-profit organizations based in Sitka, Alaska and maintain a supervisory role during project development. NOAA's objective is to oversee the planning, design, coordination, and implementation of the projects proposed in this Restoration Plan, that restore, rehabilitate, replace, and/or acquire equivalent natural resources to those resources injured by the incident. NOAA will review project progress and require regular progress reports.

Public Involvement

Throughout the NRDA process, NOAA has provided the public with information on the status of injury assessment and restoration planning efforts. NOAA published a Notice of Intent to Conduct Restoration Planning online (October 9, 2018; available via the link, below). Additionally, the Notice of Intent was sent directly to the RP, State and Federal NRDA Trustee representatives, and specific stakeholders in Sitka. The Notice of Intent states that, based on pre-assessment findings, NOAA was proceeding with restoration planning under OPA and opening an Administrative Record to facilitate public involvement in the restoration planning process. NOAA also placed information about the spill, including an electronic copy of the Administrative Record, on the NOAA website (https://darrp.noaa.gov/oil-spills/tug-powhatan). Through the above-mentioned efforts, the public was able to obtain reports, injury assessment studies, and agency contacts to obtain more information.

In response to the Notice of Intent NOAA received comments on the pre-assessment report from Polaris Applied Sciences Inc., under instruction from Schwabe Williamson & Wyatt, council to the underwriter for the RP. These comments are in the Administrative Record and were considered when drafting this draft DARP/EA.

Public review of this draft DARP/EA is an integral component to the restoration planning process. The OPA implementing regulations (15 C.F.R. Part 990), as well as NEPA and its implementing regulations (40 C.F.R. Parts 1500-1508), require that the public be provided an opportunity to review and comment on oil spill restoration plans. Through this review process, NOAA seeks public comment on the projects being proposed to restore natural resources injured as a result of the incident. An electronic copy of the draft DARP/EA was published on NOAA's website (https://darrp.noaa.gov/oil-spills/tug-powhatan). Additionally, copies of the draft DARP/EA for the Tug *Powhatan* Spill are available at the following locations:

Sitka Public Library
c/o Catheryn Hertzly, Library Director
320 Harbor Drive
Sitka AK 99835

ARLIS (Alaska Resources Library & Information Services)
Alaska Pacific University
3211 Providence Dr.
Anchorage, AK 99508

Comments regarding this plan may be submitted in writing up to 30 days after the release of this draft DARP/EA to:

Sarah Allan, Ph.D., Alaska Regional Resource Coordinator
NOAA Office of Response and Restoration
222 West 7th Ave. Suite 552
Anchorage, AK 99513
sarah.allan@noaa.gov

Administrative Record

NOAA has maintained records to document the information considered by the Trustee as it developed this draft DARP/EA. These records are compiled in an Administrative Record, which is available to the public online through a link at the website listed above. The Administrative Record facilitates public participation in the assessment process and will be available for use in future administrative or judicial review of Trustee actions to the extent provided by federal or state law. Additional information and documents, including public comments received on the draft DARP/EA, and other related restoration planning documents will become a part of the Administrative Record.

Organization of DARP/EA

The remainder of this draft DARP/EA contains the following chapters:

- **Affected Environment and Natural Resources of Concern (Chapter 2):** This chapter describes the environment affected by the incident and proposed for restoration.

- **Summary of Pre-Assessment Activities (Chapter 3):** This chapter describes the Trustees' pre-assessment activities and efforts to collect ephemeral data during and immediately following the release.

- **Injured Resources (Chapter 4):** This chapter provides NOAA's assessment of injury to natural resources.

- **Restoration Planning (Chapter 5):** This chapter describes the process used to evaluate restoration alternatives, then describes and scales the potential restoration actions.

- **Environmental Impact of Restoration Alternatives (Chapter 6):** This chapter describes the impacts the proposed restoration projects will have on the environment, in accordance with NEPA regulations.

- **Coordination with Applicable Regulations and Authorities (Chapter 7):** This chapter discusses federal, state, and local laws and regulations affecting the proposed preferred restoration alternatives.

- **Preparers, Agencies, and Persons Consulted (Chapter 8):** This chapter lists the agencies and personnel involved in developing this draft DARP/EA.

CHAPTER 2 | AFFECTED ENVIRONMENT AND NATURAL RESOURCES OF CONCERN

This chapter describes the physical and biological environments and the human uses in the vicinity of the spill and identifies the focus of NOAA's assessment. The affected environment for injury assessment and restoration planning activities includes areas within Sitka Sound, in the vicinity of the Western Channel and Starrigavan Bay, located approximately seven miles north of Sitka. The biological environment where oil came to be located includes a myriad of fish, birds, mammals, and other biota found within the water column, shoreline, and intertidal habitats. The human uses of natural resources within this area include recreation, commercial fishing, and non-commercial harvest of natural resources.

Specifically, the geographic scope includes open water and nearshore sub-tidal and tidal aquatic environments where oil was observed. Oil sheens in open water were observed by USCG responders, ADF&G biologists, and the RP, and documented during the spill via aerial imagery when conditions allowed. As such, the full extent of oil on the water's surface was not continuously accounted for. The aerial imagery obtained can be used as a surrogate to estimate the minimum extent of surface oil. However, sheen was also present on days and in areas where photo documentation was not obtained (for further explanation see aerial imagery section).

Physical Environment

Sitka Sound, Alaska is located on the western edge of Southeast Alaska. This area consists of a narrow strip of land and offshore islands adjacent to the Province of British Columbia, Canada. Covering approximately 23 million acres, Southeast Alaska consists of over 5,000 islands making up the Alexander Archipelago. Collectively, the entire length of the coastline exceeds 18,000 miles and makes up approximately 20% of the coastline of the entire United States (Audubon 2016).

The topography of the region is dominated by high mountains that rise to over 4,500 meters (15,000 feet), which are bisected by glacial fjords and major river systems. These river systems discharge approximately 90 cubic meters of freshwater annually, creating a unique coastal environment. Many of the coastal river systems are short due to the surrounding elevation and contain large wetland and riparian areas (Audubon 2016).

The Biological Resources

Numerous species of wildlife can be found within the geographic scope of the assessment, including fish, invertebrates, birds, and marine mammals.

Fish and Marine Invertebrates

The productive marine habitats of Sitka Sound support a diverse array of fish species including, but not limited to, Pacific herring (*Clupea pallasii*), Pacific halibut (*Hippoglossus stenolepis*), nine anadromous fish species (e.g., salmon), and multiple species of invertebrates (e.g., crabs and bivalves). During the time of the release, Pacific herring in Sitka Sound were emerging from their egg stage and transported as larvae via currents throughout Sitka Sound.

Additionally, Starrigavan Creek, which is located within the geographic scope of the assessment, is listed in the ADF&G's Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes (known as the Anadromous Waters Catalog; ADF&G 2017a). At the time of the release, salmon smolt were observed in the mouth of Starrigavan Creek and in the vicinity of boat ramps and docks in the bay. The surrounding terrestrial ecosystems are intertwined with the aquatic biota (e.g., anadromous fish transport marine nutrients to freshwater and adjacent habitats) and are composed primarily of coastal temperate forests, a unique habitat that constitutes only 3% of the world's temperate forests (Audubon 2016).

Birds and Marine Mammals

As reported in Audubon (2016), over 200 species of marine and terrestrial birds can be found in Southeast Alaska. Many of these species utilize the waters of Sitka Sound and prey on biota found within the geographic scope of the assessment. Examples of birds in the region include bald eagles (*Haliaeetus leucocephalus*), marbled murrelet (*Brachyramphus marmoratus*), black oystercatcher (*Haematopus bachmani*), and the pelagic cormorant (*Phalacrocorax pelagicus*). Examples of marine mammals that utilize the waters of Sitka sound include sea otters (*Enhydra lutris*), Steller sea lions (*Eumetopias jubatus*), humpback whales (*Megaptera novaeangliae*), and killer whales (*Orcinus orca*). No birds or marine mammals were reported to have been exposed to oil during the incident.

Human Use

The plentiful and diverse resources in Southeast Alaska support numerous human use activities, including recreation, commercial fishing, and non-commercial harvest.

Recreation

The natural resources of Southeast Alaska, including Sitka Sound, provide abundant hunting, fishing and sightseeing opportunities. Wildlife viewing is popular among visitors, many of which travel via cruise ships or on the Alaska Marine Highway to Sitka, Alaska. According to ADF&G, Sitka Sound provides opportunities to view humpback whales, killer whales, seabirds, bald eagles, sea lions, sea otters, and other wildlife. In addition to cruise ships, numerous smaller tour boats provide wildlife viewing tours. Further, recreational fishers travel to Southeast Alaska from around the globe to fish for salmon and other anadromous and marine fish such as steelhead (*Oncorhynchus mykiss*), Dolly Varden (*Salvelinus malma*), halibut and multiple species of rockfish. Residents engage in a variety of recreational activities, including fishing, boating, hunting, and hiking.

Commercial Fishing

In Southeast Alaska, including Sitka Sound, commercial fishing is a major economic driver. In 2011, between five and ten million pounds of salmon were harvested from Sitka Sound alone (Audubon 2016). Although five species of salmon are harvested commercially, in the last decade, pink salmon (*Oncorhynchus gorbuscha*) have dominated the harvest biomass, accounting for about 74% of the harvest across Southeast Alaska. The salmon fishery in Alaska is managed as a "limited entry" fishery, which determines the total number of vessels allowed to use different gear types and results in specific harvest limits by gear type and species. Further, throughout Southeast Alaska, including in Sitka Sound, state-run hatcheries aim to increase salmon abundance for commercial harvest (Audubon 2016).

In addition to salmon fisheries, by far the most widely known and economically important, Southeast Alaska also supports smaller fisheries for ground fish and shellfish (Audubon 2016). Pacific herring are also harvested in the winter for bait and during the spring for their roe. The Sitka Sound herring sac roe fishery harvested 13,923 tons of sac roe, valued at $4.29 million, in 2017 (ADF&G 2018b). Further, Sitka Sound supports two mariculture facilities producing oysters (*Crassostrea spp.*) and geoduck clams (*Panopea generosa)* (Audubon 2016).

Non-Commercial Harvest

Alaska Natives and other Alaskan residents harvest the region's natural resources. As reported in Audubon (2016), with greater than 80% of households partaking in some form recreational or non-commercial harvesting, Southeast Alaska residents average 200 pounds per year of take. In Sitka Sound specifically, fish constitute more than 75% of the harvest, followed by marine invertebrates at approximately 20%, and vegetation at about 5%. According to ADF&G, in Sitka Sound, the Sitka Tribe of Alaska harvests herring eggs using hemlock branches, kelp, and hair seaweed. Harvested eggs are shared widely as they are distributed to community members. ADF&G studies estimate approximately 100 households participating in the fishery with the harvested eggs being shared with upwards of 1,000 households. Traditionally, eggs were dried and consumed throughout the year but today freezing is the main preservation method (Sill 2015). Between 2002 and 2014, the annual non-commercial herring egg harvest in Sitka Sound ranged from 32,700 to 173,000 kilograms (Audubon 2016). Further, within Sitka Sound, Starrigavan Beach is an important shellfish harvesting site. This area is the only road-accessible clamming beach for the community of Sitka. Other shellfish, such as mussels, are also harvested from the beach. Evidence of its importance is the Sitka Tribe of Alaska's Environmental Research Lab (STAERL) monitoring program for paralytic shellfish poisoning (PSP). Such monitoring programs for PSP allow harvesters to have confidence that their harvest is safe for human consumption.

Threatened and Endangered Species and Essential Fish Habitat

While Southeast Alaska does support numerous endangered species (e.g., short-tailed albatross (*Phoebastria albatrus*)) and critical habitat (e.g., groundfish, salmon, scallop), no threatened and endangered species were identified within the vicinity of the oil spill during response actions. Additionally, no endangered species were reported to have been exposed to oil during the incident. As such, NOAA has chosen not to focus on identifying and quantifying potential injuries to endangered species or essential fish habitat (EFH).

Focus of the Assessment

Although numerous resources have been potentially impacted by the release, as part of the NRDA and restoration planning processes, NOAA must determine which resources can be effectively studied under the given circumstances, and with reasonable costs. As such, based on the extent of oiling in the open waters of Sitka Sound where sensitive early life stages of fish were present and the shellfish alerts, NOAA has chosen to focus the assessment on impacts to Pacific herring larvae which utilize the open water, Pacific herring eggs which are deposited in shallow water environments on submerged aquatic vegetation (SAV; e.g., eelgrass and kelp), and lost human use related to the shellfish alerts.

Pacific Herring

Due to the species ecological and commercial importance, Pacific herring have been the subject of numerous studies and are managed by the state of Alaska. Pacific herring are a small schooling fish found throughout the northern waters of North America and Asia. Living up to 19 years and reaching a weight of approximately one pound and a length of 18 inches, adults are often found in large schools from the surface to a depth greater than one thousand feet. Although the timing varies by latitude, adult herring migrate to inshore estuarine waters to spawn. Once in shallow coastal waters, herring spawn for about two weeks in the sub- and inter-tidal zones. As with many other species of fish, natural egg and larval mortality is high.

In Southeast Alaska, from March to June, eggs are deposited on SAV from the lower intertidal zone to approximately 12m and the distribution of eggs is dependent on the type of vegetation and the slope of the beach (Norcross and Brown 2001, NOAA 2014). Once deposited on SAV, estimates of incubation time vary from ten days to approximately three weeks (McGurk 1989, Biggs and Baker 1997, NOAA 2014). As reported in Norcross and Brown (2001), during the incubation stage, many eggs do not survive due to physical forces (e.g., wave action causing eggs to be dislodged from the SAV to which they are attached), predation, and high egg densities.

After hatching, herring larvae are transported by currents horizontally. They consume their yolk-sac between 10-14 days post hatch. Herring larvae remain in nearshore waters, close to their spawning grounds, for 2-3 months after hatching (NOAA 2014). After the larval period herring metamorphose into juveniles, form schools, and migrate to deeper waters. Feeding on plankton, these juvenile herring mature over a period of two to three years at which time they return to shallow waters to spawn. Additionally, while some population mixing does occur, Pacific herring generally stay within a school through their lifetime and show considerable spawning site fidelity (Flostrand et al. 2009).

As described in NOAA (2014), Pacific herring in Southeast Alaska play a vital role in the food web. Pacific herring are preyed upon not only by marine species but also some terrestrial species, including mammals, birds, and invertebrates. As such, Pacific herring are considered a keystone species because they provide a link between trophic levels. Two key predators of adult herring are humpback whales and Steller sea lions. Additionally, many piscivorous species of birds prey upon adult herring (e.g., gulls). Further, important ecological, recreational, and commercial species (e.g., salmon and halibut) prey upon adult herring. Herring roe provides an essential food source for many avian and invertebrate species in the intertidal zones. Numerous avian species consume herring roe, including terrestrial species (e.g., geese and crows), wading birds (e.g., black turnstones), sea ducks (e.g., scoters) and sea birds (e.g., gulls). Crabs are the predominant invertebrate species that consume herring roe.

In addition to being an essential component of the Pacific ecosystem, herring are harvested commercially and non-commercially. As described above, there are important commercial and non-commercial harvests of herring roe in Sitka Sound. Between 2007 and 2017, the commercial herring sac roe fishery harvest ranged between 5,786 and 19,539 tons (ADF&G 2018b). Adult Pacific herring are also harvested commercially for food and bait. The adult fishery generally occurs in the late summer thru winter using seines and gillnets and are managed by regulatory stocks (i.e., geographically distinct spawning aggregations defined by regulation; Woodby et al. 2005). Statewide herring harvests from 2007 thru 2017 ranged from approximately 51.8 to 108.5 million pounds (ADF&G 2018a).

Injuries to Pacific herring have been documented in past oil spills, including the *Exxon Valdez* oil spill in Prince William Sound, Alaska, and the *Cosco Busan* oil spill in California. Early life stages of herring are especially sensitive to injury from exposure to oil. Over the course of the oil spill from the Tug, herring eggs and larvae were present in areas that were oiled.

Shellfish Harvesting

Clam digging and harvesting of other shellfish is popular throughout Southeast Alaska, including the Sitka area, and is important to the cultures and economies of Southeast Alaska. Common varieties of clams harvested in the Sitka area include butter clams (*Saxidomus giganteus*), littleneck clams (*Leukoma staminea*), and cockles (*Clinocardium nuttallii*). According to ADF&G, no permit is required to harvest clams and there are no bag limits in Sitka Sound except that the Sitka Sound Special Use Area is closed to the taking of razor clams. Shellfish harvesting generally occurs during the spring low tides, which allow access to the clamming areas. During this time, Sitka residents will travel to Starrigavan Beach to harvest clams because it is the only clamming areas in Sitka accessible by road.

The importance of shellfishing to Alaskans is evident by the existence and activities of STAERL, which collects shellfish samples throughout Southeast Alaska to monitor for PSP and other toxins. The creation of the Laboratory was motivated by incidents of shellfish poisoning in Sitka residents who had collected clams at Starrigavan Bay. NOAA understands that many residents of Southeast Alaska turn to this organization and the advisories they promulgate to determine if harvesting and consuming shellfish is safe at the time. Further, NOAA understands from communications with locals and STAERL scientists that they will refrain from harvesting shellfish if STAERL has not tested an area.

The incident coincided with the low spring and summer tides when most clam harvesting occurs in Starrigavan Bay. Shorelines, including the clam beds in the Bay were oiled and advisories were posted on the beach and on the STAERL website advising against harvest and consumption of shellfish from Starrigavan Beach due to the oil spill.

CHAPTER 3 | SUMMARY OF PRE-ASSESSMENT ACTIVITIES

This chapter describes the Trustees' pre-assessment activities and efforts to collect ephemeral data during and immediately following the release. Ephemeral data efforts included collection of aerial imagery, characterization of the spilled oil, collection of environmental samples (water, sheen, and shellfish [mussels and clams]) for chemical analyses, collection of fish larvae to estimate larval densities, spawn deposition dive surveys to estimate egg densities, and collection of shellfish alert data. Other State and Federal Trustees worked with NOAA on some pre-assessment activities (see the Natural Resource Trustee Authority section in Chapter 1 for additional information); however, the pre-assessment analyses and conclusions described below were developed by NOAA.

Initiation of Pre-Assessment Activities

The Trustees initiated the pre-assessment phase on April 21, 2017, after receiving notification of an ongoing oil release due to the sinking of the Tug. The Trustees determined that the criteria promulgated at 15 C.F.R. § 990.41(a) were met:

1. An incident has occurred, as defined in § 990.30 of this part;
2. The incident is not:
    i. Permitted under a permit issued under Federal, State, or local law; or
    ii. From a public vessel; or
    iii. From an onshore facility subject to the Trans-Alaska Pipeline Authority Act, 43 U.S.C. §§ 1651 *et seq.*; and
3. Natural resources under the trusteeship of the trustee may have been, or may be, injured as a result of the incident.

Response and pre-assessment activities, as defined by OPA, focus on collecting ephemeral data essential to determine whether:

- Natural resource injuries have resulted, or are likely to result from, the incident;
- Response actions have adequately addressed, or are expected to address, the injuries resulting from the incident; and
- Feasible restoration actions exist to address the potential injuries.

The Trustees conducted some pre-assessment efforts in coordination with the RP. Specifically, the Trustees coordinated with the RP to collect source oil samples from the sunken vessel. The RP also shared shellfish tissue chemistry data and on scene observations with the Trustees. Other pre-assessment activities were carried out independently of the RP.

Aerial Imagery

At the time of the spill, the USCG initiated overflights of the impacted area of Sitka Sound using low flying fixed-wing aircraft and an attached camera. Imagery collected during these flights showed the sheen on the surface of the water (Exhibit 3.1). However, due to the spatial extent of the spill, no single image was capable of capturing the full extent of the sheen at each time. Further, in some cases the fixed-wing aircraft was not capable of collecting imagery due to adverse weather conditions or other circumstances. The USCG collected aerial imagery on April 20-23, 2017. Additional aerial imagery and observations were collected by ADF&G biologists that were surveying herring spawning in Sitka Sound from a fixed-wing aircraft on April 21. Imagery from April 26 through June 13, 2017 was collected by the RP, using a drone.

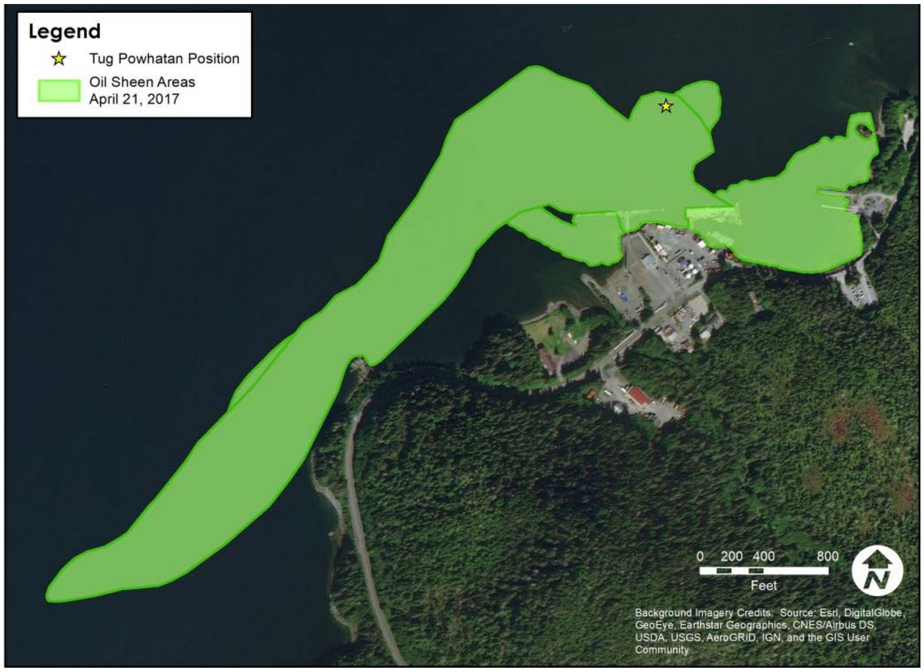
Exhibit 3.1 Select Aerial Images of Sheen (Image credit: ADFG, USCG)

Images collected by the USCG, ADF&G, and the RP were provided to the Trustees. These images were then imported into ArcGIS and the sheen areas for each day were digitized by NOAA's Spatial Data Branch (SDB). Thus, where data were sufficient, a sheen polygon in ArcGIS was produced for each day of the release (Exhibit 3.2). Using these daily polygons, a daily sheen area was computed (Exhibit 3.3). Aerial imagery of the sheen was available for April 20, 21, 23, 26-28, and 30; May 1-4, 6, 8-11, 13, 14, and 28; and June 1, 12, and 13.

Some aerial images were not of sufficient quality or did not contain geographical features or metadata to allow for georeferenced sheen area polygons to be produced. In some of these cases, when the containment boom area was visible, the sheen area was estimated based on the size of the sheen relative to the known size and location of the boomed area. Some aerial photos were not usable for estimating sheen area, despite showing surface oiling, and were disregarded.

Days without aerial imagery were estimated as the average of the two closest days with aerial imagery (one before, one after). April 19 is the exception to this method and was estimated as three-quarters the extent of the sheen on April 20 based on reports from responders that were on-scene. Based on available information, daily sheen area estimates ranged from approximately 0.01 to 5 million square meters (approximately 0.1 to 54 million square feet). Total daily sheen areas were likely greater than those estimated from available aerial imagery, due to the limited temporal coverage of the overflights and usability of the available photos for area calculations.

Exhibit 3.2 Select Digitized Areas of sheen



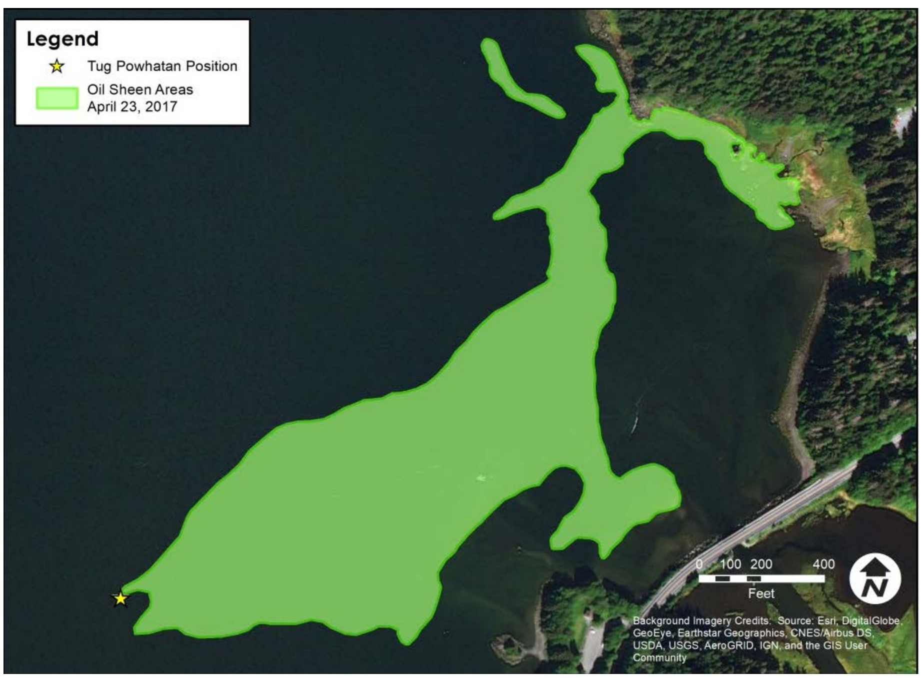


Exhibit 3.3 Daily Estimates of Sheen Area

Date	Estimated Sheen area (million m^2)

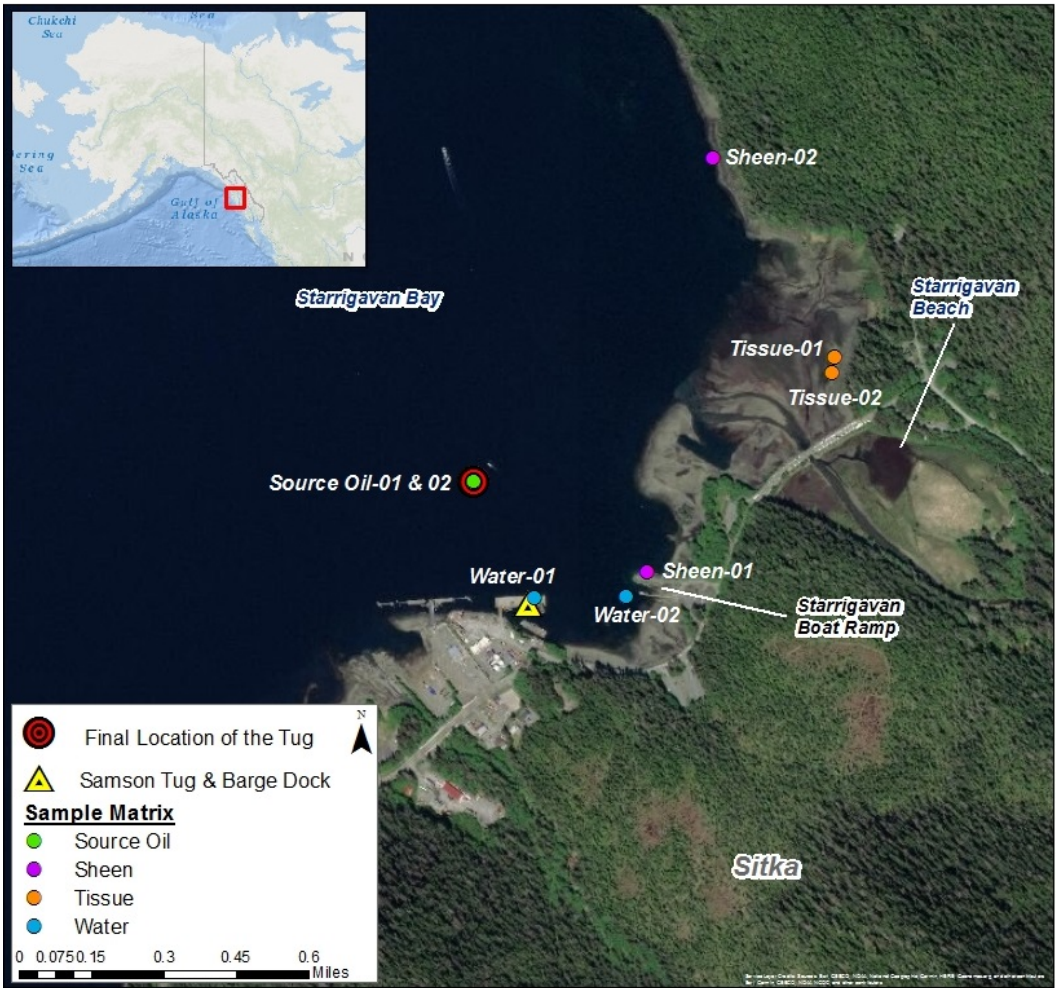
4/19/2017	2.61**
4/20/2017	3.48
4/21/2017	5.01
4/22/2017	2.56*
4/23/2017	0.11
4/24 to 4/25/2017	0.07*
4/26/2017	0.03
4/27-4/28/2017	0.04
4/29/2017	0.09*
4/30/2017	0.15
5/1/2017	0.07
5/2/2017 to 5/3/2017	0.02
5/4/2017	0.03
5/5/2017	0.02*
5/6/2017	0.02
5/7/2017	0.02*
5/8/2017	0.01
5/9/2017	0.03
5/10/2017	0.02
5/11/2017	0.03
5/12/2017	0.03*
5/13/2017	0.04
5/14/2017	0.07
5/15/2017 to 5/27/2017	0.06*
5/28/2017	0.06
5/29/2017 to 5/31/2017	0.06*
6/1/2017	0.06
6/2/2017 to 6/11/2017	0.11*
6/12/2017	0.16
6/13/2017	0.04

*Estimated as the average of the closest days, before and after, where sheen was documented via photographs.
**Estimated as 75% of the sheen area on 4/20/2017.

Field Sampling for Chemical Analysis

During emergency response activities, the USCG and the RP collected samples from the sunken Tug and the environment, including source oil samples, sheen samples, water samples, and shellfish (mussels and clams) samples (Exhibit 3.4). All samples were sent to Alpha Analytical (Mansfield, Massachusetts) for chemical analysis and fingerprinting in accordance with standard practices described in Appendix A. Following laboratory analysis, the analytical results were interpreted by Dr. Scott Stout of NewFields Companies LLC.

Exhibit 3.4 Field Sampling Locations for Chemical Analysis



The objectives of the analyses and interpretation were to determine the type(s) and composition(s) of oils released from the sunken vessel and compare the source oils to the six environmental samples collected from the area. These comparisons allow the Trustees to determine if the area's natural resources were exposed to oil released from the Tug. Comparisons between the source oils and environmental samples were made through a combination of qualitative and quantitative techniques. No single oil spill identification protocol was appropriate owing to the different matrices being compared (e.g., oil v. tissues), the effects of weathering of the Tug's source oil(s), the likely release of varying mixtures of oils among the Tug's source oils, and the low concentrations of most targeted biomarkers in the environmental samples studied. Those sheen and water samples whose chemical signatures were:

- Consistent with weathering of the source oils were considered as "matches";
- Inconsistent with weathering of the source oils were considered as "non-matches"; or
- Insufficient to yield reliable information were considered "indeterminate".

The shellfish tissue samples were analyzed only for their polycyclic aromatic hydrocarbon (PAH) concentrations, but not for total petroleum hydrocarbons (TPH) and biomarkers, which reduces the ability to determine the source of PAHs in tissues relative to water and sheen samples, which were analyzed for TPH and biomarkers. As a result, tissue samples that were a “match” to source oils were described as a “possible match” to reflect possible uncertainties with sourcing using only PAH fingerprinting.

As summarized in Exhibit 3.5, the following paragraphs provide further details regarding sampling efforts, analytical results, and interpretation.

Source Oil Sampling for Chemical Analysis

During dive operations to stabilize and recover the sunken vessel, RP representatives collected two source oil samples from different containment caps on the Tug. Laboratory analysis determined that the source oil samples predominantly contained compounds in the “diesel range” which is consistent with the fuel types believed to be on the vessel. The prominence of compounds susceptible to biodegradation compared to those not susceptible indicated the source oils had not undergone biodegradation which is consistent with the fact that the samples were collected directly from the vessel. Additionally, one of the source oil samples contained a lubricating oil component while the other did not, which is consistent with the samples being collected from different reservoirs on the vessel. The source oil samples were collected on May 4, two weeks after the Tug sank, and it is possible that the source oil composition may have changed over the course of the spill.

Water Sampling for Chemical Analysis

Two water samples were collected in the vicinity of the release (Exhibit 3.4 and 3.5). One sample was collected from an area where no oil was observed (water-02), while the other was a surface water sample that contained visible sheen (free/particulate oil [water-01]). These samples were analyzed using the methods described in Appendix A and the results were compared to the source oil sample as described above. The water collected from the Samson Pier on April 25 (FPN J17008-001; water-01) contained a weathered diesel fuel and a trace lube oil mixture that is a “match” to the source oils from the vessel. The water sample collected from the Starrigavan boat ramp on April 26 (FPN J17008-002; water-02) contained virtually no measurable hydrocarbons and thereby is classified as “indeterminate”.

Sheen Sampling for Chemical Analysis

Two sheen samples were collected with sheen nets in the vicinity of the release (Exhibit 3.4 and 3.5). These samples were analyzed using the methods described in Appendix A and the results were compared to the source oil sample as described above. The sheen sample collected from the Starrigavan boat ramp on April 26 (FPN J17008-003; sheen-01) was considered a “non-match” to the source oils from the Tug because the biodegradation rate and biomarkers were not consistent with source oil sample. It is possible that this sheen is derived from other spill(s) of slightly different diesel fuel/lubricant mix that pre-dates the sinking of the Tug or that oil from other sources mixed with oil from the Tug. However, it is also possible that the oil initially released from the sunken Tug, prior to the collection of the source oil samples, could have included oil(s) that were different from the source oils (e.g., a biodegraded diesel fuel/lube mix derived from bilge water).

The sheen sample collected in the eastern part of Starrigavan Bay on April 26 (FPN J17008-004; sheen-02) contained, along with non-petroleum (e.g. natural organic matter), a weathered diesel fuel and trace lube oil mixture that is a "match" to the source oils from the Tug.

Shellfish Tissue Sampling for Chemical Analysis

Two shellfish (mussels and clams) tissue samples were collected from Starrigavan Beach (Exhibit 3.4 and 3.5). These samples were analyzed for PAH concentrations using the method described in Appendix A, and the results were compared to the PAH distributions of the source oil samples. The tissue samples contained 151 and 95 micrograms per kilogram wet weight of total PAH (TPAH), which indicates that both tissues were impacted by PAHs. The composite mussel sample collected from Starrigavan Beach on May 3 (2017-05-03-01-02; tissue-01) contained petrogenic PAHs that are a "possible match" to those contained in the weathered source oils from the Tug. Again, the term "possible match" is used due to the limits of testing only with PAH (see Appendix A for additional information about fingerprinting and comparing samples based on PAH distributions). The composite clam sample collected from Starrigavan Beach on May 3 (2017-05-03-01-03; tissue-02) contained, in addition to minor pyrogenic PAHs of a combustion origin, petrogenic PAHs that are a "possible match" to those contained in the weathered source oils from the Tug due to only testing for PAH.

Exhibit 3.5 Forensic Classification for Six Environmental Samples

Sample ID	Map ID (Exhibit 3.4)	Sample Matrix	Collection Location	Classification
FPN J17008-001	Water-01	Water	Samson Tug and Barge Dock	Match
FPN J17008-002	Water-02	Water	Starrigavan boat ramp	Indeterminate
FPN J17008-003	Sheen-01	Sheen	Starrigavan boat ramp	Non-Match
FPN J17008-004	Sheen-02	Sheen	Eastern part of Starrigavan Bay	Match
2017-05-03-01-02	Tissue-01	Mussel Tissue	Starrigavan Beach	Possible Match
2017-05-03-01-03	Tissue-02	Clam Tissue	Starrigavan Beach	Possible Match

Fish Field Sampling for Presence, Lifestage, and Density Estimates

On April 27, NOAA initiated sampling efforts, led by the Sitka Sound Science Center (SSSC), to confirm the presence, and if possible, the density, of different life stages of fish in the water column, and nearshore waters and substrates of the area potentially impacted by the spill. Efforts included dive surveys to evaluate presence of herring eggs (embryos), ichthyoplankton surveys using Bongo nets to sample for larval Pacific herring, and beach seines to sample salmon smolt.[2] Additional details regarding each sampling effort are provided below and Appendix B provides additional details regarding methodology.

Diver Surveys for Pacific Herring Spawn Deposition

On April 27 and 28, dive operations were carried out to determine the presence/absence of herring eggs and to estimate egg densities. Field sampling methods employed were modeled after the ADF&G spawn deposition surveys and included placing a sampling frame every five meters along a transect. Transects

[2] Density estimates based on these sampling efforts are for the purposes of this NRDA only and are not intended to be extrapolated to estimate the abundance or biomass for a larger area.

were chosen randomly within the survey area, were a minimum length of 30 meters, and were separated by a minimum distance of 0.1 nautical miles (Exhibit 3.6). A total of seven dives were made along the shoreline south of Starrigavan Bay.

Three sampling frames, from two transects, contained Pacific herring eggs (transects four and six; Exhibit 3.6). As such, it was not possible to estimate egg densities. However, while eggs were not abundant within the transect sample frames, egg deposition was observed on kelp. Further, egg remnants were observed, indicating eggs had previously hatched, which, as described below, is consistent with the observation of larval Pacific herring in the water column.

According to ADF&G, the most recent spawn within the survey area occurred on April 8, 2017, though spawning occurred as late as April 21st in other parts of Sitka Sound, including in parts of the Western Channel where sheens were observed (ADF&G 2017b; E. Coonradt, personal communication, May 18, 2017). Consistent with hatch times between 10 to 21 days post-spawn, and spawning events between March 20 and April 21, it is likely that herring were emerging from early April through mid-June of that year. The small number of remaining, mostly later stage eggs, within the survey area at the time of the dives is consistent with other available data for spawn timing along those shores.

Exhibit 3.6 Approximate Pacific Herring Egg Dive Transect Locations

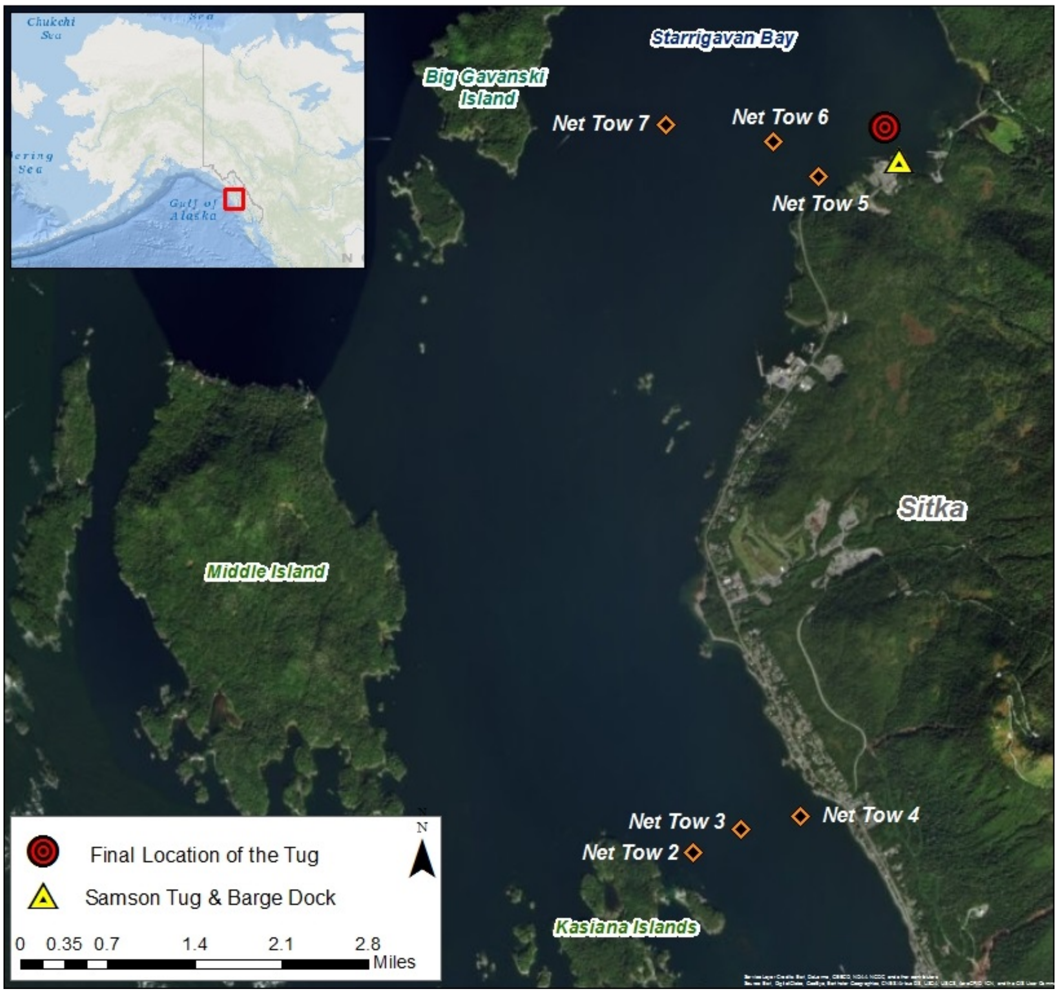
Ichthyoplankton Surveys for Pacific Herring Larvae

On April 29, using a Bongo net and a flowmeter, six net tows were conducted in the top 5m of the water column in the vicinity of the spill (Exhibit 3.7). Larval fish densities were high and in order to not exceed the ADF&G collection permit, tow time was limited to three to five minutes and the B-side Bongo net samples were released. The A-side samples were preserved in individual jars using 10% buffered formalin. Jarred samples were transported to the SSSC laboratory for enumeration.

Each sample was poured into a glass beaker and the plankton was given time to settle (10 minutes). Excess solution was then decanted through a filter and a glass pipette was used to stir the sample in a figure eight pattern to equally distribute plankton throughout the sample. The pipette was then used to draw subsamples (1-4 ml each), which were placed in a petri dish. A dissecting microscope was then used to magnify plankton and larval Pacific herring were enumerated. The number of Pacific herring enumerated in this subsample was then used to estimate the number of herring per cubic meter (i.e., density) based on the volume of water filtered per tow. The average density of herring across the six net tows was 126 herring per cubic meter and the range was approximately 14 to 530 herring per cubic meter.

Based on the survey data from ADF&G, as well as egg and larval development times, herring larvae would have begun emerging in Sitka Sound in early April and new individuals would be added to the larval population in the water column continuously through mid-June. Herring larvae remain in nearshore waters, close to their spawning grounds for 2-3 months after hatching (NOAA 2014). Larval herring densities found in the ichthyoplankton survey are consistent with other available data and life history information for this herring stock (ADF&G 2017b).

Exhibit 3.7 Start locations for Ichthyoplankton Net Tows



Beach Seine Sampling for Salmon Smolt

On April 28, using a 25' x 5' beach seine, four seine passes were made in Starrigavan Bay, straddling either side of Starrigavan Creek (Exhibit 3.8). The purpose of the effort was to identify and enumerate salmon smolt. Species and life stage identification and enumeration were conducted in the field because the ADF&G permit did not allow for retention of fish. Chum salmon smolts dominated the catch followed by pink salmon. Further, a total of 2 coho salmon smolt and 1 coho fry were taken. Salmon species, life stages, and densities observed in Starrigavan bay were consistent with written observations, photos, and videos that were provided by ADF&G on-scene observers showing salmon under oil sheens in Starrigavan Bay early in the incident.

Exhibit 3.8 Approximate Seine Locations

Shellfish Alert

The sinking of the Tug occurred on April 19, 2017, two days later residents reported that a sheen was observed on the shoreline of Starrigavan Bay. On April 21, the Sitka Tribe's Southeast Alaska Tribal Ocean Research (SEATOR) posted a notice on their website, the main portal for STAERL shellfish monitoring results, advising people to not harvest shellfish from Starrigavan Beach (Exhibit 3.9) until further notice because of the oil spill (SEATOR.org). Five days after the spill, sheens were observed by emergency responders along in intertidal clam beds, including in remnant depressions from pits that had been dug for clamming. On April 25, ADEC observed weathered oil sheens in the clam beds of North Starrigavan Bay. This same day, shellfish alert signs were physically posted at North and South Starrigavan beach access points (Old Sitka State Historic Park and U.S. Forest Service Starrigavan Recreational Area).

Exhibit 3.9 Shellfish Alert Sign (Photo Credit: Bob Mattson)

By April 28, sheens on the shoreline were reduced, but shellfish alert signs, advising against harvest and consumption, were still present at beach access points. On May 18, mussel and clam PAH tissue concentration results were provided to NRDA Trustees (sample Tissue-01 [2017-05-03-01-02] and Tissue-02 [2017-05-03-01-03]; Appendix A); this information was released to the State and Sitka Tribe on May 25, along with a risk assessment that the RP completed, indicating that PAH concentrations were below human health risk thresholds. The results of the RP's risk assessment were not endorsed by the NRDA Trustees. On June 5, unrelated to the oil spill, SEATOR issued a PSP warning for the area. The PSP warning remained in place through June 20. In August, the Alaska Department of Health and Social Services reviewed the shellfish tissue chemical analysis results and the On-Scene Coordinators determined that no further shellfish monitoring or advisories were necessary related to the oil spill. On August 10, ADEC removed the spill-related harvest and consumption advisory signs from the two access points to Starrigavan beach.

CHAPTER 4 | INJURED RESOURCES

This chapter presents NOAA's efforts to describe and quantify the injuries to natural resources and human use activities resulting from the incident. The goal of injury assessment is to determine the nature and extent of injuries to natural resources, thus providing the technical basis for evaluating and scaling restoration actions. OPA defines injury as "an observable or measurable adverse change in a natural resource or impairment of a natural resource service." Further, "Loss of use of natural resources," i.e., diminished quantity and/or quality of recreational use of natural resources, is also a compensable injury under OPA. To determine if feasible restoration actions exist to address the potential injuries, NOAA must first determine the magnitude of injuries.

Exposure of Trust Resources and Pathway

Oil released from the Tug, was positively buoyant and rose to the surface in the vicinity of the release site. As oil droplets rose through the water column, dissolution of PAHs into the water column varied based on droplet size and rise rate. As oil droplets reached the surface, they spread out and formed a sheen. The sheen was subsequently transported by waves, currents, and wind within Sitka Sound. As the oil was transported, physical processes such as wind, surface currents, and breaking waves circulated and entrained oil causing further PAH dissolution into the water column. Ultimately, oil on the water's surface was diluted and broken into continuously smaller droplets and degraded or the oil was deposited along shorelines. Pacific herring eggs were exposed to dissolved hydrocarbons in the water column beneath the oil sheen in the nearshore environments where spawning occurs. Pacific herring larvae were exposed directly to the oil via contact with the sheen at the water's surface and/or exposure to droplets and dissolved hydrocarbons in the water column beneath the sheen. Further, shellfish harvesting areas were exposed to oil as the sheen was transported via winds and currents from the release site to nearby beaches. Water (water-01), sheen (sheen-02), and shellfish (tissue-01, tissue-02) samples collected in Starrgavin Bay support this transport and exposure pathway.

Injury Determination and Quantification for Ecological Resources

Injury determination and quantification are based on available site-specific exposure data, how exposure relates to literature-based adverse effects levels, biological densities, and corresponding mortality due to exposure. As described in Chapter 2, NOAA focused the assessment of ecological resources on Pacific herring.

Injury Determination to Pacific Herring

As a result of the Tug sinking and releasing oil, Pacific herring eggs and larvae were exposed to oil as sheen, water accommodated fractions, and droplets in a plume or otherwise mixed with water. To evaluate the potential for injury to Pacific herring, exposure of larval fish to sheen and oil in water was compared to literature-based toxicity values (e.g., exposure to sheen, water accommodated fractions). Review of several technical studies concluded that when exposed to oil sheens of minimum thickness and dissolved PAHs directly below oil sheens, early life stage fish experience a mortality rate as high as

100% when exposed to UV light (Travers et al. 2015, Morris et al. 2015a, Morris et al. 2015b, NOAA 2016). However, this estimate of 100% mortality was on Gulf of Mexico species from crude oil sheen and dissolved fractions below. Herring specific mortality from bunker fuel was as high as 47% (Incardona et al. 2012).

Because herring were exposed to sheen and dissolved fractions beneath the sheen, NOAA has used the area of the sheen and the shallow mixing layer of water below the sheen (to a depth of 5m) as the metric for the volume of water containing oil and dissolved PAHs that eggs and larvae are exposed to. For the purposes of estimating injury to Pacific herring in the upper water column, NOAA assumed that herring larvae were exposed to surface sheens, as well as to entrained and dissolved oil beneath the sheen. This is consistent with documented vertical distribution and migration in Pacific herring larvae (Clay et al. 2004). Literature values indicating mortality due to sheen and oil-water mixtures are representative of the exposure and are adopted as injury thresholds. The following paragraphs provide additional details regarding oil's toxicity to fish eggs and larvae, as described in the literature, which is followed by a description of the injury quantification methods and results.

Oil Toxicity to Pacific Herring Eggs and Larvae

A review of several technical studies determined that adverse effects from oil exposure to fish, including Pacific herring, are well documented. Impacts to Pacific herring specifically, including Pacific herring from Sitka Sound, have been characterized in numerous laboratory and *in situ* studies due to the ecological importance of this species and its history of being impacted by oil spills (e.g., *Exxon Valdez* and *Cosco Busan*). Early life stages of fish, eggs and larvae, are especially sensitive to oil. Though the majority of available information is related to crude oil exposure, many of the known chemical drivers of toxicity (e.g., PAHs) are found in both crude and fuel oils. Thus, to evaluate reported impacts from crude oil exposure in the context of this spill, NOAA considered the relative toxicity of crude compared to fuel oil. Refined fuel oils are consistently reported as having higher acute toxic potential than crude oil (Anderson et al. 1974; Rice et al. 1979). As such, the use of crude oil toxicity data to inform toxicity of oil released from the Tug is likely to under-estimate the true toxicity.

Additionally, it has been demonstrated that UV light increases toxicity of oil to translucent early life stages of fish by a factor of 1.5 to greater than 100 (Barron 2017; Barron et al. 2003, 2008; NOAA 2016; Incardona et al. 2012). As such, the review of available information focused on studies that incorporated UV toxicity, or *in situ* studies that inherently included UV light. If toxicity literature was reviewed that did not account for UV light, the toxicity estimates were assumed to likely under-estimate the true toxicity. No chemical dispersants were used during response efforts, so toxicity data for chemically dispersed oil were excluded. The following provides additional details regarding studies that report mortality from exposure to sheen, water accommodated fractions, and/or whole oil:

- Barron et al. (2003) analyzed mortality of larval Pacific Herring from Sitka Sound from different exposure regimes of weathered crude oil water accommodated fractions and sunlight. They found that herring larvae exposed to various concentrations and UV scenarios experienced mortality rates ranging from 24% to 39%.

- As reported in NOAA (2016), 85% to 100% of bay anchovy, red snapper, and spotted seatrout eggs exposed directly to crude oil sheens from the *Deepwater Horizon* incident and UV in a laboratory setting died. When integrated over the upper water column (zero to 20 meters) to account for sheen toxicity and oil entrainment below the sheen, NOAA (2016) estimated a mortality rate of 21% to 45% for eggs and larvae in the open water.

- Incardona et al. (2008) reported mortality to herring eggs collected from oiled vs. non-oiled sites after the *Cosco Busan* oil spill (bunker fuel) in northern California and reared in the laboratory in clean seawater with a typical ambient light-dark exposure regime. The authors found that egg mortality for herring collected at oiled sites ranged from 56% to 76% and was statistically different relative to mortality from non-oiled sites at 16%. Additionally, of those that survived the egg stage, the authors reported larval mortality rates of 23% for exposed larvae compared to 12% for control.

- Incardona et al. (2012) exposed Pacific herring eggs to bunker oil and UV and found that mortality ranged from 6% to 91% in eggs exposed to a range of concentrations of effluent from weathered oil gravel columns, which was higher compared to controls (4% to 26%).

- Following the *Exxon Valdez* oil spill (crude oil exposure), McGurk and Brown (1996) compared egg-larval mortality rates for Pacific herring at oiled and non-oiled sites and found that mortality was greater at oiled sites than non-oiled sites.

- Following the *North Cape* oil spill (diesel fuel oil), Hughes (1999) compared egg mortality for Winter flounder at sites where there had been oiling to laboratory control egg mortality. After adjusting for the mortality in controls, Hughes found an average of 51% mortality (range 22% to 86%) of Winter flounder eggs from sites with diesel fuel oil exposure.

Further, in addition to the lethal effects described above, exposure to oil can result in a range of sublethal effects to fish including cardiotoxicity, tissue deterioration, morphological changes, genetic damage, egg yolk sac edema, inhibited swimming in larvae, and decreased growth (Incardona et al. 2012; Norcross and Brown 2001; Barron et al. 2003; Carls et al. 2002, 1999). As such, mortality estimates described above are likely to under-estimate the true impacts of exposure because sublethal effects may result in delayed mortality, reduced growth, and/or reduced reproductive output.

Injury Quantification for Pacific Herring

Injuries to Pacific herring are quantified based on estimated mortality of eggs and larvae due to exposure to oil from the Tug. It is expected that compensatory restoration projects implemented to compensate for damages will focus on reducing Pacific herring mortality due to anthropogenic impacts. For restoration scaling purpose, larval mortalities are converted to egg-equivalents using life history parameters and natural survival rates documented in the literature. Based on the information summarized in previous Chapters of this report, the following paragraphs describe the inputs required for quantifying losses.

Daily Sheen Area

As described in Chapter 3, daily sheen areas were estimated by NOAA's SDB, based on aerial imagery collected during the spill, and provided to the Trustees (see Exhibit 3.3). On one day, April 21, 2017, oil was observed in two known Pacific herring egg depositional areas for the 2017 spawn in Sitka Sound, Kasiana Islands and Battery Island. For this day, the proportion of the total sheen area presented in Exhibit 3.3 that impacted egg depositional areas was quantified as approximately 346,000 square meters (approximately 341,000 square meters around Kasiana Islands; 5,000 square meters around Battery Island).

Depth of Oil Exposure

Although NOAA did not sample along a depth profile under the oil sheens, it is known that oil is entrained by wave action, circulation, and chemical processes. Estimates of oil entrainment depth vary and have been reported to be as great as 20 meters (NOAA 2016). However, because larvae sampling did not exceed five meters, for the purposes of injury quantification for this NRDA only, NOAA assumes oil was entrained to a depth of five meters resulting in TPAH and oil droplet concentrations sufficient to cause toxicity.

Furthermore, Pacific herring larvae are positively phototactic, preferring to be at or near the water surface, and show vertical migration throughout larval development, including the yolk sac larval stage immediately after hatching (Stevenson 1962; Clay et al. 2004). It is likely that any herring larvae present in the surface mixing layer of the water column in impacted areas would come in contact with surface sheen or the entrained or dissolved oil beneath the sheen.

Pacific Herring Egg Density

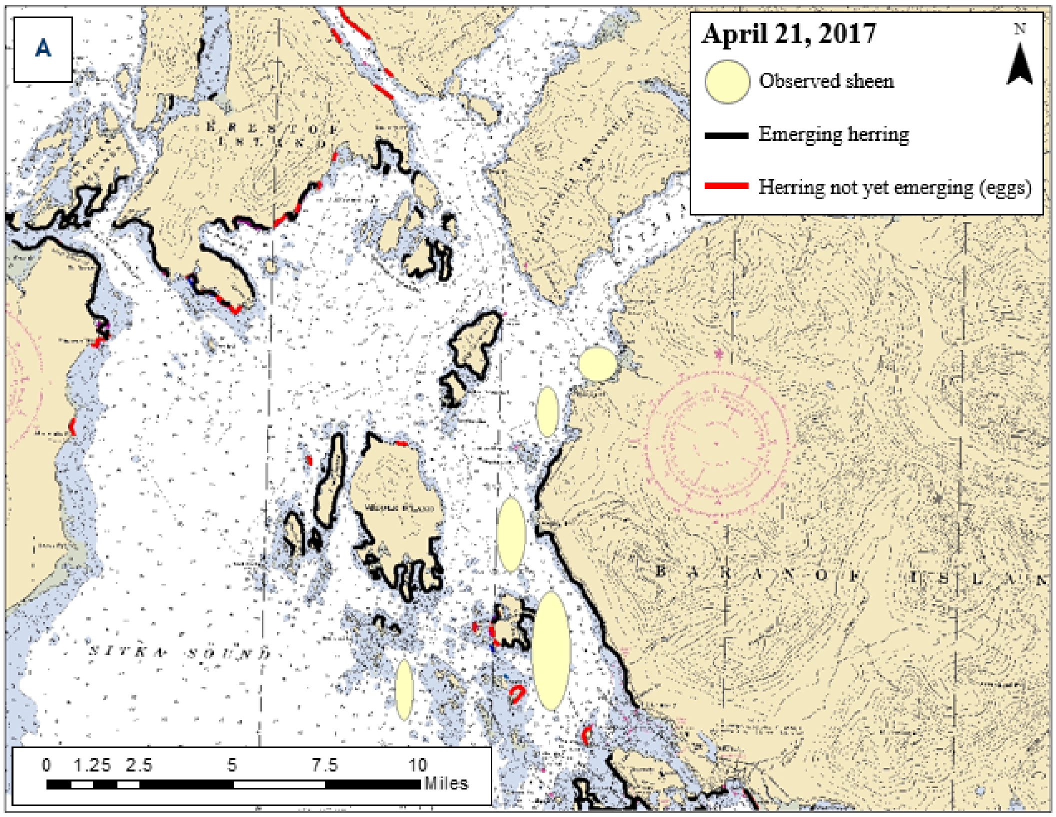
The density of herring eggs is reported in ADF&G stock assessment reports. NOAA used the actual herring egg estimates reported in the 2017 stock assessment of 521,042 eggs/m^2 (ADF&G 2017b). This estimate was further adjusted based on the area where the sheen was located, relative to spawning areas, and specifically those spawning areas where herring had/had not begun emerging. ADF&G recorded two spawning event periods: March 20-April 11 and April 12-21. At the time the spill began, herring from the earlier spawning period had mostly emerged but most eggs from the later spawning period had not yet hatched. Exhibit 4.1A demonstrates the spawning areas where eggs were emerging (black lines) and still in egg form (red lines) relative to the current sheen locations as observed by ADF&G biologists conducting overflights (ovals) and documented in aerial photos from USCG response overflights. Exhibits 4.1B and C demonstrate herring spawn events, bathymetry, and digitized sheen areas observed within egg depositional areas (April 21, 2017) around Battery Island and Kasiana Islands, respectively. Shoreline oiling was not observed in other herring spawning areas within Sitka sound.

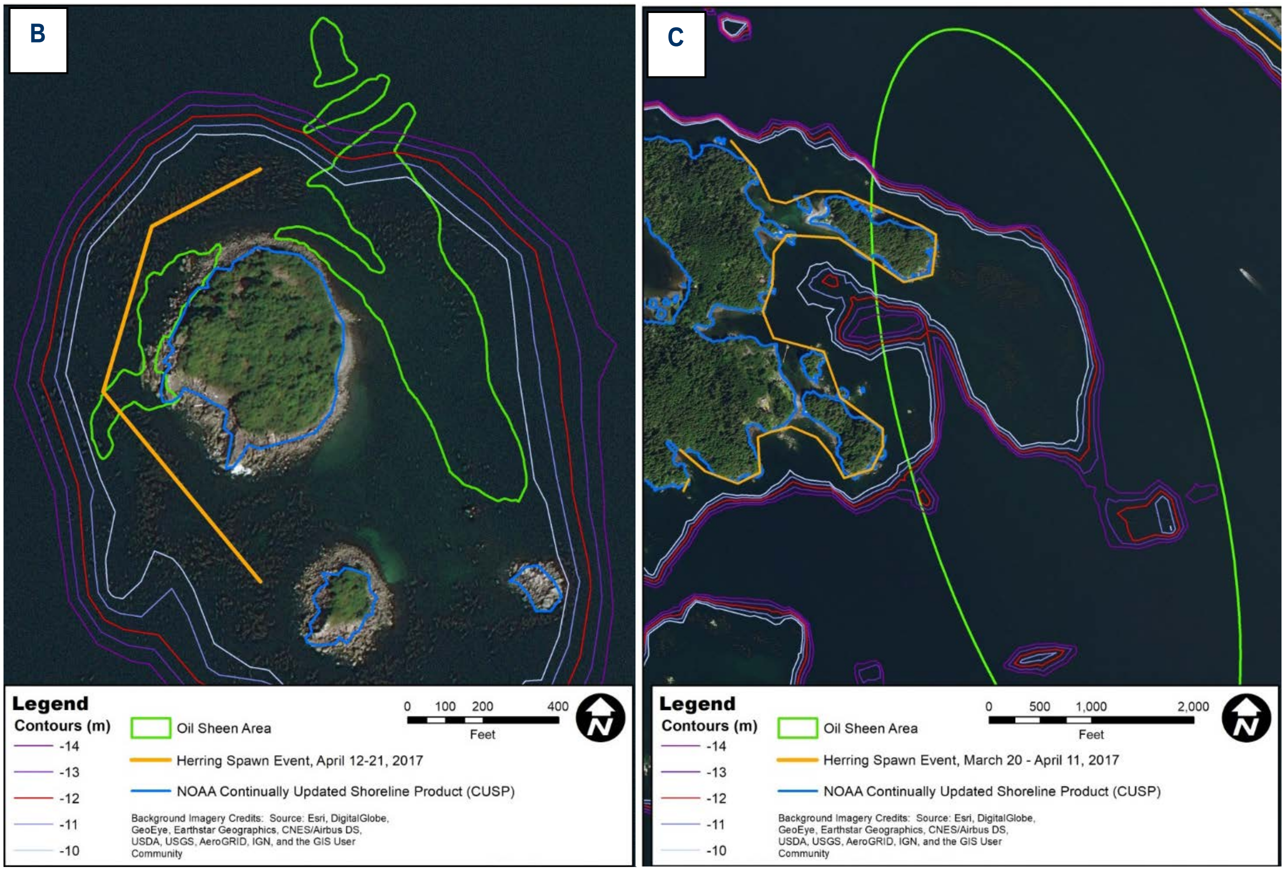
SSSC divers surveyed the eastern shoreline of Sitka Sound, south of Starrigavan Bay on April 27th and observed mostly remnants of hatched eggs from the herring spawn deposition that occurred between March 20-April 11 (ADF&G 2017b, Coonradt personal communication 2017). The March 20-April 11 spawn deposition event observed by ADF&G and the SSSC was known to extend to the waters around Kasiana Islands (Exhibit 4.1C). Based on these observations, it is likely that most of the eggs around Kasiana Islands had emerged by April 21. As such, the egg density was multiplied by 10%, assuming that approximately 90% of the eggs had emerged (i.e., “the emergent-adjusted” egg density). The emergent-adjusted egg density around Kasiana Islands is 52,104 eggs/m^2.

However, the area around Battery Island was part of a later spawning event that occurred between April 12-21 (ADF&G 2017b, E. Coonradt, personal communication, May 18, 2017; Exhibit 4.1B). Based on herring embryo development times, it is likely that most of the eggs had not emerged by April 21. As such, the egg density estimate for the waters around Battery Island is multiplied by 80%, assuming that approximately 80% of the eggs around Battery Island had not yet emerged. The emergent-adjusted egg density around Battery Island is 416,834 eggs/m^2. The egg density estimates for Kasiana and Battery Islands are based on reports, field observations, and life history information.

Exhibit 4.1 Sitka Sound April 21, 2017 Oil Sheens and Egg Locations

Oil sheen, emerging herring, and egg locations in Sitka Sound (A; image from ADF&G). Oil sheen, herring spawn, and bathymetry around Battery Island (B) and Kasiana Islands (C).





Toxicity of Oil Sheen and PAHs to Pacific Herring Eggs

As described above, numerous studies estimate toxicity of oil to fish eggs, including Pacific herring eggs. Based on NOAA's review of available information, they determined the most applicable toxicity estimates are those that expose eggs to oil sheens directly and/or to water with TPAHs and oil droplet concentrations analogous to water that would be found beneath a sheen. As such, NOAA has determined that Incardona et al. (2008) and Incardona et al. (2012) are the most applicable sources of information. For the purposes of injury quantification for this NRDA only, NOAA applies a 40% mortality rate derived from the average egg mortality reported in each of these studies (33% and 47%).

Pacific Herring Larvae Density

As described in Chapter 3, immediately following the spill, and while the release from the sunken Tug was ongoing, the SSSC collected Pacific herring larvae in the upper five meters of the water column in Sitka Sound using a Bongo plankton sampling net and estimated a range of larvae densities. For the purposes of injury quantification for this NRDA only, NOAA applies the average of the five sampling events: 126 larvae per cubic meter. Though herring larvae densities in the impacted area may have fluctuated over the course of the incident, there would have been both losses from physical transport, natural mortality, and mortality associated with the spill and gains of new individuals from physical transport and ongoing hatching. This estimate provides a reliable estimate specific to Sitka Sound, in the vicinity of the spill site, and at the time of the release.

Toxicity of Oil Sheen and PAHs to Pacific Herring Larvae

As described above, numerous studies estimate toxicity of oil to fish larvae, including Pacific herring larvae. Based on NOAA's review of available information, they determined the most applicable toxicity estimates are those that expose larvae to oil sheens directly and/or to water with TPAH and oil droplet concentrations analogous to water that would be found beneath a sheen, irrespective of the source of the oil being crude or fuel oil. As such, NOAA has determined that NOAA (2016) and Barron et al. (2003) are the most applicable sources of information. For the purposes of injury quantification for this NRDA only, NOAA applies a 31% mortality rate derived from Barron et al. (2003), which evaluated the toxicity of oil with UV to herring from Sitka Sound. This estimate is lower than the mid-point of the range reported in NOAA (2016) and is likely to under-estimate toxicity because crude oil acute toxicity is known to be lower than that for fuel oil.

Converting to Egg-Equivalents

To manage commercial and recreational fisheries, natural resources managers often rely on life history traits and life-stage specific survival estimates to determine allowable harvests. As such, because Pacific herring are commercially harvested NOAA was able to obtain the required information from publicly available reports. Specifically, Norcross and Brown (2001) report estimates of survival for eggs and post hatch larvae. Based on these values, for the purposes of injury quantification for this NRDA only, NOAA estimated for every 5.25 eggs produced one survives to become a post hatch larva.

Injury Quantification Steps

The following sections describe the injury quantification steps taken for Pacific herring eggs and larvae, respectively.

Pacific Herring Eggs

Using the estimates described above, egg losses are quantified for one day, April 21, 2017, using the following steps:

- The sheen areas for April 21, 2017 that overlapped in spawning habitat (m^2) around Kasiana Islands and Battery Island were multiplied by estimates of the density of herring eggs[3] (eggs/m^2) around Kasiana Islands and Battery Island, respectively, to produce the number of eggs exposed to dissolved and/or entrained oil below the sheen.
- The number of eggs exposed at Kasiana Islands and Battery Island were summed to produce total number of eggs exposed.
- The total number of eggs exposed is then multiplied by the lethal toxicity value (%) to produce the number of eggs killed.

To avoid double counting, because Pacific herring eggs hatch into larvae and enter the water column, impacts were assumed to last one day. That is, larval exposure and mortality is quantified separately, so this approach assumes one day of eggs being exposed (where no additional eggs are being laid) then all other exposure is to larvae. It was not necessary to convert to "egg-equivalents" because the impacts were to eggs directly. Because no impacts are expected to occur beyond 2017, the egg kill value

[3] Egg density was adjusted from that reported in ADF&G (2017b) to account for those areas where eggs had not yet begun emerging on April 21, 2017.

computed using this approach represents the 2017 value and no future losses are quantified. To discount losses that occurred in 2017 to present value (2019), a three percent discount rate was applied.

Pacific Herring Larvae

Using the estimates described above, larval losses are quantified daily using the following steps:

- The daily sheen area was multiplied by the depth of entrainment to produce a volume impacted (m^3).
- The daily volume impacted (m^3) is multiplied by the density of Pacific herring larvae (#/m^3) to produce the number of individuals exposed.
- The number of individuals exposed is then multiplied by the lethal toxicity value (%) to produce the number of individuals killed.
- The number of individual larvae killed is then multiplied by the number of eggs required to produce one larva which results in an egg-equivalent kill value.

Knowing that Pacific herring larvae were emerging across Sitka Sound from April through June and were transported by currents, NOAA assumed that on a daily basis new larvae were transported into the impacted area and came in contact with the oil sheen (i.e., a turnover rate of one-day). As such, for each day that sheen was observed (through June 13, 2017; see Exhibit 3.3), the above computation is repeated and the daily egg-equivalent kill values are summed to derive a total kill. Because no impacts are expected to occur beyond 2017, the egg-equivalent kill value computed using this approach represents the 2017 value and no future losses are quantified. To discount losses that occurred in 2017 to present value (2019), a three percent discount rate was applied.

Injury Quantification Results for Pacific Herring

Total egg-equivalent losses are the sum of losses from the day the release began until sheen was no longer observed. The sum of egg-equivalents (17.6 billion) can be added to the direct eggs killed (7.9 billion) to result in the total egg-equivalent losses resulting from the spill. The results of this quantification indicate approximately 25.5 billion egg-equivalent Pacific herring were killed in 2017 due to exposure to oil released from the Tug. Using a three percent discount rate, this represents a present value (2019) loss of 27.1 billion egg equivalents.

Injury Determination and Quantification for Human Use Resources

Injury determination and quantification are based on the timing and duration of a shellfish alert, site and state-specific data on baseline shellfish harvesting rates/trips, and shellfishing values from the economics literature. A unit-value benefits transfer methodology is used to estimate human use losses, with lost shellfishing trips multiplied by the value of a shellfishing trip to estimate total losses. As described in Chapter 2, NOAA has chosen to focus the human use assessment on shellfishing losses at Starrigavan Beach.

Injury Determination for Shellfishing

Injury determination for shellfishing is based on the timing and duration of a shellfish alert at Starrigavan Beach. On April 21, two days after the Tug sank and began releasing oil, SEATOR posted a notice on its website recommending against harvesting clams from Starrigavan Beach due to the oil spill.

Six days after the Tug sank, on April 25, ADEC posted shellfish alert signs at Starrigavan Beach access points recommending against harvesting and consuming shellfish due to the recent petroleum spill (see Exhibit 3.9). The signs were removed from Starrigavan Beach on August 10. Because shellfish are typically harvested for consumption in this area, recommendations against harvesting shellfish constitute a *de facto* shellfishing closure at Starrigavan Beach from April 21 to August 10, a period lasting 112 days.

During a portion of this 112-day closure period, a *de facto* shellfishing closure would have been in affect at Starrigavan Beach under baseline conditions due to high PSP levels. Specifically, a June 2 sample from Starrigavan Beach was tested on June 5 and found to exceed the PSP threshold of 80 milligrams per 100 grams. A PSP advisory was then posted on the SEATOR website recommending against harvesting shellfish from Starrigavan Beach due to PSP. SEATOR personnel indicated that this advisory remained in place through June 20, when follow-up testing indicated that PSP levels had declined to safe levels. In our analysis, NOAA assumes zero baseline trips to Starrigavan Beach during the entire PSP advisory period (June 5 to 20). Exhibit 4.2 shows the number of days each month that were affected by the spill-related shellfishing closure at Starrigavan Beach. During each of the impacted months in Exhibit 4.2, there were multiple days where tidal conditions were favorable for shellfishing (e.g., minus tides). Further, the lowest spring tides, considered the most favorable, especially for clamming, occurred during the alert period.

Exhibit 4.2 Starrigavan Beach Shellfishing Closure Dates

Month	Closure Dates	Closure Length (days)
April	4/21/17 to 4/30/17	10
May	5/1/17 to 5/31/17	31
June[A]	6/1/17 to 6/4/17 and 6/21/17 to 6/30/17	14
July	7/1/17 to 7/31/17	31
August	8/1/17 to 8/10/17	10
	Total	**96**

Notes:
[A]As discussed in the text, the PSP closure period (June 5 to June 20) was omitted when calculating the length of the spill-related closure in June.

Injury Quantification for Shellfishing

Lost Shellfishing Trips

As described above, Starrigavan Beach was unavailable for shellfishing for 96 days as a result of the spill. NOAA estimates lost shellfishing trips as the difference between estimated baseline use and actual use during this 96-day period. It is assumed that no shellfishing occurs during the entire 96-day period.

Information about baseline shellfishing activity at Starrigavan Beach is available from a household resource harvesting survey implemented in Sitka by ADF&G (Sill and Koster 2017). The survey involved in-person interviews conducted in February and March of 2014 with a probability sample of 212 Sitka households. Each household provided information about its use and harvest of wild resources throughout 2013. With respect to shellfishing, respondents noted all locations where household members had been shellfishing in 2013, as well as the months in which this shellfishing activity took place. This allows us to estimate the total number of Sitka households that went shellfishing at Starrigavan Beach during April, May, June, July, and August of 2013 (Exhibit 4.3).[4]

The Sill and Koster (2017) study does not provide information about the number of persons in a household participating in shellfishing trips, nor does it provide information about the total number of shellfishing trips per month for each household. As a result, NOAA's analysis uses information from shellfishing studies conducted in other locations to approximate values for these two parameters.[5] NOAA assumes 2.46 persons per shellfishing trip, averaging results reported in two shellfishing studies, one conducted in Oregon that reported 3.2 persons per trip (Dean Runyan Associates 2009) and one conducted in Cape Cod, Massachusetts that reported 1.72 persons per trip (Damery and Allen 2004).

Exhibit 4.3 Baseline Monthly Shellfishing Trips at Starrigavan Beach

Month	Proportion of Sitka households surveyed that reported shellfishing at Starrigavan Beach	Total estimated Sitka households shellfishing at Starrigavan Beach	Total estimated baseline shellfishing Trips at Starrigavan Beach
April	0.0217	64.5	392
May	0.0092	27.4	166
June	0.0040	11.8	72
July	0.0040	11.8	72
August	0.0072	21.5	131

Notes:
Source: Sill and Koster (2017) and personal communication with Lauren Sill, August 2017.
Estimated shellfishing households times 6.08 (see text for details).

NOAA assumes 2.47 shellfishing trips per month per household, relying on information reported in the Damery and Allen (2004) study as well as information from a recent shellfishing study focused on Puget Sound, Washington (Anderson and Plummer, 2016). The Anderson and Plummer (2016) study asked survey respondents to indicate which months within a typical year they were actively engaged in shellfishing for clams/oysters in Puget Sound as well as the total number of Puget Sound shellfishing trips targeting clams/oysters in the past year. Dividing the average annual shellfishing trips targeting clams/oysters (6.1) by the average number of active shellfishing months targeting clams/oysters (3.6) provides an estimate of 1.69 trips per active shellfishing month. Damery and Allen's (2004) Cape Cod survey reported 11.7 average annual shellfishing trips which, if divided by the average number of active shellfishing months reported in Anderson and Plummer (2016; 3.6), provides an estimate of 3.25 shellfishing trips per active month. Averaging the Damery and Allen (2004) and the Anderson and Plummer (2016) estimates results in an overall average of 2.47 shellfishing trips per month (2.47 = (1.69 + 3.25)/2). This assumption may under-estimate the true value because it includes winter months when shell fishers in Alaska are likely to be less active.

[4] Month-specific data on shellfishing activity at Starrigavan Beach were provided by the lead author of the report, Lauren Sill, in August 2017.

[5] For the purposes of this analysis, NOAA assumes that shellfishing trips are equivalent to shellfishing days (i.e., one trip per day). NOAA acknowledges that a small number of shellfishing households may take multiple-day shellfishing trips (or multiple trips in a single day).

Overall, the two adjustments (2.46 persons per shellfishing trip and 2.47 shellfishing trips per month) produce an expansion factor of 6.08 (6.08 = 2.46 x 2.47), which is applied to the estimates of Sitka households shellfishing at Starrigavan Beach each month to estimate baseline monthly shellfishing trips to Starrigavan (Exhibit 4.3). A value of 6.08 households may be an under-estimate because it excludes non-Sitka households and is based on studies conducted in areas outside of Alaska.

The baseline monthly shellfishing estimates for Starrigavan Beach are multiplied by the proportion of each month affected by the closure to estimate lost shellfishing trips (Exhibit 4.4). The proportion of each month affected by the closure is calculated as the number of spill-related closure days in each month (reported above) divided by the total number of days in the month. In August, for example, 10 out of 31 days, or 32% of days, were affected by the spill (i.e., August 1 to August 10).

Exhibit 4.4 Lost Shellfishing Trips at Starrigavan Beach

Month	Baseline shellfishing trips at Starrigavan Beach	Proportion of month affected by Starrigavan Beach closure	Lost shellfishing trips at Starrigavan Beach
April	392	0.33	131
May	166	1.00	166
June	72	0.47	33
July	72	1.00	72
August	131	0.32	42

Value of Lost Shellfishing Trips

Two published studies were identified that provide information about the value of a shellfishing trip. English (2010) uses a travel cost model to evaluate shellfishing trips to 11 coastal towns in southeastern Massachusetts, finding an average value of $27.51 per trip.[6] Anderson and Plummer (2017) apply a count model demand system to contingent behavior data on shellfishing trips in Puget Sound, Washington, finding at average value of $138.77 per trip. Averaging the results from these two studies, NOAA obtains an average value per shellfishing trip of $83.14. This average may under-estimate the value of shellfishing trips in Sitka sound since it is based on studies from more urban areas outside of Alaska.

Lost Human Use Results

Total shellfishing losses are calculated by multiplying the number of estimated lost shellfishing trips at Starrigavan Beach (444) by the estimated value per lost shellfishing trip from the literature ($83.14) to obtain a total estimated loss of $36,914.

This estimate of total human use losses excludes potential losses to Starrigavan Beach users who were not shellfishing (e.g., beach visitors who may have been impacted by the presence of posted advisory signs) and potential losses due to the cancellation of a school field trip to Starrigavan Beach.[7] In the case

---

[6] All values have been updated to February 2019 dollars using the CPI Inflation Calculator.

[7] On May 9, the Unified Command became aware of a school field trip planned for the May 12, 2017 by the Keet Gooshi Heen Elementary School of the Sitka School District. On May 10, the USCG Federal on Scene Coordinator met with the school's principal, Mr. Demert, and presented the

of beach users who were not shellfishing, no data are available to quantify the loss. In the case of the cancelled field trip, the losses are expected to be minimal. The estimate also excludes two days of potential beach visitor losses that may have occurred after the Tug sank but before the shellfishing advisories were officially posted. Beach visitors may have avoided the area during this period due to the presence of oil sheens and response activities. As such, the assumption applied and the results obtained are likely to under-estimate the true losses because losses to two groups were not quantified.

Injury Determination to Other Resources

Salmon fry and smolt were exposed to oil in the waters of Starrigavan Bay as they out-migrated from Starrigavan Creek into marine waters that were impacted by the spill. Based on the information gathered during the pre-assessment, NOAA chose not to quantify injuries to salmon in this NRDA.

Wildlife, such as birds and mammals, may have been oiled and injured from the spill. Field observations identified minimal impacts to wildlife. Although approaches could be developed and implemented to help further assess the likelihood of and quantify potential impacts to wildlife, NOAA believe that the compensatory restoration proposed in this document reflect reasonable compensation for natural resource damages associated with the spill.

---

shoreline assessment information so that he could make an informed decision on whether the field trip should be postponed or if an alternate site should be chosen. The Federal on Scene Coordinator did not make any statements about the safety of the shoreline, only stating that there is an ongoing incident that is being monitored by USCG. On a subsequent conference call, the State on Scene Coordinator, informed the Trustees that the field trip was cancelled.

CHAPTER 5 | RESTORATION PLANNING

The goals of restoration planning under OPA are to quantify the natural resource injuries and identify actions appropriate to restore natural resources or services to the condition that would have existed if the incident had not occurred and compensate for interim service losses. The later goal is achieved through the restoration, rehabilitation, replacement, or acquisition of equivalent natural resources and/or services (33 U.S.C. § 2706(b)). Further, the development and consideration of restoration alternatives is required to fulfill the intent of NEPA. This chapter focuses on restoration evaluation criteria, the development and evaluation of restoration alternatives, the scaling of the alternatives, the justification of preferred restoration alternatives, performance measures and monitoring, Trustee oversight, and the formulation of the final natural resource damages claim.

Restoration Strategy

The restoration planning process may involve two components: primary restoration and compensatory restoration. Primary restoration actions are designed to assist or accelerate the return of a resource, including its services, to baseline conditions (i.e., the condition that would have existed if the incident had not occurred). In contrast, compensatory restoration actions serve to compensate for the interim loss of resources and their services incurred from the time the injury began until the return of the resource to baseline conditions or service levels. The scale of a compensatory restoration project depends on the nature, extent, severity, and duration of the resource injury. Primary restoration actions that speed resource recovery reduce interim losses, as well as the amount of restoration required to compensate for those losses.

In the case of this spill, response actions undertaken following the spill were expected to protect natural resources from future harm and to allow resources to return to pre-injury conditions within a reasonable timeframe. Oil not contained and recovered was transported in the sea and degraded via natural processes or deposited on shorelines where oil recovery was either infeasible, would not result in a net benefit, and/or be cost effective. Accordingly, NOAA is not pursuing primary restoration and focus on compensatory restoration alternatives capable of restoring lost Pacific herring and lost shellfish harvesting days.

In accordance with the OPA NRDA regulations, NOAA evaluated a range of project alternatives capable of restoring lost natural resources due to the oil spill and the services they provide. Consideration of an appropriate range of alternatives also addressed NEPA requirements. To identify restoration projects capable of restoring lost Pacific herring and lost shellfishing days, NOAA consulted with local, State, and Federal governmental agencies, Tribal organizations, non-profit organizations, and stakeholders. During this process, NOAA focused on resource-to-resource approaches (i.e., approaches that would provide natural resources and/or services of the same type and quantity as those lost). Alternatively, to ensure sufficient restoration actions were available to compensate for losses, NOAA also considered restoration projects that provide natural resources and/or services of comparable type, quality, or value to those lost. Identified projects were then subjected to a screening process to narrow the field of potential projects and focus information-gathering efforts on the alternatives with the greatest potential to meet NOAA's restoration goals. Additionally, as required by OPA and NEPA regulations, a "No Action/Natural Recovery" alternative is also included for consideration.

Project Evaluation Criteria Development

NOAA adopted a two-tier approach for evaluating potential restoration projects. Tier One screening determined the project's potential to result in a quantifiable increase in the services provided by one or more of the injured resources in Sitka Sound (i.e., nexus to the injury). Tier One also evaluated whether sufficient information exists for evaluation under OPA and NEPA, scaling, costing, and implementation within a reasonable timeframe following receipt of funding.

Tier Two screening included the criteria presented in the OPA regulations and site-specific criteria adopted by NOAA. The OPA regulations (15 C.F.R. § 990.54(a)) identify the following criteria:

- Cost to carry out the alternative;
- Extent to which each alternative is expected to meet the Trustees' goals and objectives in returning the injured natural resources and services to baseline and/or compensating for interim losses;
- Likelihood of success of each alternative;
- Extent to which each alternative will prevent future injury as a result of the incident and avoid collateral injury as a result of implementing the alternative;
- Extent to which each alternative benefits more than one natural resource and/or service; and
- Effect of each alternative on public health and safety.

In addition to the six OPA criteria, NOAA adopted the following criteria to assess the appropriateness of proposed restoration alternatives:

- Compliance with site ownership and/or access requirements; and
- Opportunities to collaborate with local entities involved in restoration projects.

Project Identification and Alternative Evaluation

Potential restoration projects were identified by engaging Federal, State, Tribal, and local natural resource planners and managers. Proposed projects were reviewed by NOAA and information was gathered to determine if they met the Tier One and Tier Two criteria described above. NOAA identified and evaluated the following projects:

1. No Action/Natural recovery.
2. Pacific herring research.
3. Open- and closed-pound spawn-on-kelp activities.
4. Marine debris removal (preferred alternative for herring loss).
5. Enhance access, accessibility, and amenities for shellfish harvesting at Starrigavan beach.
6. Sustain or increase shellfish monitoring program (preferred alternative for human use).

NOAA identified other potential restoration projects that were not evaluated further after it was determined that they did not meet the tier one criteria. For example, Starrigavan Creek restoration would primarily benefit salmon and estuarine habitat but would not adequately address injuries to herring or shellfish harvesting. Classroom education, support for the Sitka Herring Festival, and maintenance of the boardwalk trail in the Starrigavan estuary were all projects with a strong educational component, but they were not thought to result in a quantifiable increase in the services provided by the resources that were injured by the spill. There was not sufficient information to evaluate and/or scale the impact of invasive species monitoring or removal.

The following table summarizes how each restoration project was evaluated based on the criteria described in the preceding section.

Exhibit 5.1 Evaluation of Restoration Projects

Criteria	No Action/ Natural Recovery	Pacific herring research	Spawn on kelp activities	Marine debris removal	Starrigavan beach access & amenities	Shellfish monitoring program
Quantifiable increase in services provided by injured resource(s)	No	No	Yes	Yes	Yes	Yes
Sufficient information for evaluation, scaling and costing	N/A	No	Yes	Yes	No	Yes
Implementation in a reasonable timeframe	N/A	Yes	Yes	Yes	No	Yes
Cost	Lowest	High	Medium	Medium	High	Low
Meets Trustee restoration goals	No	No	No	Yes	No	Yes
Likelihood of success	N/A	Medium	Medium	High	High	High
Prevent future injury from spill/avoid collateral injury from implementation	No/Yes	No/No	No/No	No/Yes	No/No	No/Yes
Benefits more than one natural resource and/or service	No	No	No	Yes	Yes	No
Effect on public health and safety	None	None	None	Positive	Positive	Positive
Compliance with site ownership and access	N/A	N/A	Not Evaluated	Yes	Not Evaluated	Yes
Opportunity to collaborate with local entities	N/A	Yes	Yes	Yes	Yes	Yes
Determination				Preferred		Preferred

The following sections discuss each alternative that was evaluated in more detail.

Alternative 1: No Action Alternative/Natural Recovery

Under the No Action alternative, no restoration, rehabilitation, replacement, or acquisition actions would occur. This alternative costs the least because no action would be taken. If selected, there would be no restoration or replacement of the lost resources and their services and the public would not be made whole for past injuries from the Tug. Thus, the No Action Alternative is not a preferred alternative since it does not meet the tier one criteria and compensatory restoration is required.

Alternative 2: Pacific Herring Research

ADF&G and other State and Federal agencies and groups (e.g., the Prince William Sound Science Center) maintain long-term research initiatives to inform Pacific herring fisheries management decisions. Such research efforts provide a myriad of benefits that include providing robust data sets on which to base management decisions, information to fill important data gaps, and public outreach. However, NOAA has determined that such research efforts, while important, will not result in quantifiable benefits in terms of herring egg-equivalents, would likely not benefit the specific Pacific herring population harmed, and there is insufficient information for scaling purposes. Alternative 2 did not meet the tier one screening criteria and is therefore not a preferred alternative.

Alternative 3: Open- and Closed-Pound 'Spawn-on-Kelp' Activities

In Southeast Alaska, several "spawn-on-kelp" fisheries exist for the purpose of harvesting Pacific herring eggs. Such fisheries deliberately place kelp fronds and hemlock branches in the water during the herring spawn and the deposited eggs are then harvested. An open-pound fishery involves placing a floating structure with kelp and/or branches in areas where Pacific herring normally spawn. A close-pound fishery involves releasing sexually mature herring into a net with suspended kelp/branches. In both cases the eggs are harvested for human consumption. However, for the purposes of restoration in the context of this spill, NOAA considered deploying such floating structures and not harvesting the eggs, allowing them to mature and hatch. Although such an action is conceptually possible, to the best of the NOAA's knowledge, Pacific herring are not egg-substrate limited. That is, adding substrate for eggs to attach to would not be restoring the losses because those eggs would have adhered to another natural substrate. Further, such a project could cause ecological impacts since it would remove eggs from the natural environment and prevent predation (i.e., a food source for birds and invertebrates would be removed). Alternative 3 met tier one and some of the tier two criteria (see Exhibit 5.1), but did not meet NOAA's restoration goals, had the potential to cause minor collateral damage to other natural resources, and did not benefit other resources, services or public health and safety. As such, Alternative 3 is not a preferred alternative.

Alternative 4: Marine Debris Removal (Preferred Alternative)

This project would remove marine debris from beaches adjacent to Pacific herring spawning habitat in Sitka Sound, reducing impacts to herring eggs and herring egg habitat due to abrasion, smothering, contamination, and changes in the physical and chemical composition of sediments and beaches that are attributable to marine debris (Carson et al. 2011; NOAA 2014). Abrasion and smothering by marine debris can result in the eggs directly being killed or egg habitat impaired, and physical forces such as altered sediment regimes can result in indirect impacts that ultimately reduce the survival rates of Pacific herring eggs (Griffin et al. 2009). As such, the removal of marine debris would result in reductions of these metrics and the outcome would result in Pacific herring eggs not killed due to impacts from marine debris.

Although Southeast Alaska is sparsely populated compared to the continental United States, marine debris is found in great quantities (Alaska Marine Stewardship Foundation 2014). Due to ocean currents and shipping traffic routes, it is not uncommon to find debris from as far away as Asia, in addition to locally used items. Commonly found items in Sitka Sound include fishing nets (gill and trawl), buoys and floats, rope, assorted plastics, commercial packaging materials, and metal (SSSC 2016). Such debris can have a myriad of ecological and social impacts.

Impacts relevant to this NRDA and the scaling approach described below include smothering and abrasion and altered physical process (e.g., siltation, wave action). For example, crab pots that settle on

SAV are known to smother underlying SAV (Uhrin et al. 2005; Uhrin and Schellinger 2011) and it is likely that other forms of marine debris have similar effects. Further, as marine debris is mobilized, further impacts to SAV may occur that would impact Pacific herring eggs (e.g., abrasion). Herring eggs are present in the subtidal zone at the same time that extreme spring tides occur, which means that remobilization of marine debris deposited on beaches is more likely. Collectively, smothering and abrasion can result in direct impacts to herring eggs causing eggs to become damaged and/or dislodged. It is also likely that the existence of marine debris in tidal areas results in localized changes to wave actions and siltation as waves and currents interact with the marine debris and such processes (e.g., siltation) can result in impacts to Pacific herring eggs.

Over the last decade, there have been numerous surveys to quantify the types and amount of marine debris along Alaska's shoreline and numerous removal programs have been implemented. Further, specific to Sitka Sound, the SSSC in collaboration with NOAA's Marine Debris Program successfully implemented a project from 2014 to 2016 to remove marine debris from areas around Sitka, including areas in the vicinity of this oil spill. The outcomes of the SSSC project provide information that can be used to quantify, scale, and cost a restoration project aimed at removing marine debris from Sitka Sound. In addition, NOAA has consulted with the SSSC and determined that the SSSC is willing and able to plan and implement such a project should funding be available.

Alternative 4 meets the tier one criteria; it has a nexus to the injury to Pacific herring and sufficient information exists to evaluate this project under OPA and NEPA, scale it to the injury, and generate cost estimates. This project also performs well when evaluated using the tier two criteria (see Exhibit 5.1). It would meet NOAA's restoration goals, has a high likelihood of successful implementation in a reasonable timeframe, is cost effective, and provides an opportunity to collaborate with local entities. In addition, it may benefit other natural resources and services in the spill impacted area and could have a positive effect on public health and safety. As such, marine debris removal is a preferred restoration alternative.

Alternative 5: Enhance Access, Accessibility, and Amenities for Shellfish Harvesting at Starrigavan Beach

Starrigavan Beach is an important shellfish harvesting site because it is the only road-accessible beach for the community of Sitka to harvest shellfish such as clams. There is access to shellfish harvesting beaches on Starrigavan Bay and Starrigavan Creek with amenities including parking, picnic areas, restrooms, and camp sites. Current access on the Bay side includes 11 parking spots, four picnic areas, four restrooms, and three camping spots (there are 15 additional parking spots for the camp sites and some picnic shelters). On the Starrigavan Creek side, there are 12 parking spaces with no restroom. Additionally, there are no Americans with Disabilities Act (ADA) compliant parking spaces or access ramps to the beaches. This project would restore for lost shellfishing days by providing increased access, accessibility, and amenities.

For the purposes of restoration in the context of this spill, NOAA considered improving access by adding parking spaces (including ADA compliant spaces), enhancing accessibility by providing two ADA compliant beach access points, and constructing additional amenities such as restrooms on the Starrigavan Creek side.

NOAA did not have sufficient information to evaluate the impact that enhanced access, accessibility, and amenities at Starrigavan Beach would have on human uses of resources impacted by the spill, including shellfish harvesting. Furthermore, considering tier two criteria, implementing these improvements (e.g., parking, restrooms, walkways) would be cost prohibitive and would cause collateral ecological impacts associated with removing earth and biota (e.g., trees) and potentially contributing to runoff and suspended sediment loading. As such NOAA determined that Alternative 5 is not a preferred alternative.

Alternative 6: Shellfish Monitoring (Preferred Alternative)

In consultation with SEATOR and based on discussions with community leaders, NOAA determined that shellfish harvesting is avoided when there is uncertainty about the safety of food sources. In particular, Tribal and rural residents may choose not to harvest shellfish when PSP monitoring does not occur because harvesters are concerned for their health. Uncertainty in the safety of the food source leads to reduced number of people willing to risk harvesting and PSP monitoring is a way to reduce this uncertainty. There are opportunities to sustain and/or expand the SEATOR shellfish monitoring program, including testing for PSP and other toxins, and SEATOR is willing and able to do so should funding be available. Increasing shellfish monitoring would result in an increase in the number of trips taken because harvesters would have more confidence that they are harvesting shellfish not containing dangerous toxins, thus replacing those trips lost due to the shellfish alerts that were posted during and after the spill.

Based on a review of available information, NOAA has determined that sufficient information exists to evaluate this shellfish monitoring project under OPA and NEPA. Alternative 6 meets the tier one criteria and performs well when evaluated against the tier two criteria (see Exhibit 5.1). It has a high likelihood of being successfully implemented and meeting NOAA's restoration goals. Furthermore, it is a cost effective project that is unlikely to cause collateral injury and would have a positive impact on public health and safety. As such, shellfish monitoring is a preferred restoration alternative.

Preferred Restoration Alternatives Scaling

The two preferred restoration projects identified by NOAA are scaled to compensate for injuries to Pacific herring and lost human uses resulting from the spill, as described and quantified in Chapter 4.

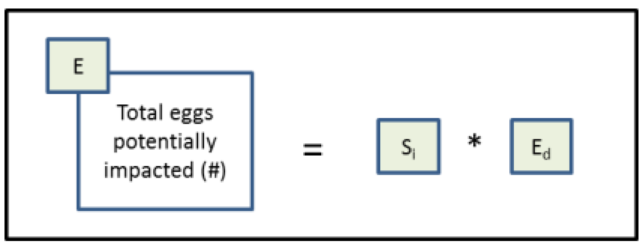
Marine debris removal (Alternative 4) Scaling

NOAA determined that approximately 27.1 billion Pacific herring egg-equivalents were killed (present value, 2019) due to exposure from oil released from the Tug (see Chapter 4). To compensate for these losses, the preferred restoration project removes marine debris from shoreline areas adjacent to Pacific herring spawning habitat to reduce the number of eggs potentially killed due to marine debris-related smothering, abrasion, and altered physical parameters. To estimate the number of eggs not killed due to marine debris removal, for the purposes of this assessment only, NOAA reviewed available information and developed the quantification approach as follows:

Whereby:

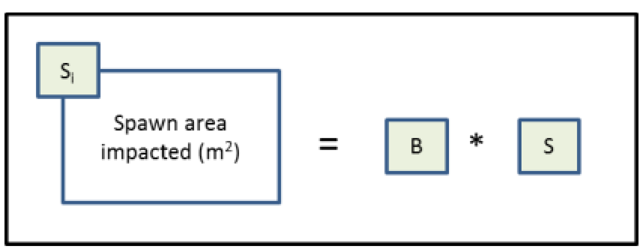
- I is the percent of Pacific herring eggs killed from marine debris due to abrasion, smothering, wave actions, and siltation due to presence of marine debris (noted as MD in equations) on the beach adjacent to spawn depositional areas. For the purposes of this assessment only, based on a review of available information on the impacts of anthropogenic activities on SAV habitat, NOAA assumed 50 percent of potentially impacted eggs are killed due to marine debris impacts (e.g., Eriksson et al. 2004).

- E is the total number of eggs potentially impacted, which is quantified based on the spawn area impacted (S_i) multiplied by the average egg densities (E_d). Future egg density is estimates as the geometric mean[8] of the past nine years of egg density data from herring stock assessments, as reported by ADF&G (2009, 2012a, 2012b, 2013, 2014, 2015, 2016, 2017b, 2017c):



Whereby:

- S_i is the spawn area impacted (m^2) which is estimated based on the percent of beach area cleared (B) multiplied by the area of egg depositional habitat parallel to the beach cleared (S; m^2):



[8] The geometric mean of the data was selected due to the distribution of the data (i.e., the data are left skewed). The use of the arithmetic mean would result in higher predicted future egg densities and thus lower damages due to increased benefits resulting from marine debris removal. Such a reduction in damages would be on the order of approximately 10%.

Whereby:

- S is the area of assumed herring spawning habitat adjacent to the beach where marine debris removal efforts were conducted (m^2). This is calculated by multiplying the length of the beach surveyed and cleaned (B_{LC}; m; reported in SSSC 2016) by the assumed width of spawning habitat from the shoreline (S_{HW}; 61 m). S_{HW} represents the assumed adjacent marine area suitable for eggs based on the average egg survey transect lengths reported by ADF&G from the past nine years of egg surveys in Sitka Sound (ADF&G 2009, 2012a, 2012b, 2013, 2014, 2015, 2016, 2017b, 2017c).

$$\underbrace{S}_{\text{Area of potential adjacent herring spawning habitat}} = B_{LC} * S_{HW}$$

Whereby:

- B is the percent of beach area cleared, which is calculated based on the footprint (F; m^2) of marine debris removed divided by a porosity factor (P; %) and divided by the total beach area (A_B; m^2; reported in SSSC 2016). Of note, this footprint (F) is that of a solid unit which NOAA knows is not the case because, for example, gill nets are porous. The porosity of an item expands the item's area of impact because the more porous an item is the greater its surface-to-volume ratio, which increases the total area in contact with the surrounding environment. As such, NOAA applies a porosity factor of 1.3 percent as derived in Appendix D. A porosity factor of 1.3 percent likely over-estimates the true footprint because it is based on the porosity of fishing nets, the most porous items found on the beach. Thus, this estimate is likely to ultimately over-estimate the benefits of marine debris removal because not all items on the beach are as porous as fishing nets.

$$\underbrace{B}_{\text{\% of beach area cleared}} = \frac{\;\frac{F}{P}\;}{A_B}$$

Whereby:

- F is the footprint of marine debris removed (m^2), which is calculated by the volume of marine debris removed (V; m^3) divided by an assumed average height of marine debris (H_{MD}; m). The estimated height of 0.08 m (3 inches) may over- or under-estimate the height of marine debris found on the shorelines of Sitka Sound.

$$\underbrace{F}_{\text{Footprint of MD removed } (m^2)} = \frac{V}{H_{MD}}$$

Whereby:

- V is the volume of marine debris removed (m^3) from the SSSC (2016) project, which is calculated by the sum of volumes for each marine debris category (V_C; m^2).

$$\underbrace{V}_{\text{Volume of MD } (m^3)} = \sum V_C$$

Whereby:

- V_C is the volume (m^3) of marine debris removed for a specific marine debris category (e.g., fishing line, trawl net, gill net, metal, plastic bottles), which is calculated by the sum of all the weights removed for each debris category (W; lbs; reported in SSSC 2016) divided by an assumed density of the category material (D; lbs/m^3).

$$\underbrace{V_C}_{\text{Volume of MD by category } (m^3)} = \frac{W}{D}$$

Whereby:

- Weight of marine debris removed by category (W) is calculated as the total weight of marine debris removed across all beaches and years as reported in SSSC (2016).

- Density (D) for each marine debris category was obtained as commonly reported for engineered materials (i.e., for net categories, an assumed density of 1.2 grams per cm^3 for nylon fishing line [converted to pounds per m^3] was applied; Appendix C). These assumed densities may over- or under-estimate the actual densities of individual marine debris items.

The assumptions presented above are for the purposes of this assessment only.

Using the methodology described above, NOAA estimates that a marine debris removal project similar in scale to that reported in SSSC (2016) would result in approximately 16.4 billion eggs not killed (Exhibit

5.2). Due to the frequency of marine debris in Alaskan waters and the need to continuously monitor and remove debris, the benefits of the removal program to Pacific herring eggs would be for one spawning year. That is, the benefits of the project will accrue in the year of implementation only. This assumption is consistent with the literature and other marine debris removal programs (e.g., Gulf States Marine Fisheries Commission 2015).

As such, a marine debris removal project that surveys and clears approximately 41.5 km (25.8 miles) of beaches that are adjacent to herring spawning habitat in Sitka Sound would compensate the public for the 27.1 billion egg-equivalents lost (present value, 2019). This equates to approximately 17.9 thousand kg of marine debris being removed. NOAA assumes that the marine debris removed by the restoration project will be similar in composition and distribution to what was reported by the SSSC in 2016 and that survey and removal methods will be comparable.

Exhibit 5.2 Marine Debris Removal Benefits Quantification and Scaling

Input	Equation Symbol	Value*	Source
Total volume of marine debris (m^3)	V	17.3	Estimated based on weights reported in SSSC (2016) and assumed densities
Assumed marine debris height (m)	H_{MD}	0.08	Trustee estimate based on personal observations/communications
Footprint of marine debris (m^2)	F	227	Calculated
Porosity Factor (%)	P	1.3	Estimated based on assumed porosity of fishing nets
Area of beach surveyed and cleared (m^2)	A_B	564,595	SSSC (2016)
Percent of beach cleared	B	3.1	Calculated
Beach length (m)	B_{LC}	25,157	SSSC (2016)
Spawning habitats width (m)	S_{HW}	61	ADF&G 2009, 2012a, 2012b, 2013, 2014, 2015, 2016, 2017b, 2017c
Area of Spawn habitat (millions of m^2)	S	1.53	Calculated
Egg Density (eggs per m^2)	E_D	693,317	ADF&G 2009, 2012a, 2012b, 2013, 2014, 2015, 2016, 2017b, 2017c
Impacted spawn habitat (m^2)	Si	47,328	Calculated
Total eggs potentially impacted (billion)	E	32.8	Calculated
Percent of eggs killed (%)	I	50	Trustee assumption based on available literature
Eggs not killed (billion) resulting from the example project	E_{NK}	16.4	Calculated
Required length of beach surveyed and cleared to compensate for 27.1 billion egg-equivalents (km)	-	41.5	Calculated
Approximate weight of Marine Debris removed (thousand kg)	-	17.9	SSSC (2016)
*Values may not sum due to rounding			

Shellfish Monitoring (Alternative 6) Scaling

Consistent with the NRDA regulations (15 C.F.R. § 990.53(d)(3)(ii)) and standard NRDA practice, NOAA employs a value-to-cost approach to determine adequate compensation. A value-to-cost approach selects a restoration project(s) such that the total cost of the project(s) is equal to the total value lost. Such an approach is often employed when the cost and or time of pursuing alternative scaling methods are not cost-effective and/or feasible (NOAA 2002; FWS 2012). The injury assessment utilized a unit value benefits transfer methodology to estimate the dollar value of the lost trips and thus NOAA would provide the full $36,914 to SEATOR to sustain and/or expand their shellfish monitoring program.

Performance Measures, Monitoring, and Adaptive Management

As promulgated by the NRDA regulations (15 C.F.R. § 990.55), a restoration plan must include "*monitoring for documenting restoration effectiveness, including performance criteria that will be used to determine the success of restoration or need for interim corrective action*." As such, when developing the Restoration Implementation and Monitoring Work Plan for this NRDA, NOAA will identify performance measures and establish a monitoring plan that identifies adaptive management procedures should the scaling assumptions and/or performance measures not be met. NOAA anticipates performance measures including, but not being limited to, miles of beach surveyed for marine debris, miles of beach cleared of marine debris, and/or weight of marine debris cleared for the Pacific herring restoration project. Performance measures for restoration of lost human use may include, number of shellfish samples collected/analyzed for PSP, and number of sample results posted online. Additionally, NOAA will consider adequate public outreach (e.g., fact sheets, community meetings) a performance measure. Adaptive management may include additional clearing of marine debris, implementation of new shellfish monitoring regimes, and further public outreach.

CHAPTER 6 | ENVIRONMENTAL IMPACTS OF RESTORATION ALTERNATIVES

This chapter addresses the potential overall impacts and other factors to be considered under NEPA regulations. NEPA requires that the environmental impacts of a proposed federal action be considered before implementation. Generally, when it is uncertain whether an action would have a significant impact, federal agencies would begin the NEPA planning process by preparing an environmental assessment (EA). Federal agencies may then review public comments prior to making a final determination. Depending on whether an impact is considered significant, an environmental impact statement (EIS) or a final Finding of No Significant Impact (FONSI) would be issued.

Restoration Alternative Evaluation Criteria

In undertaking their NEPA analysis, NOAA evaluated the potential significance of proposed actions, considering both context and intensity. For the actions considered in this draft DARP/EA, the appropriate context for considering potential significance of the action is at the local or regional level, as opposed to national, or worldwide. This draft DARP/EA is intended to accomplish NEPA compliance by:

1. Summarizing the current environmental setting of the proposed restoration,
2. Describing the purpose and need for restoration action,
3. Identifying alternative actions, assessing the preferred actions' environmental consequences, and
4. Providing opportunities for public participation in the decision process.

The environmental setting for these restoration projects is the same as the affected environment (described in Chapter 2) where the incident occurred in Sitka Sound, Sitka, Alaska. The purpose and need for restorative actions are to compensate the public for injuries to natural resources and services (lost Pacific herring and lost shellfish harvesting days) incurred from the time the injury began until the return of the resource to baseline conditions or service levels (described in Chapter 5). The alternative actions are described in Chapter 5, with their environmental consequences described in this chapter. This draft DARP/EA is designed to allow NOAA to meet the public involvement requirements of OPA and NEPA concurrently.

NEPA regulations (40 C.F.R. § 1508.27) require consideration of ten factors in determining significance of a proposed action:

1. Likely impacts of the proposed project.
2. Likely effects of the project on public health and safety.
3. Unique characteristics of the geographic area in which the project is to be implemented.
4. Controversial aspects of the project or its likely effects on the human environment.
5. Degree to which possible effects of implementing the project are highly uncertain or involve unknown risks.
6. Effect of the project on future actions that may significantly affect the human environment.

7. Possible significance of cumulative impacts from implementing this and other similar projects.
8. Effects of the project on National Historic Places, or likely impacts to significant cultural, scientific, or historic resources.
9. Degree to which the project may adversely affect endangered or threatened species or their critical habitat.
10. Likely violations of environmental protection laws.

The above factors were evaluated in concert with the applicable law, statutes, and regulations in Chapter 7 to determine the impacts of each potential restoration project.

NEPA Analysis

This draft DARP/EA describes and compares the potential impacts of the proposed action and alternatives, including the No Action alternative. In particular, this draft DARP/EA analyzes the potential direct, indirect, and cumulative ecological, social, cultural, and economic impacts associated with the alternatives.

The following definitions were generally used to characterize the nature of the various impacts evaluated with this EA:

> **Short-term or long-term impacts**. These characteristics are determined on a case-by-case basis and do not refer to any rigid time period. In general, short-term impacts are those that would occur only with respect to a particular activity or for a finite period. Long-term impacts are those that are more likely to be persistent and chronic.
>
> **Direct or indirect impacts.** A direct impact is caused by a proposed action and occurs contemporaneously at or near the location of the action. An indirect impact is caused by a proposed action and might occur later in time or be farther removed in distance but still be a reasonably foreseeable outcome of the action. For example, a direct impact of erosion on a stream might include sediment-laden waters in the vicinity of the action, whereas an indirect impact of the same erosion might lead to lack of spawning and result in lowered reproduction rates of indigenous fish downstream.
>
> **Minor, moderate, or major impacts.** These relative terms are used to characterize the magnitude of an impact. Minor impacts are generally those that might be perceptible but, in their context, are not amenable to measurement because of their relatively minor character. Moderate impacts are those that are more perceptible and, typically, more amenable to quantification or measurement. Major impacts are those that, in their context and due to their intensity (severity), have the potential to meet the thresholds for significance set forth in Council of Environmental Quality (CEQ) regulations (40 C.F.R. § 1508.27) and, thus, warrant heightened attention and examination for potential means for mitigation to fulfill the requirements of NEPA.
>
> **Adverse or beneficial impacts.** An adverse impact is one having adverse, unfavorable, or undesirable outcomes on the man-made or natural environment. A beneficial impact is one

having positive outcomes on the man-made or natural environment. A single act might result in adverse impacts on one environmental resource and beneficial impacts on another resource.

Cumulative impacts. CEQ regulations implementing NEPA define cumulative impacts as the "impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." (40 C.F.R. § 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time within a geographic area.

After considering NEPA requirements, NOAA believes that the preferred projects proposed in this draft DARP/EA would not cause significant negative impacts to the environment, or to natural resources or the services they provide. Further, NOAA does not believe the preferred project alternatives would adversely affect the quality of the human environment or pose any significant adverse environmental impacts. Instead, marine debris removal would restore habitat and benefit aquatic species by restoring suitable spawning habitat. Likewise, the proposed restoration actions would provide positive benefits for human recreational use by potentially increasing herring spawning habitat and survivability of herring. Additionally, increased PSP monitoring will provide positive benefits to individual, commercial, and non-commercial shellfish harvesters. A summary of the NOAA's analysis for the preferred and non-preferred alternatives is located below.

Alternative 1: No Action Alternative/Natural Recovery

NEPA requires NOAA to consider a "no action" alternative, and the OPA regulations require consideration of the "natural recovery" option. These alternative options are equivalent. Under this alternative, NOAA would take no direct action to restore injured natural resources or compensate for lost services pending natural recovery. Instead, NOAA would rely on natural processes for recovery of the injured natural resources. While natural recovery would occur over varying time scales for the injured resources, the interim losses suffered would not be compensated under the No Action alternative.

The principal advantages of this approach are the ease of implementation and low cost. This approach relies on the capacity of ecosystems to "self-heal." OPA, however, clearly establishes Trustee responsibility to seek compensation for interim losses pending recovery of the natural resources. This responsibility cannot be addressed through a "no action" alternative. NOAA has determined that there will be no primary restoration for injuries resulting from this incident and that the No Action alternative is rejected for compensatory restoration, as it does not meet the purpose and need for action. Losses were suffered and impacts continued during the period of recovery from this spill and technically feasible, cost-effective alternatives exist to compensate for these losses.

Although the No Action alternative was rejected, NEPA requires that the direct, indirect, and cumulative impacts be addressed. In comparison to the preferred alternatives, this alternative would have no direct or indirect adverse impacts to physical and biological resources or socioeconomics. However, there would be no direct and indirect beneficial ecological and socioeconomic impacts. There would be no cumulative impacts from this alternative.

Alternative 2: Pacific Herring Research

This alternative would increase research on Pacific herring. This alternative would collect data on Pacific herring, and as such, it would have no direct, short or long-term adverse or beneficial impacts to physical and biological resources, or socioeconomics. There would be no direct, local or regional, short or long-term cumulative impacts to physical, biological, or socioeconomic resources from this alternative. There is potential for indirect beneficial impacts to Pacific herring and related socioeconomics associated with improved management based on knowledge gained from research.

Alternative 3: Open- and Closed-Pound 'Spawn-on-Kelp' Activities

This alternative would provide Pacific herring spawning habitat by adding temporary floating structures for eggs to adhere to. Spawning habitat is close to the shoreline and consists of kelp and other SAV. There may be direct and indirect, short-term, minor adverse impacts to the physical and biological resources (e.g., substrates, aquatic vegetation, air quality) from disturbances due to boating and installation (mooring) of the structures during construction and removal. Further, the removal of eggs from the natural environment may cause direct short-term, minor adverse impacts on the birds, invertebrates and other biological resource that are prevented from consuming the eggs. Pacific herring are not egg-substrate limited in Sitka Sound, so the overall direct and indirect impacts would be minor and beneficial to herring and possibly other marine resources that prey on herring. There is the potential for short-term, minor, beneficial impacts to socioeconomics resulting from increased job opportunities during implementation. There would be no local or regional, short or long-term, cumulative impacts to physical, biological, or socioeconomic resources from this alternative.

Alternative 4: Marine Debris Removal (Preferred Alternative)

This alternative would remove marine debris from beaches adjacent to Pacific herring spawning habitat, resulting in Pacific herring eggs not being killed. This alternative would include accessing beaches and removing debris by water (i.e., vessel) or land. There would be direct and indirect, short-term, minor adverse effects to physical (e.g., water quality) and biological (e.g., nearshore and shoreline vegetation) resources from increased vessel and/foot traffic and debris removal in the vicinity, which can disturb substrates and increase turbidity. Additional short term, minor disturbances may result from decreased air quality in the vicinity of the vessel used to access remote locations and, as well as a temporary increase in the presence of people and anthropogenic noise in these areas. There would be direct and indirect, long-term, beneficial impacts to the biological environment (aquatic vegetation, fish, marine invertebrates, birds, and marine mammals) from removing harmful marine debris. There may be indirect, short and long-term, beneficial impacts to socioeconomics from short-term jobs and increasing recreational opportunities. There may be local and regional, long-term, moderate beneficial cumulative impacts on biological resources (e.g., Pacific herring, other fish, birds, marine mammals) from increased marine debris removal projects. Further, for the purposes of removing marine debris to reduce adverse impacts to marine biota and environments, under NEPA, NOAA has conducted an environmental review and promulgated a Programmatic Environmental Assessment which concluded that activities to reduce marine debris impacts "will not significantly impact the quality of the human environment"[9]

Alternative 5: Enhance Access, Accessibility, and Amenities for Shellfish Harvesting at Starrigavan Beach

This alternative would enhance access and accessibility for shellfish harvesting at Starrigavan Beach which would potentially increase the number and quality of trips taken to harvest shellfish by increasing the available parking, ADA accessibility, and restroom facilities. Because this alternative includes construction, it would have direct and indirect, short-term and long-term, minor to moderate, adverse effects on physical and biological resources, including air and water quality and terrestrial vegetation and wildlife. Construction activities such as excavation in the terrestrial environment would result in the conversion of forest and uplands habitats to impervious surfaces. In the short-term, construction activities would increase runoff and sediment transport to waterbodies, although best management practices (e.g., silt screens) could be implemented to minimize these impacts. Long-term impacts from these improvements would be increased stormwater runoff from increased impervious surfaces, which could adversely impact the shellfish, which are filter feeders, and the quality of those shellfish for human consumption. Indirect effects of the improvements could include increased vehicle and foot traffic, which could have short and long-term minor adverse impacts to physical and biological resources in the coastal uplands, shoreline, and intertidal areas. Additional indirect effects could include short and long-term beneficial impacts to socioeconomics from increased recreational opportunities. There are potential short and long-term adverse cumulative impacts to local or regional biological resources when this alternative is added to other development projects that increase impervious surfaces or human activity.

Alternative 6: Shellfish Monitoring (Preferred Alternative)

This alternative would increase shellfish monitoring for PSP, which would potentially increase the number of trips taken to harvest shellfish by reducing uncertainty about the safety of the food. Because the monitoring will require collection of shellfish samples, the monitoring proposed would have direct, short-term, minor adverse impacts to shellfish. Indirect effects of increased shellfish harvesting could have short and long-term minor adverse impacts to physical (e.g., intertidal substrates) and biological (e.g., marine invertebrates and birds) resources from increased foot traffic and harvest activities. Indirect effects could include short and long-term beneficial impacts to socioeconomics from increased recreational opportunities. There may be long-term moderate beneficial cumulative impacts due to increased recreational opportunities, and minor adverse cumulative impacts due to increased shellfish harvesting.

[9] https://marinedebris.noaa.gov/sites/default/files/mdp_pea.pdf

CHAPTER 7 | COORDINATION WITH APPLICABLE REGULATIONS AND AUTHORITIES

OPA and its regulations provide the basic framework for natural resource damage assessment and restoration for oil discharges. NEPA sets forth a specific process of impact analysis and public review and requires the Trustees comply with other applicable laws, regulations, and policies at the federal, state, and local levels. This chapter describes the primary laws, regulations, and policies that NOAA must comply with at federal, state, and local levels. NOAA will have complied with all laws, regulations, and policies described below prior to the implementation of the preferred alternative(s).

Key Statutes, Regulations, and Policies

Oil Pollution Act of 1990 (OPA)

OPA (33 U.S.C. §§ 2701 *et seq.*; 15 C.F.R. Part 990) establishes a liability regime for oil spills that injure or are likely to injure natural resources and/or the services that those resources provide to the ecosystem or humans. Federal and state agencies and Indian tribes act as Trustees on behalf of the public to assess the injuries, scale restoration to compensate for those injuries and implement restoration. Section 1006(e)(1) of OPA (33 U.S.C. § 2706(e)(1)) requires the President, acting through the Under Secretary of Commerce for NOAA to promulgate regulations for the assessment of natural resource damages resulting from a discharge or substantial threat of a discharge of oil. Assessments are intended to provide the basis for restoring, replacing, rehabilitating, and acquiring the equivalent of injured natural resources and services.

National Environmental Policy Act (NEPA)

Congress enacted NEPA (42 U.S.C. §§ 4321 *et seq.*; 40 C.F.R. Parts 1500-1508) in 1969 to establish a national policy for the protection of the environment. NEPA applies to federal agency actions that affect the human environment. NEPA requires that an EA be prepared in order to determine whether the proposed restoration actions would have a significant effect on the quality of the human environment. Generally, when it is uncertain whether an action would have a significant effect, federal agencies would begin the NEPA planning process by preparing an EA. The EA may undergo a public review and comment period. Federal agencies may then review the comments and make a determination. Depending on whether an impact is considered significant, an EIS or a FONSI would be issued.

Federal Water Pollution Control Act (Clean Water Act/CWA)

The CWA (33 U.S.C. §§ 1251 *et seq.*) is the principal law governing pollution control and water quality of the nation's waterways. Section 404 of the law authorizes a permit program for the disposal of dredged or fill material into waters of the United States. The United States Army Corps of Engineers (Corps) administers the program. In general, restoration projects that move significant amounts of material into or out of waters or wetlands -- for example, hydrologic restoration of marshes -- require Section 404 permits. Likewise, under Section 401 of the CWA, restoration projects that involve discharge or fill to wetlands or waters must obtain certification of compliance with state water quality standards.

Generally, restoration projects with minor wetlands impacts (i.e., a project covered by a Corps general permit) do not require Section 401 certification, while projects with potentially large or cumulative impacts do.

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §§ 1801 *et seq.*) as amended and reauthorized by the Sustainable Fisheries Act (Public Law 104-297) established a program to promote the protection of EFH in the review of projects conducted under federal permits, licenses, or other authorities that affect or have the potential to affect such habitat. After EFH has been described and identified in fishery management plans by the regional fishery management councils, federal agencies are obligated to consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect any EFH.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 U.S.C. §§ 661 *et seq.*) requires that federal agencies consult with the FWS, NOAA's National Marine Fisheries Service and State wildlife agencies for activities that affect, control or modify waters of any stream or bodies of water, in order to minimize the adverse impacts of such actions on fish and wildlife resources and habitat. This consultation is generally incorporated into the process of complying with Section 404 of the CWA, NEPA, or other federal permit, license, or review requirements.

Rivers and Harbors Act of 1899

The development and use of the nation's navigable waterways are regulated through the Rivers and Harbors Act (33 U.S.C. §§ 401 *et seq.*). Section 10 of the Act prohibits unauthorized obstruction or alteration of navigable waters and vests the U.S. Army Corps of Engineers with authority to regulate discharges of fill and other materials into such waters. Restoration actions that require Section 404 CWA permits are likely also to require permits under Section 10 of the Rivers and Harbors Act. However, a single permit usually serves for both.

Executive Order 12898 - Environmental Justice

The purpose of Executive Order 12898 (59 FR 7629) is to address environmental justice in minority and low-income populations. This Executive Order requires each federal agency to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies and activities on minority and low-income populations. EPA and the Council on Environmental Quality have emphasized the importance of incorporating environmental justice review in the analyses conducted by federal agencies under NEPA and of developing mitigation measures that avoid disproportionate environmental effects on minority and low-income populations.

Executive Order 11514 - Protection and Enhancement of Environmental Quality

The purpose of Executive Order 11514 (35 FR 4247) is to protect and enhance the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans, and programs to meet national environmental goals.

Executive Order 13112 – Invasive Species

The purpose of Executive Order 13112 (64 FR 6183) is to prevent the introduction of invasive species and provide for their control, and to minimize the economic, ecological, and human health impacts that invasive species cause.

Marine Mammal Protection Act (MMPA)

The MMPA (16 U.S.C. §§ 1361 *et seq.*) provides for long-term management and research programs for marine mammals. It places a moratorium on the taking and importing of marine mammals and marine mammal products, with limited exceptions. The Department of Commerce is responsible for whales, porpoise, seals, and sea lions. The Department of the Interior is responsible for all other marine mammals.

National Historic Preservation Act

The purpose of the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq.*) is to protect and preserve historical and archaeological sites in the United States. This act created the National Register of Historic Places and the list of National Historic Landmarks. Through the process, called Section 106 Review, federal agencies are required to evaluate the impact of federally funded or permitted projects on historic property.

CHAPTER 8 | PREPARERS, AGENCIES, AND PERSONS CONSULTED

The following Trustee representatives were involved the preparation of this document and with the selection of the preferred alternative:

Sarah Allan, Ph.D., NOAA-Office of Response and Restoration, 222 West 7th Ave., Anchorage, AK 99513

Erika Ammann, NOAA-Restoration Center, 222 West 7th Ave., Anchorage, AK 99513

John Fiorentino, NOAA-Restoration Center, 1315 East West Hwy, Bldg. SSMC3, Silver Spring, MD 20910

Technical support for the damage assessment, restoration planning and development of this document was provided by:

Industrial Economics, Incorporated, 2067 Massachusetts Avenue, Cambridge, MA 0214

In addition, the following people were consulted and provided technical support in the development of this document:

Eric Coonradt, ADF&G, Sitka Area Office, 304 Lake Street, Room 103. Sitka, Alaska 99835

REFERENCES

Alaska Department of Fish and Game (ADF&G). 2018a. Statewide Herring Harvest and Gross Earnings. Accessed July 16, 2018. http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisheryherring.herring_grossearnings

Alaska Department of Fish and Game (ADF&G). 2018b. Commercial Herring Fisheries. Accessed August 27, 2018. http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareasoutheast.herring#harvest

Alaska Department of Fish and Game (ADF&G). 2017a. Anadromous Waters Catalog. https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=maps.AWCData

Alaska Department of Fish and Game (ADF&G). 2017b. Southeast Alaska 2017 Herring Stock Assessment Surveys. Fishery Data Series No. 17-49. Kyle Hebert, ADF&G. December 2017.

Alaska Department of Fish and Game (ADF&G). 2017c. Southeast Alaska 2016 Herring Stock Assessment Surveys. Fishery Data Series No. 17-01. Kyle Hebert, ADF&G. March 2017. 2009.

Alaska Department of Fish and Game (ADF&G). 2016. Southeast Alaska 2015 Herring Stock Assessment Surveys. Fishery Data Series No. 16-04. Kyle Hebert, ADF&G. February 2016.

Alaska Department of Fish and Game (ADF&G). 2015. Southeast Alaska 2014 Herring Stock Assessment Surveys. Fishery Data Series No. 15-10. Kyle Hebert, ADF&G. May 2015.

Alaska Department of Fish and Game (ADF&G). 2014. Southeast Alaska 2013 Herring Stock Assessment Surveys. Fishery Data Series No. 14-13. Kyle Hebert, ADF&G. February 2014.

Alaska Department of Fish and Game (ADF&G). 2013. Southeast Alaska 2012 Herring Stock Assessment Surveys. Fishery Data Series No. 13-08. Kyle Hebert, ADF&G. March 2013.

Alaska Department of Fish and Game (ADF&G). 2012a. Southeast Alaska 2011 Herring Stock Assessment Surveys. Fishery Data Series No. 12-53. Kyle Hebert, ADF&G. September 2012.

Alaska Department of Fish and Game (ADF&G). 2012b. Southeast Alaska 2010 Herring Stock Assessment Surveys. Fishery Data Series No. 12-46. Kyle Hebert, ADF&G. September 2012.

Alaska Department of Fish and Game (ADF&G). 2009. Southeast Alaska 2009 Herring Stock Assessment Surveys. Fishery Data Series No. 09-72. Kyle Hebert, ADF&G. December 2009.

Alaska Marine Stewardship Foundation. 2014. A Review of Marine Debris Surveys, Accumulations and Cleanup Projects in Alaska through 2014. December 2014.

Anderson, L. and M. Plummer. 2017. Recreational Demand for Shellfish Harvesting Under Environmental Closures. Marine Resource Economics. 31(1):43-57.

Anderson, L. and M. Plummer. 2016. Puget Sound Recreational Shellfishing Survey: Methodology and Results. NOAA Technical Memorandum. NMFS-NWFSC-132. September 2016.

Anderson, J. W., Neff, J. M., Cox, B. A., Tatem, H. E., & Hightower, G. M. 1974. Characteristics of dispersions and water-soluble extracts of crude and refined oils and their toxicity to estuarine crustaceans and fish. Marine biology, 27(1), 75-88.

Audubon (2016). Ecological Atlas of Southeast Alaska. http://ak.audubon.org/conservation/ecological-atlas-southeast-alaska.

Barron, M. G. 2017. Photoenhanced toxicity of petroleum to aquatic invertebrates and fish. Archives of Environmental Contamination and Toxicology, 73(1), 40-46.

Barron, M. G., Vivian, D., Yee, S. H., & Diamond, S. A. 2008. Temporal and spatial variation in solar radiation and photo-enhanced toxicity risks of spilled oil in Prince William Sound, Alaska, USA. Environmental toxicology and chemistry, 27(3), 727-736.

Barron, M. G., Carls, M. G., Short, J. W., & Rice, S. D. 2003. Photoenhanced toxicity of aqueous phase and chemically dispersed weathered Alaska North Slope crude oil to Pacific herring eggs and larvae. Environmental Toxicology and Chemistry, 22(3), 650-660.

Biggs, E. D., & Baker, T. T. 1997. Studies on Pacific Herring, *Clupea Pallasi*, Spawning in Prince William Sound Following the 1989 *Exxon Valdez* Oil Spill, 1989-1992: Draft Final Report to the *Exxon Valdez* Oil Spill Trustee Council for Natural Resource Damage Assessment Fish-shellfish Study Number 11. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Central Region.

Carls, M. G., Marty, G. D., & Hose, J. E. 2002. Synthesis of the toxicological impacts of the *Exxon Valdez* oil spill on Pacific herring (*Clupea pallasi*) in Prince William Sound, Alaska, USA. Canadian Journal of Fisheries and Aquatic Sciences, 59(1), 153-172.

Carls, M. G., Rice, S. D., & Hose, J. E. 1999. Sensitivity of fish embryos to weathered crude oil: Part I. Low-level exposure during incubation causes malformations, genetic damage, and mortality in larval pacific herring (*Clupea pallasi*). Environmental Toxicology and Chemistry, 18(3), 481-493.

Carson, H. S., Colbert, S. L., Kaylor, M. J., & McDermid, K. J. 2011. Small plastic debris changes water movement and heat transfer through beach sediments. Marine Pollution Bulletin, 62(8), 1708-1713.

Clay, T. W., S. M. Bollens, A. B. Bochdansky and T. R. Ignoffo. 2004. The effects of thin layers on the vertical distribution of larval Pacific herring, *Clupea pallasi*. Journal of Experimental Marine Biology and Ecology 305(2): 171-189.

Damery, D. T., & Allen, P. G. 2004. An economic valuation of recreational shellfishing on Cape Cod. University of Massachusetts Amherst. Department of Resource Economics. Working Paper No. 2004-10.

Dean Runyan Associates. 2009. Fishing, Hunting, Wildlife Viewing, and Shellfishing in Oregon. 2008 State and County Expenditure Estimates. May.

English, E. 2010. Annual Fees and Recreation Choice. American Journal of Agricultural Economics, 92(4), 1103-1113.

Eriksson, B. K., Sandström, A., Isæus, M., Schreiber, H., & Karås, P. 2004. Effects of boating activities on aquatic vegetation in the Stockholm archipelago, Baltic Sea. Estuarine, Coastal and Shelf Science, 61(2), 339-349.

Flostrand, L. A., Schweigert, J. F., Daniel, K. S., & Cleary, J. S. 2009. Measuring and modelling Pacific herring spawning-site fidelity and dispersal using tag-recovery dispersal curves. ICES Journal of Marine Science, 66(8), 1754-1761.

Griffin, F. J., Smith, E. H., Vines, C. A., & Cherr, G. N. 2009. Impacts of suspended sediments on fertilization, embryonic development, and early larval life stages of the pacific herring, *Clupea pallasi*. The Biological Bulletin, 216(2), 175-187.

Gulf States Marine Fisheries Commission. 2015. The Blue Crab Fishery of the Gulf of Mexico: A Regional Management Plan. Pub. No. 243.

Hughes, J. B. 1999. Cytological-cytogenetic analyses of winter flounder embryos collected from the benthos at the barge *North Cape* oil spill. Marine Pollution Bulletin 38(1): 30-35.

Incardona, J., Ylitalo, G., Myers, M., Scholz, N., Collier, T., Vines, C., ... & Cherr, G. 2008. The 2007 *Cosco Busan* oil spill: Assessing toxic injury to Pacific herring embryos and larvae in the San Francisco estuary. Draft Report, NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA, USA. September 2008.

Incardona, J. P., Vines, C. A., Linbo, T. L., Myers, M. S., Sloan, C. A., Anulacion, B. F., ... & Scholz, N. L. 2012. Potent phototoxicity of marine bunker oil to translucent herring embryos after prolonged weathering. PLoS One, 7(2), e30116.

McGurk, M. D., & Brown, E. D. 1996. Egg larval mortality of Pacific herring in Prince William Sound, Alaska, after the *Exxon Valdez* oil spill. Canadian Journal of Fisheries and Aquatic Sciences, 53(10), 2343-2354.

McGurk, M. 1989. Early Life History of Pacific Herring: Relationships of Larval Dispersal and Mortality to Environmental Conditions. Final Report of 1989 Port Moller Reconnaissance Survey.

Morris, J.M., M.O. Krasnec, M.W. Carney, H.P. Forth, C.R. Lay, I. Lipton, A.K. McFadden, R. Takeshita, D. Cacela, J.V. Holmes, and J. Lipton. 2015a. *Deepwater Horizon* Oil Spill Natural Resource Damage Assessment Comprehensive Toxicity Testing Program: Overview, Methods, and Results. DWH NRDA Toxicity Technical Working Group Report. Prepared for National Oceanic and Atmospheric Administration by Abt Associates, Boulder, CO. [REVISED] (December 16, 2015).

Morris, J.M., H.P. Forth, C.R. Lay, R. Takeshita, and J. Lipton. 2015b. Toxicity of Thin Floating Oil Slicks to Fish and Invertebrates. DWH NRDA Toxicity Technical Working Group Report. Prepared for National Oceanic and Atmospheric Administration by Abt Associates, Boulder, CO.

National Oceanic and Atmospheric Administration (NOAA). 2016. Chapter 4: Injury to Natural Resources. Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement (PEIS).

National Oceanic and Atmospheric Administration (NOAA). 2014. Status Review of Southeast Alaska Herring (*Clupea pallasi*). Threats Evaluation and Extinction Risk Analysis. NOAA/National Marine Fisheries Service, Alaska Region. March 2014.

National Oceanic and Atmospheric Administration (NOAA). 2002. Final Damage Assessment And Restoration Plan/Environmental Assessment for the Fort Lauderdale Mystery Oil Spill. August 26.

Norcross, B.L. and E.D. Brown. 2001. Estimation of First-Year Survival of Pacific Herring from a Review of Recent Stage-Specific Studies. In: Herring: Expectations for a New Millenium. Alaska Sea Grant College Program. AK-SG-01-04. pgs 535-551.

Rice, S.D., A. Moles, T.L. Taylor, and J.F. Karinen. 1979. Sensitivity of 39 Alaskan Marine Species to Cook Inlet Crude Oil and No. 2 Fuel Oil. International Oil Spill Conference Proceedings: March 1979, Vol. 1979, No. 1, pp. 549-554.

Sill, L.A. and D. Koster. 2017. The Harvest and Use of Wild Resources in Sitka, Alaska, 2013. Technical Paper No. 423. Alaska Department of Fish and Game, Division of Subsistence. March, 2017.

Sill, L. 2015. Gathering Herring Eggs: Subsistence Harvest a Sign of Spring. Alaska Fish & Wildlife News. April 2015. Alaska Department of Fish and Game.
http://www.adfg.alaska.gov/index.cfm?adfg=wildlifenews.view_article&articles_id=704

Sitka Sound Science Center (SSSC). 2016. Final Marine Debris Removal Report. Sitka Alaska Coastal Community Cleanup of tsunami marine debris from the Tohoku earthquake (TDCCC).

Stevenson, J.C., 1962. Distribution and survival of herring larvae *(Clupea pallasi Valenciennes*) in British Columbia waters. Journal of the Fisheries Board of Canada, 19(5), pp.735–810.

Travers, C., C. Wobus, J. Morris, C. Lay, M. Rissing, H. Forth, J. Holmes. 2015. Mortality Estimates of Invertebrates and Early Life Stage Fish, and Other Injury Metrics in the Upper Mixed Layer of the Water Column during the *Deepwater Horizon* Oil Spill: Technical Report. (August 31, 2015).

Uhrin, A. V., & Schellinger, J. 2011. Marine debris impacts to a tidal fringing-marsh in North Carolina. Marine pollution bulletin, 62(12), 2605-2610.

Uhrin, A. V., Fonseca, M. S., & DiDomenico, G. P. 2005. Effect of Caribbean spiny lobster traps on seagrass beds of the Florida Keys National Marine Sanctuary: damage assessment and evaluation of recovery. In American Fisheries Society Symposium (Vol. 41, p. 579). American Fisheries Society.

U.S. Fish and Wildlife Service (FWS). 2012. Enbridge Line 6-B NRDA. Lost Recreational Use Assessment Plan Interim Advanced Funding Claim. April 26, 2012.

Woodby, D., D. Carlile, S. Siddeek, F. Funk, J.H. Clark, and L. Hulbert. 2005. Commercial Fisheries of Alaska. Alaska Department of Fish and Game. Special Publication No. 05-09, Anchorage

APPENDIX A: NEWFIELDS CHEMICAL FINGERPRINTING

September 20, 2017

Sarah E. Allan, Ph.D.
NOAA Office of Response & Restoration
Alaska Regional Resource Coordinator
222 West 7th Avenue
Anchorage, Alaska 99513
Ph: (907) 271-5146

Chemical Fingerprinting Results
Powhatan Tug Vessel Oil Spill
Sitka, Alaska

Dear Dr. Allan,

NewFields Companies, LLC is pleased to provide you with this report concerning the chemical fingerprinting analysis of various samples collected in the course of your investigation of the oil spill resulting from the sinking of the *Powhatan* tugboat near Sitka, Alaska on April 19, 2017. I understand the out-of-service tugboat was owned by Samson Tug & Barge Company and unexpectedly sunk near its dock in Starrigavan Bay then slid approximately 330 m to the northwest into deeper water, and leaked an unknown volume of oil.[1]

The samples analyzed and considered herein are inventoried in Table 1 and their locations are shown in Figure 1. These samples were collected by representatives of Polaris Applied Sciences, Inc. (Polaris), a representative of Samson Tug & Barge, and the United States Coast Guard (USGC), and included two source oil samples recovered from the sunken tug by divers and six samples collected from the environment (Table 1; Fig. 1). The latter included two waters, two floating oil sheens, and two composite (mussel or clam) tissue samples in the Starrigavan Bay area (Table 1; Fig. 1).

The objectives of the analyses were to: (1) determine the type(s) and composition(s) of the source oils recovered from the sunken tug and (2) compare the tug's source oils to the six environmental samples collected from the area. These objectives were pursued as a means to assess the degree to which the area's natural resources were exposed to the tug's spilled petroleum.

Samples and Analytical Methods

All of the samples were sent to Alpha Analytical (Mansfield, MA) for chemical fingerprinting in accordance with standard practices described in detail elsewhere.[2] The source oils, waters, and oil sheen samples were prepared and analyzed using a (1) modified EPA Method 8015B and (2) modified EPA Method 8270, descriptions of which are summarized as follows:

(1) *Total Petroleum Hydrocarbon Quantification and Fingerprinting*: a modified EPA Method 8015D employing high resolution gas chromatography-flame ionization detection

[1] State of Alaska, Div. of Spill Prevention Preparedness and Response; http://dec.alaska.gov/spar/ppr/ response/sum_fy17/ 170419101/170419101_index.htm; accessed Sept. 6, 2017.
[2] Douglas, G.D., Emsbo-Mattingly, S.D., Stout, S.A., Uhler, A.D., and McCarthy, K.J. (2015). Hydrocarbon Fingerprinting Methods. In: *Introduction to Environmental Forensics, 3rd Ed.*, B. Murphy and R. Morrison, Eds., Academic Press, New York, pp. 201-309.

(GC/FID) was used to determine the TPH concentration (C_9-C_{44}) and concentrations of *n*-alkanes (C_9-C_{40}) and selected (C_{15}-C_{20}) acyclic isoprenoids (e.g., pristane and phytane), while simultaneously provide a detailed fingerprint of the extractable hydrocarbons present in each sample.

(2) *PAH Quantification and Fingerprinting*: a modified EPA Method 8270D was used to determine the concentrations of 75 semi-volatile compounds or compound groups, included Priority Pollutant PAHs, alkylated PAHs, decalins, and sulfur-containing aromatics. The concentration of total PAHs are presented as:

TPAH50 = sum of 50 analytes ranging from naphthalene to benzo-(*ghi*)perylene, exclusive of retene and benzo(*b*)fluorene.

(3) *Quantitative Biomarker Fingerprinting*: a modified EPA Method 8270D was used to determine the concentration of 55 tri-, tetra- and penta-cyclic triterpanes, regular and rearranged steranes, and aromatic steroids. These highly diagnostic compounds can be used to distinguish different hydrocarbon sources. Numerous biomarker ratios were calculated and biomarker distributions ("fingerprints") were normalized to 17α(H),21β(H)-hopane (hopane).

Per the request of Polaris upon their submitting the samples, the composite tissue samples were homogenized, extracted and analyzed using only the *PAH Quantification and Fingerprinting* method (2, above).

The concentrations of all target compounds in the oils and sheens were reported in mg/kg_{oil}, calculated using the gravimetric weights determined separately. Owing to the very low gravimetric weight of the two sheen samples' extracts the TPH, PAH, and biomarker concentrations reported by Alpha are biased high. Regardless, each sheen sample's analyte distributions ("fingerprints") are unaffected by the low gravimetric weights so that diagnostic ratios among and normalized distributions of target analytes are still useful for comparisons.

The concentrations of all target compounds in the waters were reported in either mg/L (TPH) or ng/L (PAH and biomarkers). The concentrations of all PAH-related target compounds in the tissues were reported in $\mu g/kg_{wet\ wt}$.

Interpretive and Classification Methods

Comparisons between the source oils and environmental samples were made through a combination of qualitative and quantitative techniques. No single oil spill identification protocol was appropriate owing to the different matrices being compared (e.g., oil v. tissues), the obvious effects of weathering of the tug's source oil(s), the likely release of varying mixtures of oils among the tug's source oils,[3] and the low concentrations of most targeted biomarkers in the environmental samples studied.

In the case of the water and sheen samples, GC/FID chromatograms were compared qualitatively to the source oils[4] since common diagnostic ratios[5] in the water and sheen samples containing petroleum were clearly affected by weathering (see below). Normalized PAH

[3] diesel fuel #2 with varying proportions of lubricating oil; see below.
[4] In accordance with ASTM D3328, Standard Test Methods for Comparison of Waterborne Petroleum by Gas Chromatography. ASTM Int'l., West Conshohocken, PA.
[5] Pr/Ph, C17/Pr, C18/Ph

distributions were also qualitatively compared to assess whether those of the water and sheen samples were reasonably attributable to weathering of the source oils, or not. Extracted ion profiles showing individual PAH isomer patterns were inspected but, owing to the weathering effects evident in the water and sheen samples, these were not used to conclude or exclude matches. Those water and sheen samples whose GC/FID chromatograms and normalized PAH distributions were qualitatively; (1) consistent with weathering of the source oils were considered as "*matches*", (2) inconsistent with weathering of the source oils were considered as "*non-matches*", and (3) considered "*indeterminate*" if insufficient oil was present to yield reliable chromatograms or PAH distributions. Additionally, because the concentrations of most targeted biomarkers were low in the water and sheen samples, and dependent upon the presence of any lubricating oil (which may or may not have been present in any oil released from sunken tug; see below), their distributions in the water and sheen samples were qualitatively compared to the source oils. Furthermore, quantitative comparisons were made using three common diagnostic ratios associated with four prominent hopanoid biomarkers,[6] using a 5% relative standard deviation (RSD) threshold.[7] Those water and sheen samples whose biomarkers both qualitatively and quantitatively matched the source oil(s)[8] were considered as "*matches*". If both the GC/FID/PAH and biomarkers indicated "*matches*" the water or sheen sample was considered as a "*match*" to the *Powhatan* tugboat source oils.

In the case of the tissue samples, only PAH data were available for samples that were collected from one location (Fig. 1) at point in time (May 3). The latter precluded any spatial or temporal assessment of exposure to the tissues to the incident oil. As such, the only basis upon which to compare the tissue samples to the tugboat source oils was the qualitative distribution of PAHs and quantitative comparison of two common PAH-based diagnostic ratios.[9] If the qualitative distribution of PAHs in tissues were consistent with those expected due to weathering of the source oils, and the diagnostic ratios matched within a 5% RSD threshold, the samples were considered to "*match*". However, owing to the limited number of tissue samples in space and time and limited (PAH-only) data, I consider any tissue "*match*" to be less robust than a "*match*" among the water or sheens studied (described above). To emphasize this difference it more appropriate to refer to any tissue "*match*" as a "*possible match*" to the *Powhatan* tugboat source oils; see additional discussion below.

Results and Discussion

The tabulated concentrations and chromatographic data generated by Alpha (Batch IDs; 1708008 and 1705003) were provided to NOAA separately and therefore are not included in this report. Selected metrics for the samples studied reported by Alpha or calculated from the reported data are presented in Table 2 and figures discussed below are shown in Figures 2 to 10.

<u>*Character of Source Oils*</u>

The GC/FID chromatograms for the two source oils recovered from the sunken *Powhatan* tug are shown in Figure 2. Inspection reveals them both to exclusively (Fig. 2A) or predominantly (Fig. 2B) be comprised of compounds that occur within the C10 to C28 carbon range, or "diesel

---

[6] Ts/Hop, Tm/Hop, H29/Hop; other diagnostic ratios based on low concentration biomarkers were considered less reliable for quantitative analysis.

[7] As per, CEN/TR 15522-2: 2012. Oil Spill Identification – Waterborne Petroleum and Petroleum Products - Part 2: Analytical Methodology and Interpretation of Results (2012)138 p. European Committee for Standardization.

[8] particularly the 2017-05-04-01-02 source oil, which was will be shown below contained a lubricating oil component containing relatively high concentrations of biomarkers.

[9] DBT2/PA2 and DBT3/PA3

range". The resolved peaks within this range are dominated by n-alkanes that reach a maximum at n-C16. Additionally, other resolved peaks include acyclic isoprenoids, viz., pristane (Pr) and phytane (Ph), and numerous alkylated naphthalene isomers (Fig. 2). The prominence on alkanes, which are relatively susceptible to biodegradation compared to isoprenoids, indicates the source oils are not biodegraded. This would be expected given the oils were collected from accumulation of oil directly on the sunken tug. The ratios of n-C17/pristane (C17/Pr) and n-C18/phytane (C18/Ph) are 1.4 to 1.3 and 1.9 to 1.8, respectively (Table 2).

Beneath the resolved peaks is a "hump", known as the unresolved complex mixture (or UCM), which contains hundreds of chemicals that cannot be chromatographically-resolved (and is typical of many types of petroleum). The UCM "hump" spans from about C10 to C25 and exhibits an "up-and-down" pattern that is consistent with a middle distillate product (having been distilled on both the front and back ends), such as diesel fuel #2.

Notably, the 2017-05-04-01-02 source oil contains a second, higher boiling UCM that spans from about C25 to C40 (Fig. 2B). There are no obvious resolved peaks present atop this second UCM, although small peaks representing various triterpane biomarkers are present. These features indicate that the 2017-05-04-01-02 source oil contains a lubricating oil component that is not present in the 2017-05-04-01-01 source oil. These results seem largely consistent with the presumed compositions of these source oils as suspected based on the locations from which they were collected on the sunken tug (Table 1).

The distributions and concentrations of PAHs and related compounds in the two source oils are shown in Figure 3. The *y*-axis are equally-scaled to reveal the lower concentration of PAHs in the 2017-05-04-01-02 source oil (TPAH50 5,462 mg/kg) than in the 2017-05-04-01-01 source oil (18,714 mg/kg; Table 2). The dominant PAHs in both source oils, however, are lower boiling PAHs, i.e., those containing 2- or 3-rings. These results indicate that the vast majority of the PAHs measured are associated with the diesel fuel component in each of the source oils and, as is typical of (commonly de-aromatized) lubricating oil, few higher molecular weight PAHs are present (Fig. 3B). The disparate concentrations in TPAH50 (Table 2) suggests that the 2017-05-04-01-02 source oil contains approximately ~70 wt% lubricating oil.[10]

The relative abundances of sulfur-containing aromatics (dibenzothiophenes) in the two source oils appear comparable. This can be measured using the DBT2/PA2 and DBT3/PA3 ratios, which reveals both source oils to be highly comparable (0.8 and 1.1, respectively, in both source oils; Table 2). This indicates that the diesel fuel #2 component in both of the source oils appears to be the "same" specific type of diesel fuel, which is not surprising given they were both collected from the sunken tug.

Figure 4 shows the distributions and concentrations of target biomarkers in the two source oils. Again, the *y*-axis are scaled to the concentrations and it is clear that most of the biomarkers detected are associated with the higher boiling lubricating oil component present in the 2017-05-04-01-02 source oil (Fig. 4B); only the lowest boiling biomarkers (tricyclic triterpanes, T4-T6) are prominent in the 2017-05-04-01-01 source oil (Fig. 4A). This result is consistent with the boiling range of the targeted biomarkers, as depicted in Fig. 2. Thus, opposite to the case of PAHs,

[10] This was calculated assuming the diesel fuel contributed all 18,714 mg/kg TPAH50 to the 2017-05-04-01-01 source oil, indicating that the 5,462 mg/kg TPAH50 in the 2017-05-04-01-02 source oil indicates it was diluted with ~70% lubricating oil. This 70 wt% estimate seems higher than might be evident visually in the GC/FID chromatogram (Fig. 1B) but is likely due to a significant non-chromatographable (C40+) fraction in the 2017-05-04-01-02 source oil that cannot be seen by conventional GC/FID.

nearly all of the biomarkers (except the low boiling tricyclic triterpane) are present in the lubricating oil component. As is also consistent with (commonly de-aromatized) lubricating oil, the aromatic steroid biomarkers are present in low concentrations or absent (yellow bars in Fig. 4B).

In summary, the two source oils collected from the sunken *Powhatan* tugboat on May 4th are comprised of unweathered diesel fuel #2 (2017-05-04-01-01) or a mixture of unweathered diesel fuel #2 and lubricating oil (2017-05-04-01-02). The PAHs present in both source oils are dominated by 2- and 3-ring PAHs typical of diesel fuel; the lubricating oil component in the 2017-05-04-01-02 source oil likely contributes little to the total PAHs. Oppositely, however, the lubricating oil component in the 2017-05-04-01-02 source oil contributes most all of the biomarkers. This result is relevant in comparing the environmental samples to the tug's source oils (see below).

Comparison of Tug Source Oils to Environmental Samples
In this section the source oils collected from the sunken *Powhatan* tugboat (described above) are compared to the three pairs of environmental samples (waters, sheens, then tissues) studied. The methods by which these comparisons were made were described in the *Interpretive and Classification Methods* section above.

Water Samples: The GC/FID chromatograms for the two water samples studied are shown in Figure 5. The sample collected April 26 from the end of the pier at the Starrigavan boat ramp (FPN J17008-002; Fig. 1) contained no detectable TPH (Table 2) and its chromatogram shows only internal standards to be present (Fig. 5B). This water also contained only traces of PAHs (Table 2), most of which were also present in the laboratory's procedural blanks. As such, the FPN J17008-002 water is considered "clean", and thereby classified as *indeterminate.* It will not be discussed further.

The sample collected April 25 from the SE corner of the Samson Pier (FPH J17008-001; Fig. 1) contained 118 mg/L of TPH (Table 2), the character of which is consistent with evaporated diesel fuel #2 (Fig. 5A). Despite being a water sample, the Samson Pier water sample clearly contained free/particulate oil (and not only dissolved hydrocarbons). Relative to the "fresh" diesel fuel present in the source oils (Fig. 2) the Samson Pier water's diesel fuel has lost most mass below C14 and has reduced mass up to about C18 (Fig. 5A). As such, its Pr/Ph ratio is reduced (1.1) compared to the source oils (1.6-1.7; Table 2). The ratios of C17/Pr and C18/Ph also are reduced relative to the "fresh" source oils, a change that is consistent with incipient biodegradation of the oil in the Samson Pier water sample. Thus, the oil in the Samson Pier water appears consistent with a weathered (evaporated and mildly biodegraded) diesel fuel #2.

The normalized distributions of the Samson Pier water sample's PAHs and biomarkers are compared to the *Powhatan* tugboat source oils in Figure 6.[11] The Samson Pier water sample clearly contains reduced abundances of most PAHs (and decalins) relative to the source oils. There is a greater reduction in the lower boiling and less alkylated PAHs, both losses of which

---

[11] In this figures and others to follow the PAH distributions are normalized to C4-dibenzothiophenes (DBT4) and the biomarker distributions are normalized to hopane. Because the PAHs are overwhelmingly derived from the diesel fuel component in the tugboat source samples, yet most PAHs are affected by weathering in the environmental samples, DBT4 represented both an abundant and less weathering-susceptible analyte and was thereby appropriate for normalization. By the same approach, hopane, which was overwhelmingly derived from the lubricating oil component in the tugboat source sample (2017-05-04-01-02), represented both an abundant and less weathering-susceptible analyte for normalization of the biomarker distributions.

are consistent with weathering (dissolution and evaporation). Thus, qualitatively the PAH distribution of the Samson Pier water sample appears consistent with a weathered diesel fuel such as is present in the *Powhatan* tugboat source oils (Fig. 6A). This weathering is extensive enough to have increased the DBT2/PA2 and DBT3/PA3 ratios of the Samson Pier water sample (Table 2).

Qualitative comparison between the normalize biomarkers shows the Samson Pier water sample to closely match the *Powhatan* tugboat source oils (Fig. 6B). Minor differences among lower concentration biomarkers are anticipated due to the low absolute concentration of biomarkers in the water sample. However, when diagnostic ratios among the prominent hopanoid biomarkers (Ts, Tm, H29, and hopane; Fig. 6B; Table 2) are considered there is a quantitative match between the Samson Pier water sample and the lubricating oil-bearing source oil from the *Powhatan* tugboat (2017-05-04-01-02).

In conclusion, the available data indicate:

(1) the water collected from the Starrigavan boat ramp on April 26 (FPN J17008-002) contained virtually no measurable hydrocarbons and thereby is classified as "*indeterminate*" and

(2) the water collected from the Samson Pier on April 25 (FPN J17008-001) contained a weathered diesel fuel and (trace) lube oil mixture that is a "*match*" to the source oils from the *Powhatan* tugboat on May 4.

<u>*Sheen Samples*</u>: The GC/FID chromatograms for the two sheen samples studied are shown in Figure 7. Normalized distributions of PAHs and biomarkers for both of these samples are shown in Figures 8 and 9. These two sheens are discussed separately in the following paragraphs.

The GC/FID chromatogram for the sheen collected April 26 near the boat ramp/jetty (FPN J17008-003; Fig. 1) reveals it to be comprised of diesel range petroleum dominated by a large symmetrical UCM in the C14 to C25 range (Fig. 7A). The only prominent resolved peaks atop the UCM are acyclic isoprenoids (e.g., pristane and phytane); n-alkanes are absent. The absence of n-alkanes indicates the oil in this sheen has experienced severe biodegradation. There is a minor, higher-boiling UCM also present. Collectively, these features indicate the boat ramp/jetty sheen is predominantly comprised of a severely weathered (evaporated, biodegraded, and likely water-washed) diesel fuel #2 and a trace amount of a heavier (lube or waste) oil.

Qualitative comparison of the normalized PAH distribution in the boat ramp/jetty sheen to the *Powhatan* tugboat source oils, and to the "matched" Samson Pier water sample (described above), shows that sheen to be a reasonable match, especially to the water sample (Fig. 8A). Thus, it is tempting to consider the sheen as a match to the weathered source oil. However, the severity of the biodegradation of the diesel fuel in the boat ramp/jetty sheen is difficult to attribute to a diesel fuel that has spent only 7 days (or less) in the environment (i.e., the tug sunk April 19 and the sheen was collected April 26). Severe biodegradation of a floating oil (sheen) over this short period of time is, in my experience, difficult to achieve. In addition, when the normalized distribution of biomarkers in the boat ramp/jetty sheen is compared to the *Powhatan* tugboat source oils (Fig. 8B) there are some notable differences. For example, the sheen contains relatively abundant Ts, Tm, and H29 compared to the lubricating oil-bearing source oil from the *Powhatan* tugboat (2017-05-04-01-02; Fig. 8B). Quantitative comparison of diagnostic ratios among these prominent hopanoid biomarkers (Table 2) reveals a non-match between the boat ramp/jetty sheen and the 2017-05-04-01-02 source oil (i.e., the source oil that had contained lubricating oil).

Thus, the combination of the anomalous severity of biodegradation of the diesel fuel component (allegedly within only 7 days or less) and the non-matching character of the biomarkers in the lubricating oil component warrants that:

(3) the boat ramp/jetty sheen (FPN J17008-003) collected April 26 be considered a "*non-match*" to the source oils collected from the *Powhatan* tugboat on May 4.

It is possible that this sheen is derived from another spill(s) of slightly different diesel fuel/lubricant mix that pre-dates the sinking of the Powhatan tugboat, which happened to manifest near the boat ramp/jetty April 26. However, it is also possible that the oil initially released from the sunken tug, prior to the May 4th collection of the source samples studied, could have included oil(s) that were different from the source oils studied; e.g., a biodegraded diesel fuel/lube mix derived from bilge water.[12]

The GC/FID chromatogram for the sheen collected April 26 from the eastern part of Starrigavan Bay (FPN J17008-004; Fig. 1) reveals it to be comprised of a mixture of petroleum and non-petroleum. The latter is evident in the large number of resolved peaks both below C15 and above C25, the distribution of which are inconsistent with petroleum (Fig. 7B). These compounds are likely associated with naturally-occurring organic matter (or contaminants present on the sampling materials). The breadth/peak shape of many early-eluting peaks suggests the presence of polar compounds, e.g., organic acids, which might appear as sheens. Regardless of the origin of the non-petroleum component, there is also some diesel fuel #2 present in the sheen as indicated by the prominent UCM in the C15 to C25 range, atop which exists n-alkanes and acyclic isoprenoids (Fig. 7B). Ratios associated with these peaks (Pr/Ph, C17/Pr, and C18/Ph) are lower than in the *Powhatan* tugboat source oils (Table 2), which is consistent to weathering. In contrast to the severely biodegraded diesel fuel #2 in the boat ramp/jetty sheen (FPN J17008-003; described above), biodegradation of the diesel fuel #2 in the eastern Starrigavan Bay sheen (FPN J17008-004) is only moderately advanced, and to a degree that is reasonable to achieve in floating oil in 7 days (or less). A small UCM is also present in the C25+ range (Fig. 7B), suggesting a minor lubricating oil component is also present in the sheen.

Qualitative comparison the normalized PAH distribution of the eastern Starrigavan Bay sheen to the source oils collected from the sunken *Powhatan* tugboat, and to the "matched" Samson Pier water sample (described above), is shown in Fig. 9A. The PAHs in the eastern Starrigavan Bay sheen are extremely weathered even compared to the Samson Pier water sample. Nonetheless, the severity of the PAH weathering in the eastern Starrigavan Bay sheen is not unreasonable given the apparent distance it may have traveled from the sunken tug's location (Fig. 1). In summary, the GC/FID chromatogram (Fig. 7B) and normalized PAH distribution (Fig. 9A) of the eastern Starrigavan Bay sheen are reasonable qualitative matches to the source oils collected from the sunken *Powhatan* tugboat.

Qualitative comparison of the normalized distribution of biomarkers in the eastern Starrigavan Bay sheen and the *Powhatan* tugboat source oils (Fig. 9B) reveals minor differences among

[12] I understand that collection of source oils from the sunken tug was necessarily delayed until May 4th for safety and logistical reasons.

lower concentration biomarkers. However, when diagnostic ratios among the prominent hopanoid biomarkers (Ts, Tm, H29, and hopane; Fig. 9B; Table 2) are considered, there is a quantitative match between the eastern Starrigavan Bay sheen and the lubricating oil-bearing source oil from the *Powhatan* tugboat (2017-05-04-01-02; Fig. 9B).

In conclusion, the available data indicate:

(4) the sheen collected April 26 from the eastern part of Starrigavan Bay (FPN J17008-004) contained, along with non-petroleum (e.g. natural organic matter), a weathered diesel fuel and (trace) lube oil mixture that is a "*match*" to the *Powhatan* tugboat source oils collected May 4.

<u>Tissue Samples</u>: As described in the *Samples and Analytical Methods* section, the two tissue samples were only analyzed for their PAH concentrations. Therefore, the ability to defensibly determine the source of PAHs in the tissues is reduced relative to the waters and sheens described above (in which GC/FID and biomarker data were also available). In addition, the fingerprinting of tissues is potentially complicated by the effects of uptake (e.g., of dissolved and particulate oil). Also, background (baseline) conditions or temporal trends for tissues are often useful in assessing exposure to organisms following an oil spill, and such data in Starrigavan Bay are unknown (to me). As such there is additional caution warranted in the assessment of the tissues' chemical fingerprinting described below.

The composite mussel (2017-05-03-01-02) and composite clam (2017-05-03-01-03) samples contained 151 and 95 $\mu g/kg_{wet}$ of TPAH50, respectively (Table 2). These concentrations are sufficiently high to indicate both tissues are clearly impacted by PAHs. The normalized distributions of the measured PAHs are shown in Figure 10. Clear petrogenic patterns of alkylated PAHs indicate both tissues are impacted by petroleum, particularly weathered petroleum. In addition, the composite clam sample also contains a relative prominence of fluoranthene, pyrene, benz(a)anthracene, chrysene and other 5- and 6-ring PAH (Fig. 10B inset) that indicates some additional impact from pyrogenic (combustion-derived) PAHs (not spilled petroleum). Any pyrogenic impact to the composite mussel sample was not as obvious.

Comparison of the normalized PAH distributions of the two tissues to the source oils collected from the sunken *Powhatan* tugboat, and to the "matched" Samson Pier water sample (described above) shows a qualitative comparability exists. Specifically, the composite mussel sample's PAHs are a qualitative match to the weathered petroleum found in the Samson Pier water sample (Fig. 10A). The composite clam samples PAHs are a qualitative match to a slightly less weathered petroleum than was found in the Samson Pier water sample, but one that was more weathered than the fresh source oils (Fig. 10B). Thus, qualitatively, the petroleum-derived PAHs in both tissue samples appear to "*match*" variably-weathered source oils from the *Powhatan* tugboat.

Finally, it is notable that when the only common diagnostic ratios available for the tissue samples' data (DBT2/PA2 and DBT3/PA3) are quantitatively compared to the source oils, they are found to be also "*match*" the source oils (Table 2). Although these ratios are slightly increased relative to the source oils as anticipated due to weathering (Table 2), it is unknown why these ratios remained more stable within the two tissue samples (collected May 3), than they had in the source oil found within the Samson Pier water (FPN J17008-001) and eastern Starrigavan Bay sheen (FPN J17008-004) collected April 25 and 26. This may be attributed to less weathering of particulate oil that may have entered the subsurface (near where the mollusks were exposed) or perhaps some preserving effect due to uptake of the oil by the mollusks. Alternatively, in the absence of background or temporal studies of mollusk tissues in Starrigavan Bay, one must consider if the area's mollusks may be regularly exposed to petroleum, and not necessarily (only?) leaked oil from the *Powhatan* tugboat. For this reason, and the other potential complications mentioned above:

(5) the composite mussel (2017-05-03-01-02) sample collected May 3 contained petrogenic PAHs that are a "*possible match*" to those contained in the weathered source oils collected from the *Powhatan* tugboat, and

(6) the composite clam (2017-05-03-01-03) sample collected May 3 contained, in addition to minor pyrogenic PAHs of a combustion origin, petrogenic PAHs that are a "*possible match*" to those contained in the weathered source oils collected from the *Powhatan* tugboat.

Conclusions

The two source oils collected from the sunken *Powhatan* tugboat on May 4, 2017 were comprised of unweathered diesel fuel #2 (2017-05-04-01-01) or a mixture of (the same type of) unweathered diesel fuel #2 and lubricating oil (2017-05-04-01-02).

Chemical fingerprinting comparisons of these source oils to three pairs of environmental samples – waters, sheens, and tissues collected 6 to 14 days after the tug sunk and 1 to 9 days before the tug's source oils were collected – were made using a combination of qualitative and quantitative methods.

The results of these six samples' comparisons were presented in six enumerated conclusions presented in the *Results and Discussion (*above), which are further summarized in Table 3.

If you have any questions regarding the results presented herein, please do not hesitate to call me at (781) 681-5040.

Sincerely,

Scott A. Stout, Ph.D., P.G.
Sr. Consulting Geochemist

Table 1: Inventory of samples studied.

Client ID	Lab ID	Matrix	Date Collected	Collected By	Latitude	Longitude	Sample Description
Source Oils							
2017-05-04-01-01*	1708008-01	Oil	05/04/2017	Polaris	57.131242	-135.38016	sunken tug source oil (presumed diesel oil)
2017-05-04-01-02	1708008-02	Oil	05/04/2017	Polaris	57.131242	-135.38016	sunken tug source oil (presumed lube or mixed oil)
Environmental Samples							
FPN J17008-001	1708008-03	Water	04/25/2017	USCG	57.129433	-135.37834	water from SE corner of Samson Pier
FPN J17008-002	1708008-04	Water	04/26/2017	USCG	57.12941	-135.37525	fresh water end of pier at Starrigavan boat ramp
FPN J17008-003	1708008-05	Sheen	04/26/2017	USCG	57.129619	-135.37421	sheen-net at Starrigavan Bay boat ramp by jetty rocky shore
FPN J17008-004	1708008-06	Sheen	04/26/2017	USCG	57.136653	-135.37298	sheen-net, Mosquito Trail, eastern Starrigavan Bay
2017-05-03-01-02	1705003-01	Tissue	5/3/2017	Polaris	57.133368	-135.36936	composite mussels
2017-05-03-01-03	1705003-02	Tissue	5/3/2017	Polaris	57.133101	-135.36944	composite clams

*prepared and analyzed in duplicate

Table 2: Selected metrics for the samples studied.

Matrix	Source	Source	Source	Water	Water	Sheen	Sheen	Tissue	Tissue
Client ID	2017-05-04-01-01	2017-05-04-01-01	2017-05-04-01-02	FPN J17008-001	FPN J17008-002	FPN J17008-003	FPN J17008-004	2017-05-03-01-02	2017-05-03-01-03
Lab ID	1708008-01	1708008-01D	1708008-02	1708008-03	1708008-04	1708008-05	1708008-06	1705003-01	1705003-02

Concentrations	mg/kg	mg/kg	mg/kg	mg/L	mg/L	mg/kg*	mg/kg*	ug/kg	ug/kg
TPH	823000	820000	560000	118	nd	6640000	3970000	na	na
TPAH50	18714	18345	5462	0.57	0.001	58816	12909	151	95
Hopane	2.8	2.7	41	0.001	nd	73	157	na	na

*concentrations are biased high due to low gravimetric oil weights

Diagnostic Ratios

C17/Pr	1.4	1.4	1.3	1.1	ndp	0.0	0.7	na	na
C18/Ph	1.9	1.9	1.8	1.2	ndp	0.1	0.9	na	na
Pr/Ph	1.7	1.7	1.6	1.1	ndp	1.3	0.9	na	na
DBT2/PA2	0.80	0.81	0.80	1.06	ndp	0.97	0.88	0.91	0.88
DBT3/PA3	1.08	1.08	1.10	1.35	ndp	1.33	1.39	1.23	1.19
Ts/Hop	0.00	0.00	0.22	0.23	ndp	0.37	0.24	na	na
Tm/Hop	0.00	0.00	0.25	0.26	ndp	0.46	0.28	na	na
H29/Hop	0.00	0.00	0.83	0.75	ndp	0.94	0.70	na	na

nd: not detected; na: not analyzed; ndp: no determination possible

Table 3: Forensic classification for the six environmental samples studied.

Environmental Samples

Water	Water	Sheen	Sheen	Tissue	Tissue
FPN J17008-001	FPN J17008-002	FPN J17008-003	FPN J17008-004	2017-05-03-01-02	2017-05-03-01-03
1708008-03	1708008-04	1708008-05	1708008-06	1705003-01	1705003-02

Fingerprint Classification

Match	Indeter-minate	Non-Match	Match	Possible Match	Possible Match

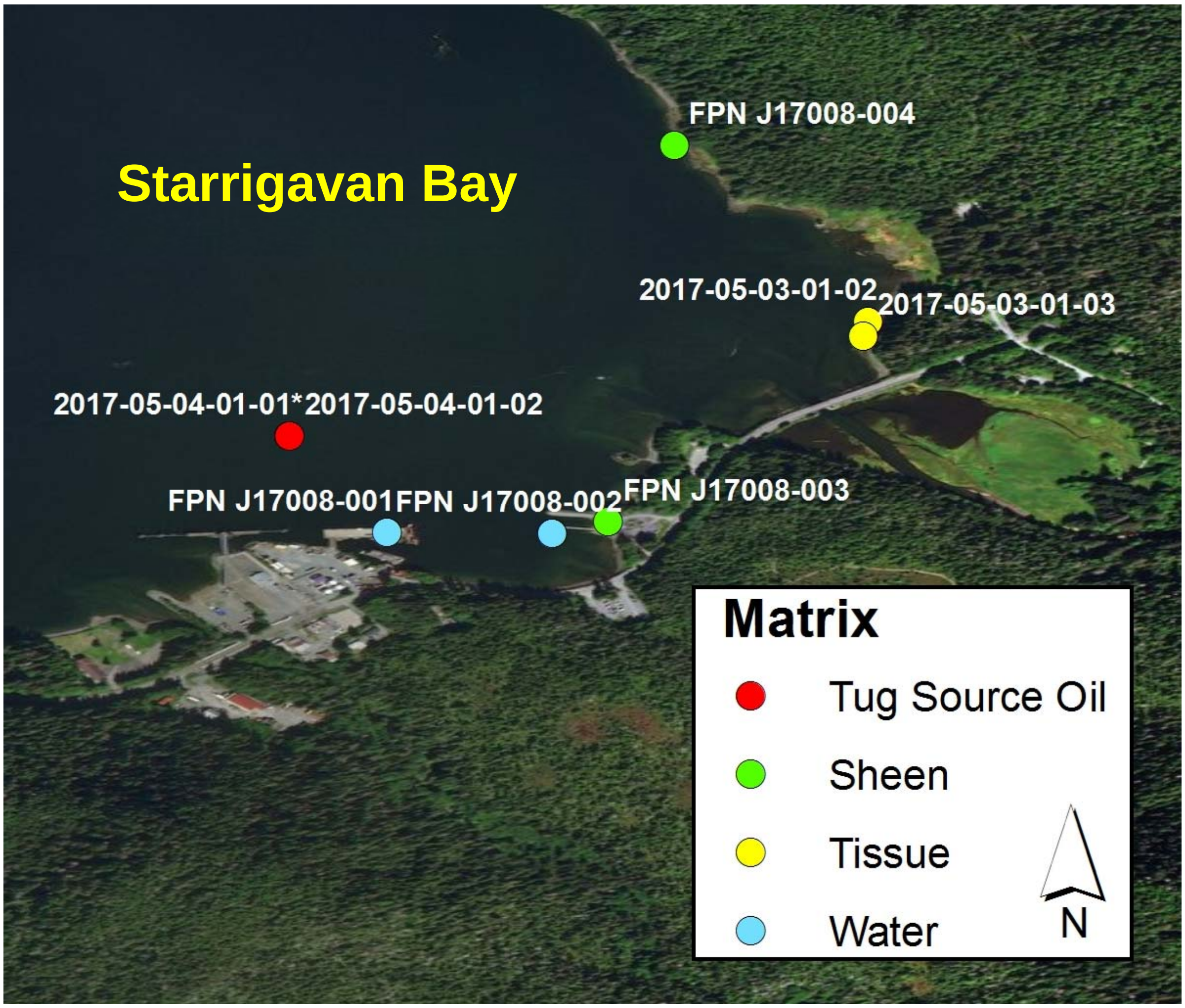


Figure 1: Aerial photograph showing the locations of the samples studied. Sample IDs and locations provided in Table 1.

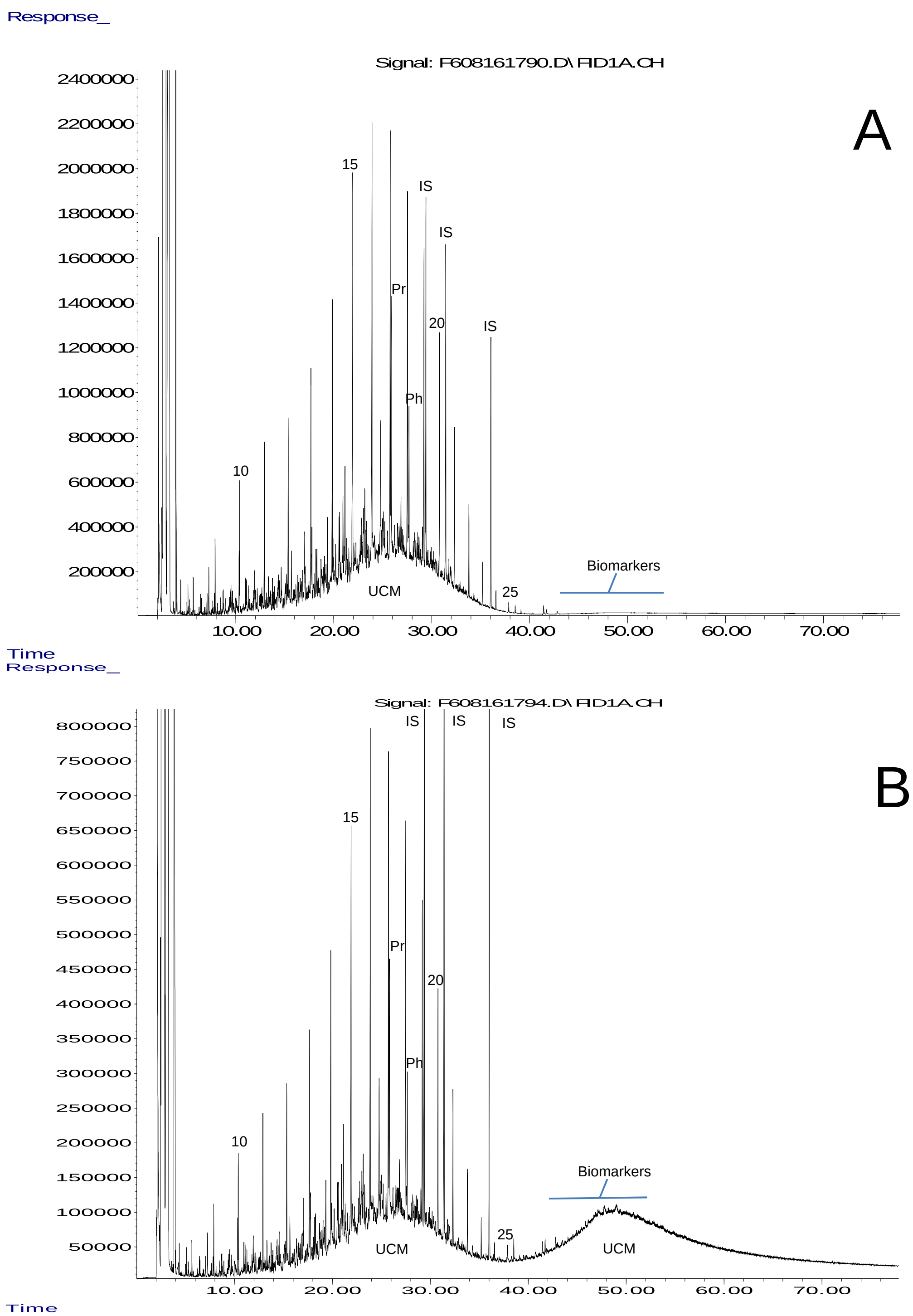


Figure 2: GC/FID chromatograms for the two source oil samples collected from the sunken *Powhatan* tugboat; (A) 2017-05-04-01-01 and (B) 2017-05-04-01-02. #: n-alkane carbon number; Pr: pristane; Ph: phytane; UCM: unresolved complex mixture; IS: internal standards.

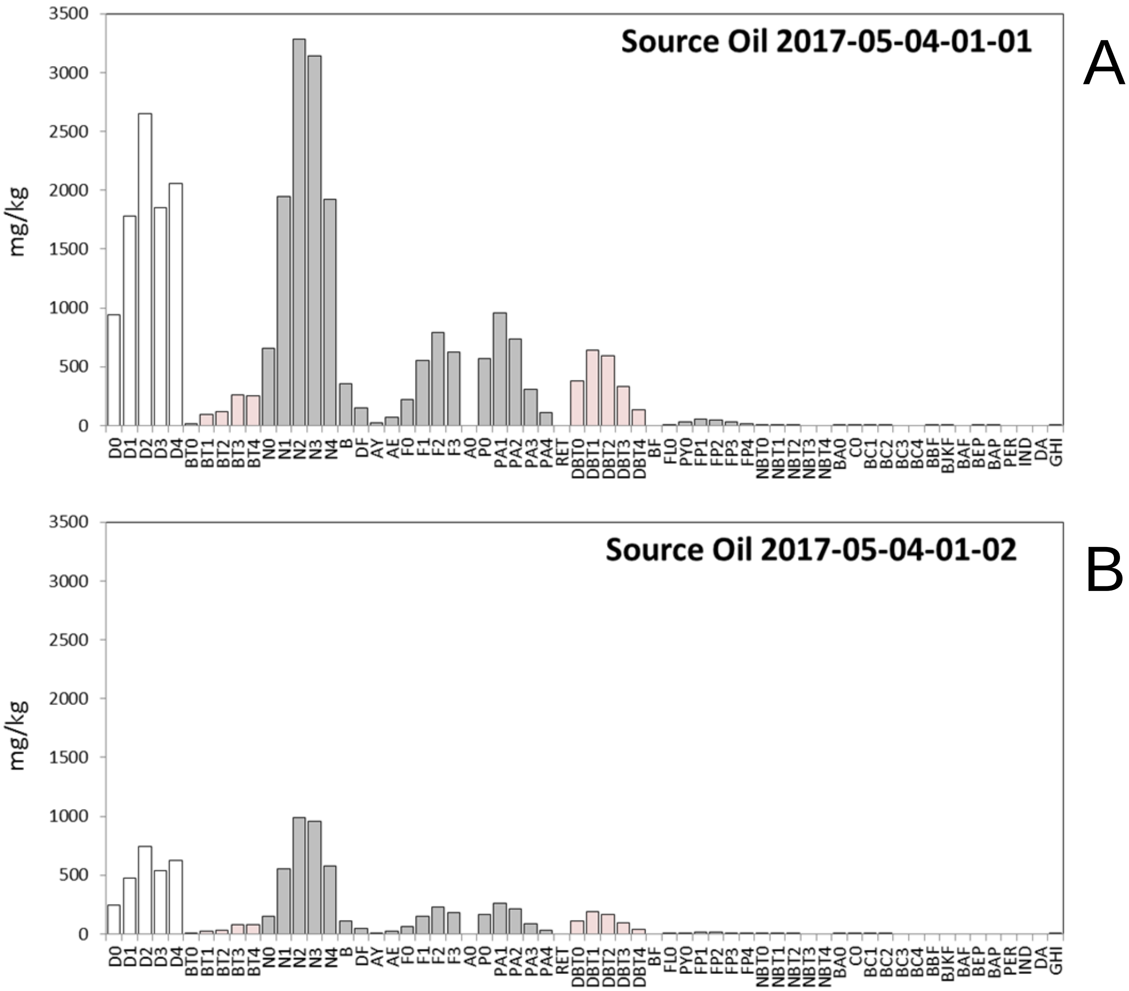


Figure 3: Histograms showing the concentrations of PAH and related analytes in the two source oil samples collected from the sunken *Powhatan* tugboat; (A) 2017-05-04-01-01 and (B) 2017-05-04-01-02. Key: decalins (white); PAHs (light grey); sulfur-containing aromatics (pink). Compound abbreviations provided in Alpha data package.

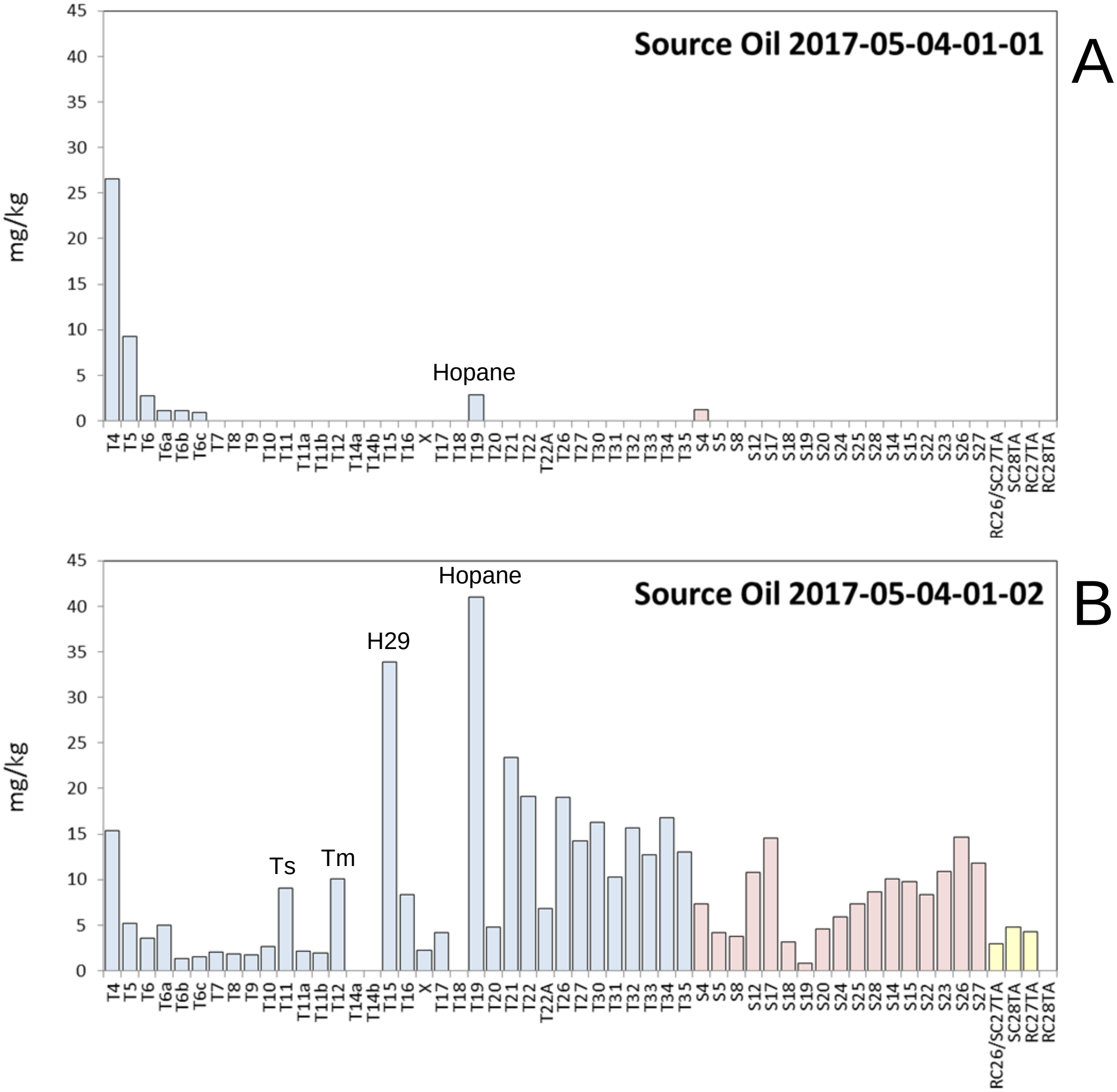


Figure 4: Histograms showing the concentrations of biomarkers in the two source oil samples collected from the sunken *Powhatan* tugboat; (A) 2017-05-04-01-01 and (B) 2017-05-04-01-02. Key: triterpanes (blue), dia- and regular steranes (red), and triaromatic steroids (yellow). Compound abbreviations provided in Alpha data package. Ts, Tm, H29 and Hopane peaks are indicated as they are discussed in the text.

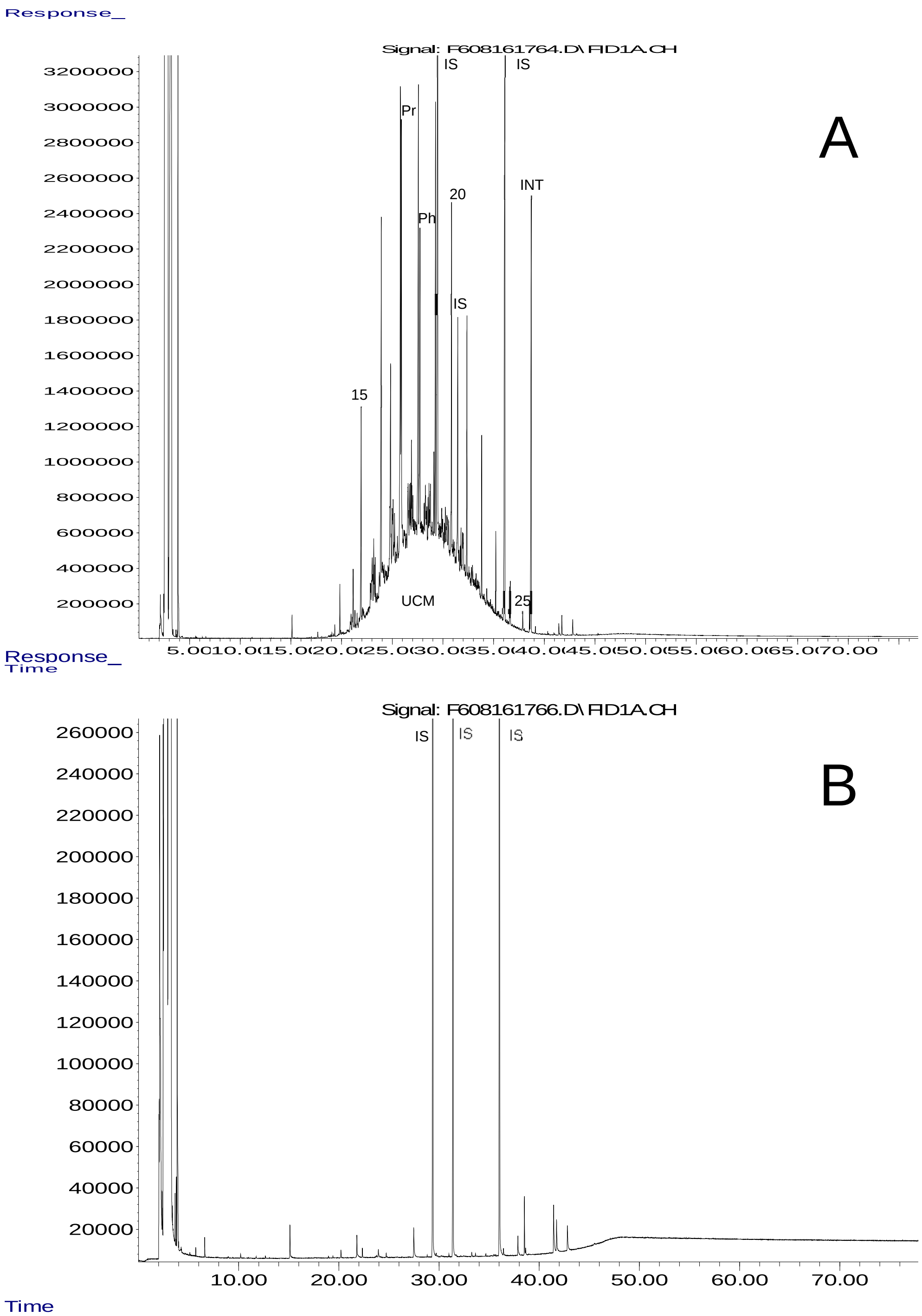


Figure 5: GC/FID chromatograms for the two water samples (A) FPN J17008-001 (Samson Pier) and (B) FPN J17008-002 (freshwater at end of other pier). #: n-alkane carbon number; Pr: pristane; Ph: phytane; UCM: unresolved complex mixture; IS: internal standards.

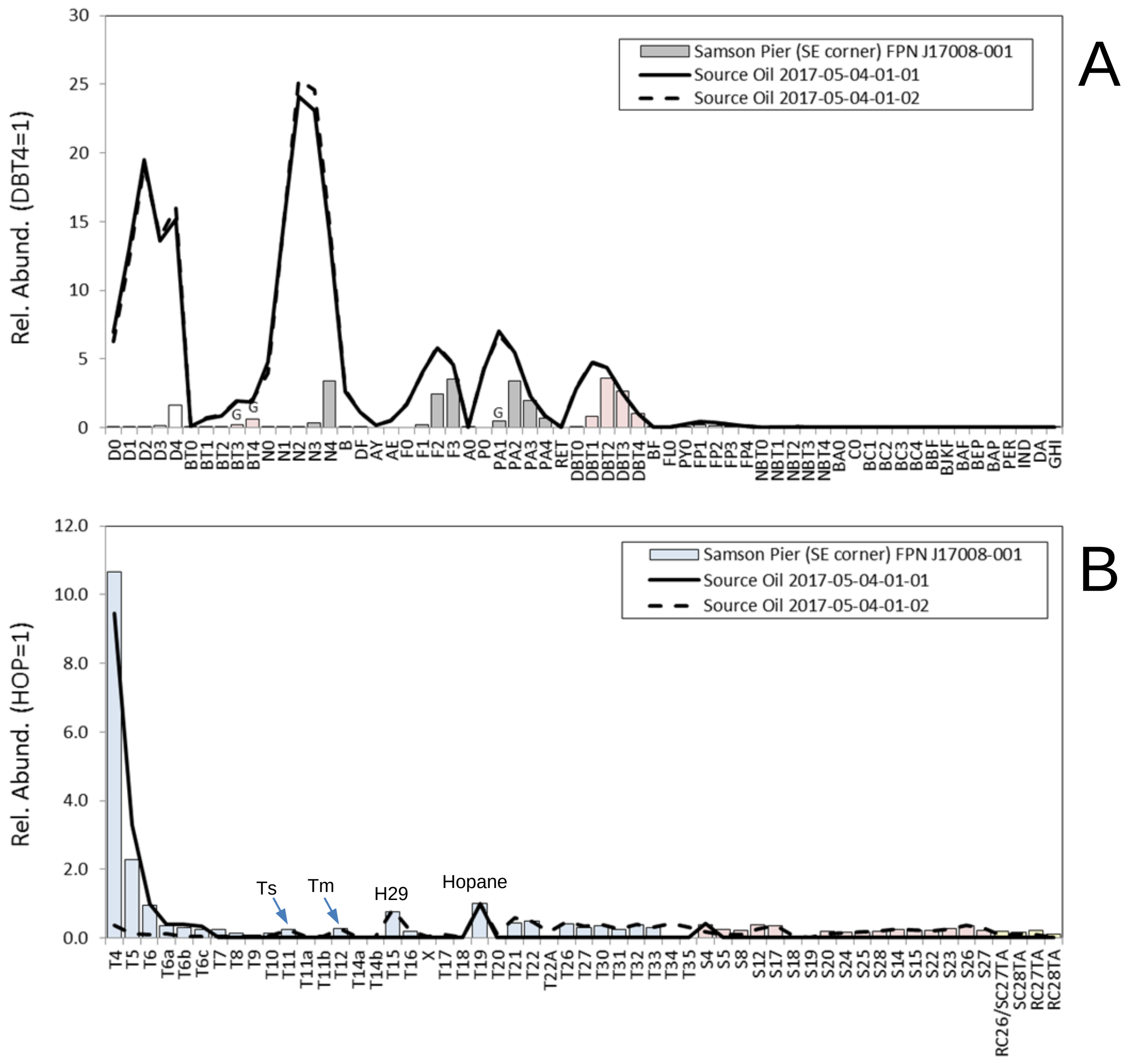


Figure 6: Normalized distributions of (A) PAHs and (B) biomarkers in the FPN J17008-001 water sample collected April 25, 2017 from the Samson Pier versus the two source oil samples collected from the sunken *Powhatan* tugboat. PAHs are normalized to C4-dibenzothiophenes (DBT4) and biomarkers are normalized to hopane (T19). G: interferant reported by the laboratory for these analytes.

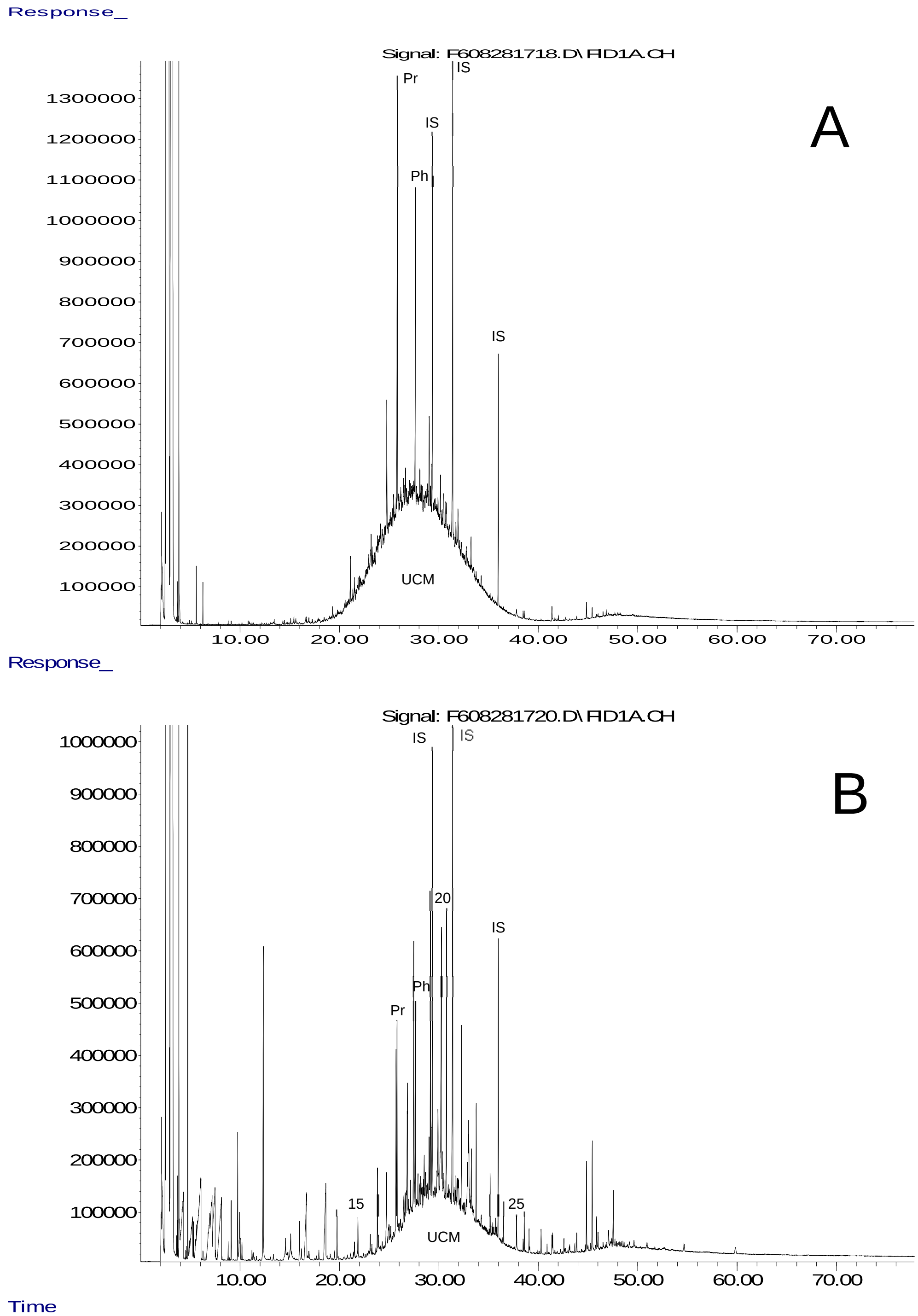


Figure 7: GC/FID chromatograms for the two sheen samples collected April 26, 2017; (A) FPN J17008-003 (boat ramp by jetty) and (B) FPN J17008-004 (Mosquito Trail). #: n-alkane carbon number; Pr: pristane; Ph: phytane; UCM: unresolved complex mixture; IS: internal standards.

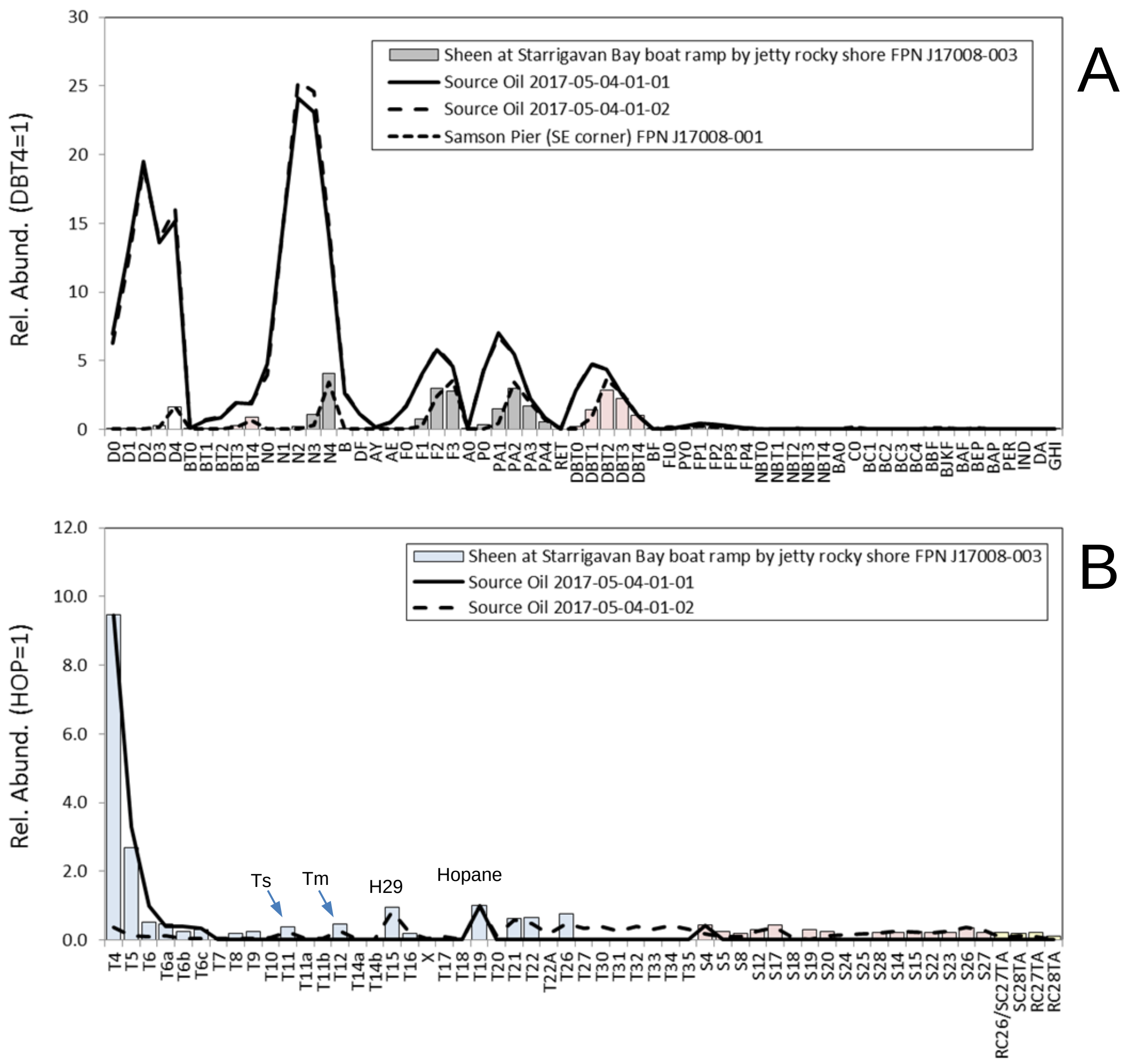


Figure 8: Normalized distributions of (A) PAHs and (B) biomarkers in the FPN J17008-003 sheen sample collected April 26, 2017 from near the boat ramp versus the two source oil samples collected from the sunken *Powhatan* tugboat. Normalized distribution of PAHs in the FPN J17008-001 water collected from Samson Pier is included in (A). PAHs are normalized to C4-dibenzothiophenes (DBT4) and biomarkers are normalized to hopane (T19).

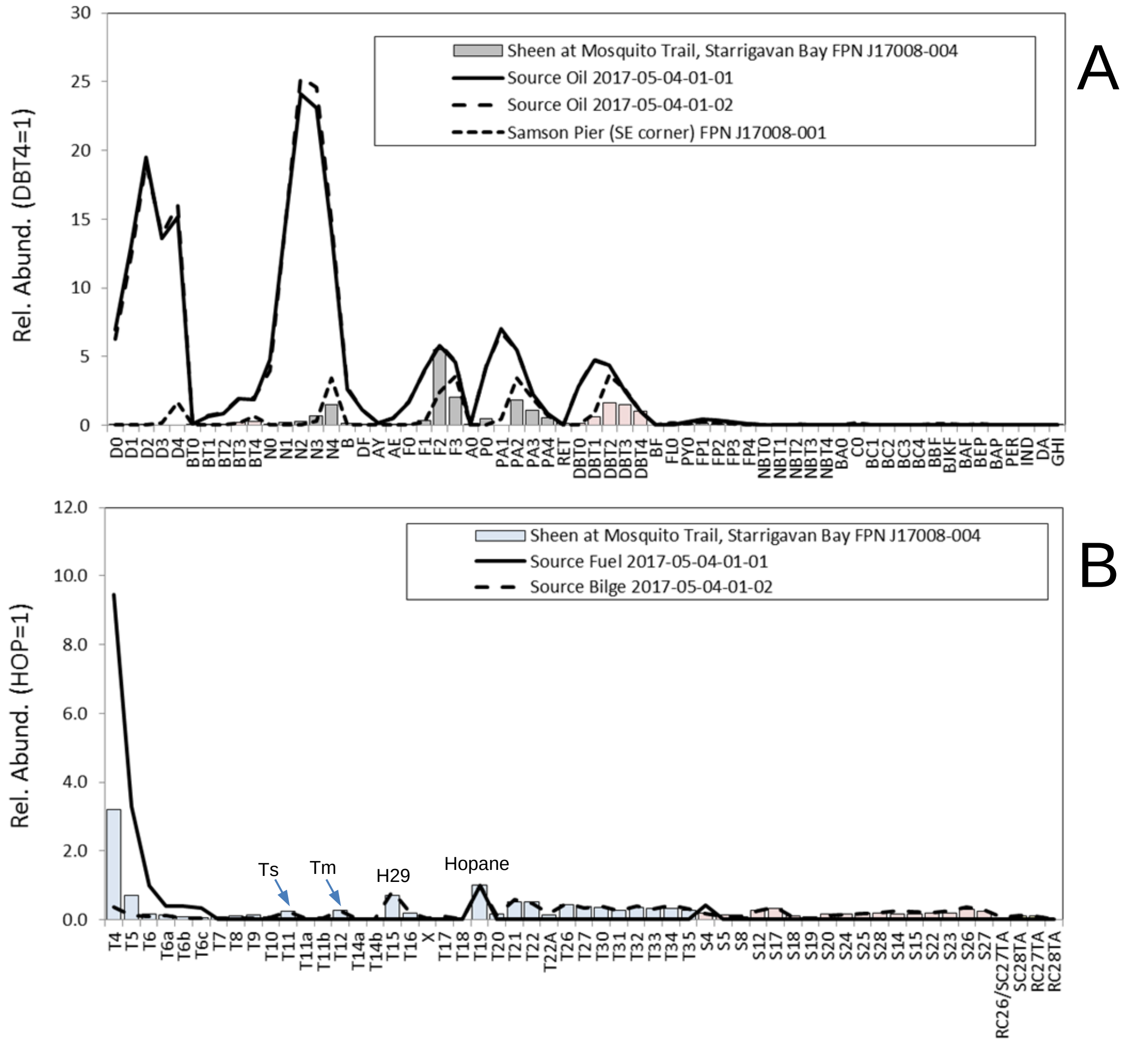


Figure 9: Normalized distributions of (A) PAHs and (B) biomarkers in the FPN J17008-004 sheen sample collected April 26, 2017 from near eastern Starrigavan Bay versus the two source oil samples collected from the sunken *Powhatan* tugboat. Normalized distribution of PAHs in the FPN J17008-001 water collected from Samson Pier is included in (A). PAHs are normalized to C4-dibenzothiophenes (DBT4) and biomarkers are normalized to hopane (T19). Noted: elevated relative abundance of F2 in (A) is attributed to baseline rise (flat baseline integration); common in low concentration samples

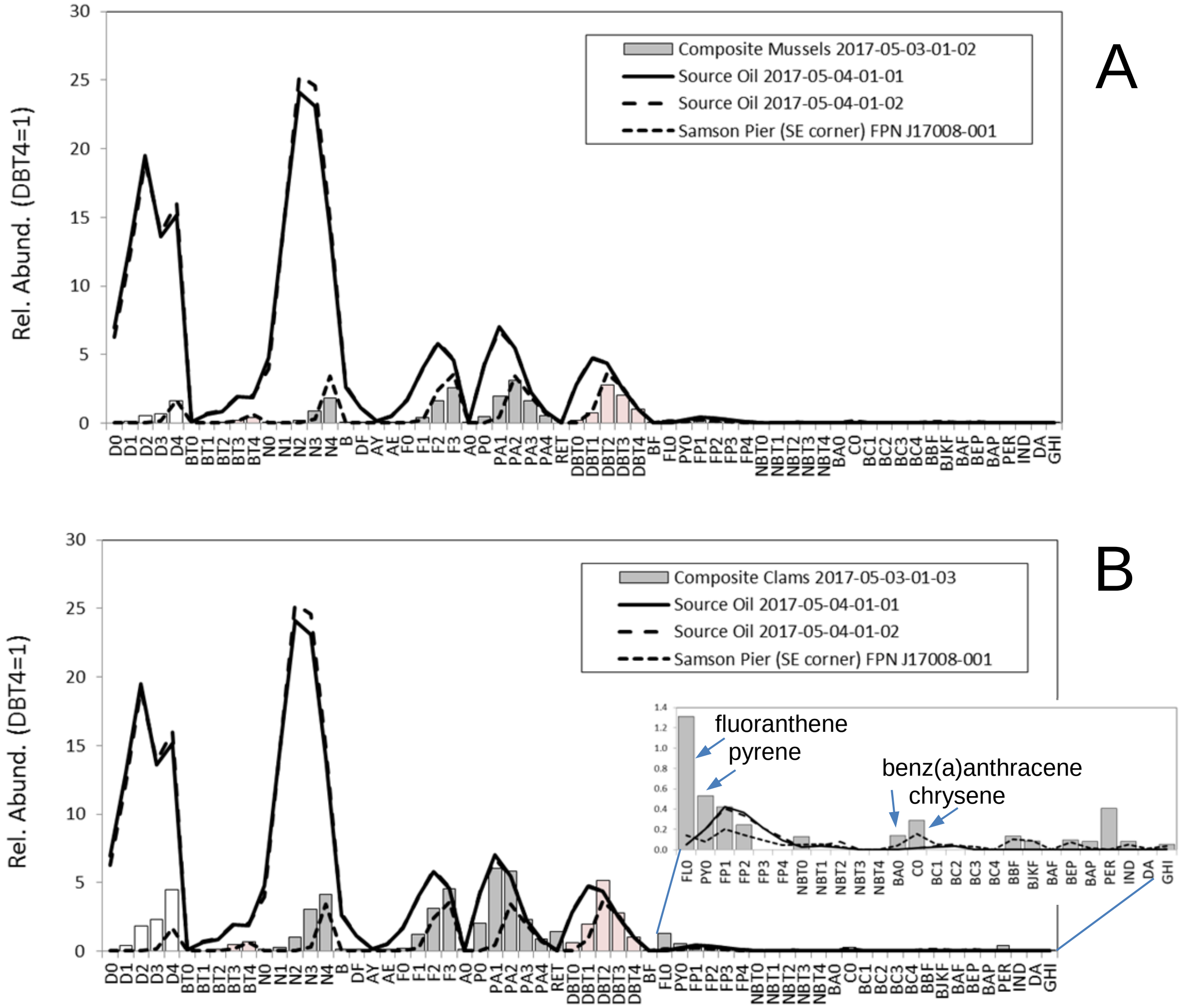


Figure 10: Normalized distributions of PAHs in (A) 2017-05-03-01-02 composite mussels and (B) 2017-05-03-01-03 composite clams collected May 3, 2017 versus the two source oil samples collected from the sunken *Powhatan* tugboat and the FPN J17008-001 water collected from Samson Pier. Inset in (B) shows expanded view of higher molecular weight PAHs. PAHs are normalized to C4-dibenzothiophenes (DBT4).

APPENDIX B: ICHTHYOPLANKTON SURVEYS

SITKA SOUND
SCIENCE CENTER
834 Lincoln Street, Suite 200
Sitka, Alaska 99835
Admin Phone: 907.747.8878
Email: lbusch@sitkascience.org

September 21, 2017

Scott Friedman
Principal
Industrial Economics, Incorporated (IEc)
2067 Massachusetts Ave.
Cambridge, MA 02140
617.354.0074
www.indecon.com

Dear Scott,

Attached please find the field notes, logs, data sheets and results from our work regarding sampling for herring spawn, larvae, and salmon smolts in the vicinity of the Powhatan sinking incident (POW). According to the ADF&G Sitka Sound Herring Fishery Update 11, the most recent spawn within the survey area occurred on April 8, 2017.

We agreed to look at areas as outlined in the map provided by Sarah Allen (attached) to conduct ichthyoplankton surveys to sample for density of larval herring/m^3, dive surveys to evaluate presence of herring spawn deposition (unhatched eggs), and beach seines to collect density of salmon smolts adjacent to the sinking site (figure 1). It is understood that these data should not be extrapolated for abundance or biomass estimates for a larger area but are rather intended to document presence/absence of herring eggs, larva, and salmon smolts in the study area.

After the ADFG permit was secured by IEc on 4/26/17 we began field operations. Gale force winds developed on 4/27 and field work was curtailed for safety.

Dive Operations: (dives identified as POWD and sequence number)
Field sampling methods were modeled after the ADF&G spawn deposition surveys. During the first day of diving, April 27, divers were shown ADF&G sampling methods by a former ADF&G diver, David Gordon. Transects were chosen randomly within the survey area with a minimum distance of 0.1 nautical miles between transect sites (figure 2). Transect direction was determined by establishing a compass bearing perpendicular to the shoreline using the physical features of the actual dive locations. Transects began at the highest point of the shore where eggs were observed and continued for a minimum transect distance of 30 meters or until no further egg deposition was observed. Following the ADFG methods taught, divers did not place or record sampling frames when no eggs were present

The ADF&G sampling procedures involve a two-stage design, the same design was used for these surveys. The dive sampling procedures involved two-person dive teams swimming along the transects and recording visual estimates of the number of eggs within a 0.1 m^2 sampling frame placed on the bottom at 5 meter intervals. A reference of 40,000 eggs per full single layer of eggs within the sampling frame was used to help estimate the number of eggs. This number was determined mathematically and is outlined by the ADF&G procedures. A photograph of each sampling frame was taken except where camera malfunctions were encountered on dives 2 and 6. No egg deposition was observed in frames not photographed. Additional data recorded included the substrate type, primary vegetation type within the sampling frame, percent vegetation coverage within the sampling frame and depth. A total of 7 dives were made (Figure 2).

Egg Density

Due to the fact that during all diving transects only three (3) sample frames contained herring eggs, we are not comfortable making density estimates. Transect 4 contained two (2) sample frames with egg deposition totaling less than an estimated 15,000 eggs over a transect distance of 50 meters and transect 6 contained a single sample frame with less than an estimated 1,000 eggs over a transect distance of 45 meters. Within transect 6, divers observed detached eggs in the water column but almost no egg deposition on vegetation or substrate. While eggs were not abundant within the transects, egg deposition was observed and noted above the bottom on *Macrocystis*. Most observations indicated eggs had previously hatched and only remnants were present.

Larval Herring Sampling (tows identified as POWT and sequence number)

The SSSC did not have a plankton net with 500-micron mesh as recommended for survey of larval herring (Ron Heintz, NMFS Auke Bay Laboratory). We ordered a General Ocean 2030R flow meter for our 235-micron plankton net (50 cm opening) and also ordered a 500 micron mesh bongo net (60 cm openings) and Sealife MF315 flow meter for that net. Arrival of this equipment delayed the start of the ichthyoplankton surveys.

On 4/28/17 the Bongo net had not yet arrived so we decided to use the 235-micron plankton net to begin our survey. Bowers calibrated the flow meter and mounted it within the mouth of the plankton net.

The ADFG permit limited our capture of herring larvae to 1000 fish. Our original sampling plan was to space plankton tows, 3 across the channel, from Kasianna Island to Starrigavan Bay for a total of 12 tows each of a 10-minute duration. However, once we got on site and made one 10-minute tow with the 235 plankton net it was obvious that the net was clogged with phytoplankton and the flow meter was not accurately measuring flow. A large number of small fish larvae were present in the sample. We decided given the limitation on the permit we would release this sample as it we would not have been able to determine density given equipment failure.

On 4/29/17 the Bongo net with arrived and we proceeded to the sampling location. Given the apparent density of larval fish in the plankton net we decided to reduce the tow time to 5 minutes and release the B side samples. Tow duration was timed using a stop watch. Start and stop locations were recorded by the skipper of the Blue Dawg. Three tows were made east of Kasianna Island Small fish larvae were visually noticeable in all three samples, but in large quantity in Tow 2. Samples from the A side of the net were retained and preserved in 10% buffered formalin. Jars were labelled externally and with an internal tag.

The vessel returned to the dock mid-day and I attempted to contract Eric Coonradt, ADFG manager to discuss potential of exceeding permitted herring larva retention. I had no luck and sent him an email requesting he call my cell.

The sampling design was modified to reduce the number and length of tows in an attempt to stay within permitted limits. The vessel moved to the most northerly sample sites, adjacent to Starrigavan Bay and 3 3-minute tows were conducted. Again, samples were retained from the A side net only and preserved in 10% buffered formalin. Samples from this area had noticeable gelatinous plankton, some macro debris of algae, eelgrass and spruce needles. Jars were labelled externally and with an internal tag.

A total of 6 bongo net tows (POWT2-7) were used to enumerate sample specific density of larval herring (figure 3).

Laboratory analysis
Jarred samples were taken to the SSSC laboratory. For each sample, the sample was poured from the sample jar into a glass beaker. The plankton was given time to settle (10 minutes) and excess solution was decanted through a filter. A glass pipette was used to stir the sample in a figure 8 pattern to equally distribute plankton throughout the whole sample. The pipette was then used to draw subsamples (1-4 ml each). Each subsamples was placed in a petrie dish. A dissecting microscope was used to magnify plankton and larval herring were counted. We did not attempt to enumerate or identify other plankton. Larval herring from sample 2A was compared with newly hatched herring larvae from the SSSC aquarium to verify identification. After counting, the subsample was returned to the sample jar, in some cases 10% buffered formalin was used to wash samples back into jar, changing total volume of stored sample. These jars are now in a sampling bucket in my office.

Density of larval herring was estimated using the following:
Distance of the tow (m) was estimated by multiplying the flowmeter count by the flowmeter constant of 0.245. The speed was then calculated by dividing the length of tow by the duration of the tow in seconds. Volume (m3) was calculated as the product of Pi x r^2 x length (Table 1).
Density of larval herring ranged from 13.59 fish/m^3 to 530.44 fish/m^3 with the highest density closest to Kasianna Island (POWT2) and the lowest density closest to the Powhantan site (POWT5).

Total herring larvae collected is estimated at 22,911 – much greater than our permit allowed. During field operations we attempted to limit sample sizes to a reduced level to avoid this possibility while still providing useful information on the distribution of larvae. Until the samples were analyzed in the laboratory I had no idea on the magnitude of catch. Mr. Coonradt called me on 5/1/17 and we discussed the overage. The total sample is within the fecundity of a single adult herring and he was not concerned by the overage. He called the permitting office to let them know he was not concerned with the sample size. In reporting to ADFG we are to document the steps we took to limit catch as well as our correspondence with Mr. Coonradt.

Beach Seine Sampling for Salmon Smolt (seines identified as POWS and sequence number).
David Magnus led the beach seine team on 4/28/2017. There was a -2.4’ lowtide at 09:01 hours. The team used a 25’x 5’ beach seine with 1/8” mesh. Sampling design was to make 4 beach seines in Starrigavan Bay straddling either side of Starrigavan Creek (figure 4).

The ADFG permit did not allow for retention of fish except of retention of up to 2 of each species for unidentified species. Consequently, the strategy was to count fish quickly in the field to minimize handling stress. To document species composition of salmonid smolts, and to estimate weight of sample fish were placed into a tote and dipnet samples were taken.

Chum salmon smolts dominated the catch followed by pink salmon. A total of 2 coho salmon and 1 coho fry were taken. Chum were almost twice as big at POWS4 (mean wt 1.878 g) as they were at POWS1 (0.77 g) perhaps indicating hatchery fish at POWS4.

I noticed in the field notes and on the data forms salmon juveniles were referred to as both smolts and fry. With the exception of one coho salmon that was still in fry coloration all salmon juveniles captured were smolts.

Density of salmon smolts
Volume was estimated as ½ the product of the area (length x width) seined x maximum depth. Salmon smolt densities ranged from 0045 fish/m^3 to 6.3 m^3 with almost no salmon captured directly adjacent to fresh water. The most fish were captured at POWS1 and POWS4 (figure 5).

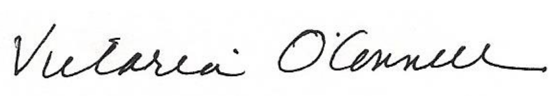
All seined fish were released as required by ADFG permits.

Conclusions

- On 4/28/17 there were larval herring present throughout the sampling area with the highest density at the southwest corner of the study area.
- The dives indicated that by 4/27 and 4/28 most herring eggs along the transects had previously hatched and it was therefore difficult to estimate density of spawn. Some eyed eggs were seen adjacent to transects with the majority of the unhatched eggs noted near Kasianna Island.
- Salmon smolts were resident in Starrigavan Bay on 4/28 with chum salmon and coho salmon dominating. Two different size classes of chum salmon, with chum salmon at POWS1 being half the weight of those at POWS4.

I have uploaded all the data sheets and field notes along with photos onto the shared drive provided to me by ICe. Please feel free to contact me if you have questions or require additional information.

Sincerely,



Victoria O'Connell
Research Director

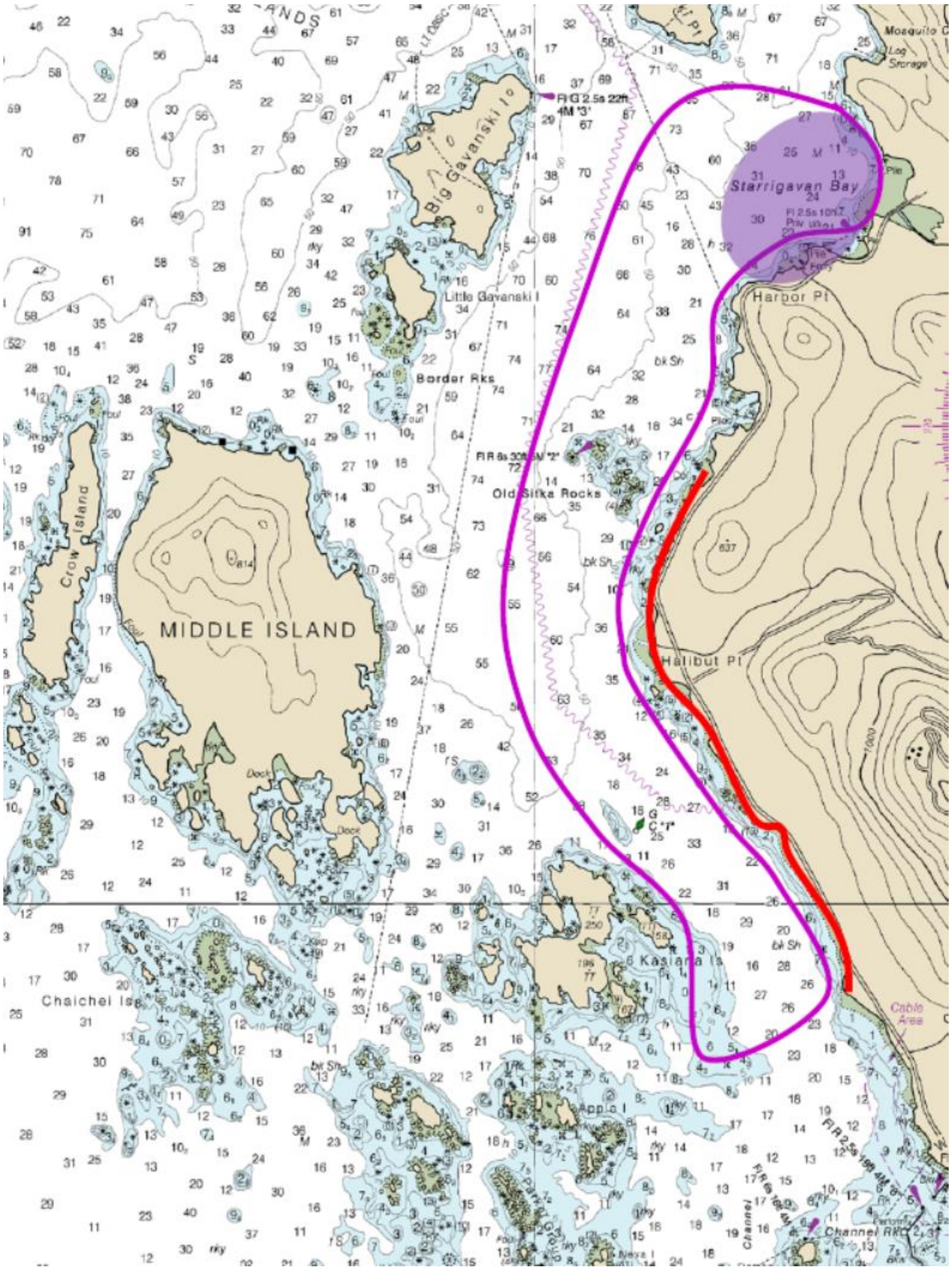


Figure 1. Study area as outlined by Sarah Allen, NOAA.

Figure 2. Dive locations to survey herring egg deposition.

Figure 3. Start locations of Bongo net tows with estimated density of larval herring per cubic meter.

Figure 4. Beach seine start locations with salmon smolt density per cubic meter.

Table 1. Net samples estimates of volume sampled and density of larval herring/m^3.

Bongo Net	*4/29/17*									
60 cm diameter each side	*500 um*	*100 cm*	*retained cup A only*							
M315 Impeller constant	*0.245*									
distance =	*total counts x constant = m*									
speed =	*total counts x constant/recorded time in sec = m/s*									
volume =	*Pi x r2 x length (m)*									
Tow	*seconds*	*Flow start*	*Flow end*	*Imp. ct*	*flow calc distance m*	*speed m/s*	*Vo* M^3	*larval herring /ml*	*larvae/ sample*	*Herring/* m^3
Bongo net										
2	*332*	*0*	*402.1*	*402.1*	*98.51*	*0.296*	*27.8*	*109.43*	*14772.8*	*530.44*
3	*318.98*	*410*	*924.5*	*514.5*	*126.05*	*0.395*	*35.6*	*8.2*	*3065.71*	*86.12*
4	*299.97*	*979.1*	*1603*	*623.9*	*152.86*	*0.509*	*43.2*	*8.88*	*1775.00*	*41.09*
5	*181.03*	*1622.1*	*2133.8*	*511.7*	*125.37*	*0.695*	*35.4*	*0.88*	*481.25*	*13.59*
6	*201.13*	*2133.8*	*2607.2*	*473.4*	*115.98*	*0.576*	*32.7*	*5.13*	*1537.50*	*47.02*
7	*203.31*	*2607.2*	*3065.8*	*458.6*	*112.36*	*0.552*	*31.7*	*1.56*	*1281.25*	*40.46*
								Total:	*22911.5*	
Plankton net	*4/28/17*									
50 cm diameter	*235 um*	*100 cm*	*flow meter not working here so will not use this tow and released sample*							
1	*623*	*0*	*3610*	*207.791*	*207.798*	*0.3335*	*10.1*			

APPENDIX C: MATERIAL DENSITY VALUES

APPENDIX C | MATERIAL DENSITY VALUES

Table C.1 lists densities for materials we assumed to be common components of marine debris items. Additionally, we list the densities of various materials, with their specific principal component material(s). Some density values are for the material alone (e.g., nylon), while others are an average of the material densities for different types of the material included (e.g., plastics, plastic bottles, rope).

Densities are reported in grams per cubic centimeter, but for the purposes of this scaling effort we converted densities to pounds per cubic meter. We converted densities to values that combine Imperial and Metric System units because pounds are used to report weight of marine debris in the SSSC (2016) report, while other studies conducted (e.g., ichthyoplankton surveys, sheen footprint, chemical analysis) use Metric System units. The conversion factor for density in grams per cubic centimeter to pounds per cubic meter is 2,204.62.

TABLE C.1 MATERIAL DENSITIES

MATERIAL(S)	MATERIALS INCLUDED	DENSITY (G/CM3)	DENSITY (LBS/M3)
Metal	Aluminum, Steel, Titanium	5.08	11,207
Styrofoam	Polystyrene	0.23	506
Fishing Line, Banding	Nylon	1.15	2,535
Fishing Line	Fluorocarbon Monofilament	1.78	3,924
Line, Rope	Nylon, silk	1.23	2,701
Rope	Nylon, polyester, polypropylene	1.16	2,547
Foam	Polyurethane	0.04	86
Plastic bottles	High density polyethylene, Low low-density polyethylene, Polyethylene terphthalate, Polycarbonate, Polypropylene, Polystyrene	0.97	2,148
Plastic (PVC)	Polyvinyl chloride (PVC)	1.38	3,031
Plastics	Polyvinyl chloride, High density polyethylene, Low low-density polyethylene, Polyethylene terphthalate, Polycarbonate, Polypropylene, Polystyrene	1.17	2,590

Table C.2 lists the density value(s) we used for each marine debris category reported in the SSSC (2016) marine debris removal report. The densities were assigned to each category by using a representative material (e.g., nylon for the trawl and net category, since that is a predominant material for netting), or calculated using an average (e.g., other plastic is an average of PVC plastic and the various plastics included in the average density for plastic bottle materials). The proxy material densities used for each category are listed in Table C.2 with which values were included.

TABLE C.2 DENSITIES BY MARINE DEBRIS CATEGORY

MARINE DEBRIS CATEGORY (SSSC 2017)	DENSITY (LBS/M3)	DENSITY VALUES INCLUDED FROM TABLE C.1
Trawl and net	2,535	Nylon fishing line
Line and rope	2,927	Average of nylon fishing line, fluorocarbon monofilament fishing line, gillnets, and rope
Gillnets	2,701	Line, Rope
Floats	296	Average of Styrofoam and Foam
Other fishing related	3,317	Average of metal, Styrofoam, fishing line, line/rope, rope, foam, and PVC plastic
Banding	2,535	Nylon banding
Plastic beverage bottle	2,148	Plastic bottles
Other plastic	2,590	Other plastics: average of plastic bottles and PVC plastic
Metal	11,207	Metals
Foam	506	Styrofoam
Other non-vessel	3,127	Average of all categories

APPENDIX D: POROSITY FACTOR DERIVATION

APPENDIX D | POROSITY FACTOR DERIVATION

The calculation of the footprint of marine debris in this scaling method results in an area of a solid mass[1] of marine debris three inches high (0.08 meters). In reality, marine debris comes in all shapes and sizes, with different ratios of material to open air. For example, a gillnet when laid out flat, can occupy a large footprint, but in actuality, the material used to make that net only occupies a small percentage of the total area. Although nets and other marine debris are never perfectly flat, the object will maintain a constant porosity ratio (ratio of material to open space) regardless of the space it occupies.

To address the solid mass of the marine debris footprint (F), we calculated a porosity factor. This factor would more accurately reflect what is observed with marine debris. We used a paper that reported all the required net dimensions (e.g., mesh line diameter, mesh size, height, length) for various nets to calculate the area occupied by mesh netting relative to the entire footprint occupied by the net (Beneditto et al. 1998). Table D.1 reports the net dimension for six assorted net sizes.

TABLE D.1 NET DIMENSIONS (FROM BENEDITTO ET AL. 1998)

NET	MESH LINE DIAMETER (M)A	MESH SIZE (M)B	NET HEIGHT (M)C	NET LENGTH (M)D
1	0.0007	0.14	5.6	110
2	0.0015	0.17	3.1	32
3	0.0012	0.18	3.4	32
4	0.0005	0.07	1.8	53
5	0.0006	0.12	2.7	36
6	0.0005	0.10	10	120

a. Mesh line diameter is the diameter of the line used to make the net. Data were originally reported in millimeters but converted to meters here.
b. Mesh size is the size of the length plus the height of one square of mesh. Data were originally reported in centimeters but converted to meters here.
c. Net height is the height of the net if it were on a flat plane (rectangular in shape).
d. Net length is the length of the net if it were on a flat plane (rectangular in shape).

We used the values in Table D.1 to calculate the values in Table D.2, which resulted in the porosity factor (as a percent). We calculated the area of the mesh line used to make the net (m^2) and divided that by the area of the net (length multiplied by width; m^2) then multiplied that by 100 to get the porosity factor as a percent. To calculate area of the line we used the following equation:

[1] Mass here is defined as a body of material.

$$Area\ of\ Mesh\ Line = 2 * \left(\frac{Net\ Length}{Mesh\ Size}\right) * Net\ Height * Mesh\ Diameter$$

TABLE D.2 DENSITIES BY MARINE DEBRIS CATEGORY

NET	AREA OFMESH LINE (M^2)	TOTAL AREA OF NET (M^2)	NET POROSITY (%)
1	6.2	616	1.0
2	1.8	99	1.8
3	1.5	109	1.3
4	1.5	95	1.5
5	1.0	97	1.0
6	12.0	1,200	1.0
Average Porosity			1.3
Notes: Values may be off due to rounding.			

We calculated the porosity factor, assuming the net was two-dimensional, since calculating the net as three dimensional would increase the number of steps, but yield the same result (calculated for a cube-shaped object). This method overestimates the porosity factor, because the mesh line used to create the net is cylindrical, whereas calculating the porosity based on a footprint assumes the mesh line is a cube (i.e., diameter of the mesh line becomes the width of the mesh line). As such, the actual porosity would be 78.5% of the values we have here, but we kept the porosity factor as 1.3% because marine debris varies in porosity and nets are some of the most porous objects.

References

Beneditto, A. P. M. D., Ramos, R. M. A., & Lima, N. R. W. (1998). Fishing activity in northern Rio de Janeiro State (Brazil) and its relation with small cetaceans. Brazilian Archives of Biology and Technology, 41(3), 0-0.