

Form Rev. 10.3.14

**1. Program Number:** *See*, Reporting Policy at III (C) (1).

15120114-S

**2. Project Title:** *See*, Reporting Policy at III (C) (2).

Long-term Monitoring: Lingering Oil - Extending the Tracking of oil levels and weathering (PAH composition) in PWS through time

**3. Principal Investigator(s) Names:** *See*, Reporting Policy at III (C) (3).

Mark Carls, Mandy Lindeberg

**4. Time Period Covered by the Report:** *See*, Reporting Policy at III (C) (4).

February 1, 2015 - January 31, 2016

**5. Date of Report:** *See*, Reporting Policy at III (C) (5).

March 1, 2016

**6. Project Website (if applicable):** *See*, Reporting Policy at III (C) (6).

<http://www.gulfwatchalaska.org/monitoring/lingering-oil/lingering-oil-weathering-and-tracking/>

**7. Summary of Work Performed:** *See*, Reporting Policy at III (C) (7).

**Key Findings:**

- A new forensic biomarker model provides more source information than the standard Nordtest approach.
- *Exxon Valdez* oil was definitively identifiable with biomarkers in sequestered oil from 1989 to 2015.
- Biomarker concentrations initially increased as the oil lost volatile components.
- Biomarker concentrations generally declined thereafter; rates varied within and among beaches.
- Differential biomarker weathering was observed.
- Biomarkers generally weathered less loss in the Gulf of Alaska (except Cape Gull) than in Prince William Sound.
- Polynuclear aromatic hydrocarbon (PAH) weathering patterns were similar, though the process was more rapid for these smaller molecules.
- Current PAH loss rates are low, demonstrating oil deposits are no longer a threat for organisms that live outside of beach sediment.
- PAH and alkane loss rates decreased with molecular mass; this is controlled by thermodynamics.

Appendix A (*see accompanying pdf document*) contains three draft papers in support of these observations. Chapter X reviews PAHs and alkanes across multiple sites in Prince William Sound (PWS) and the Gulf of Alaska from the year of the spill (1989) through the most recent

collection (2015). Chapter Y presents the biomarker history from 1989 to 2014; this was written and submitted to a journal before completion of the 2015 data. Chapter Z adds the 2015 biomarker data and places them in the historical context. It significantly improves on interpretation of the biomarker record by interpreting the weathering patterns and finding that biomarker loss rates are generally higher in PWS than in the Gulf of Alaska, consistent with the same geographic pattern observed for PAHs.

- Field sampling has been completed to determine the quantity and weathering state of oil on 9 PWS beaches. We proposed 10 sites would be sampled but due to higher charter and fuel costs the survey was reduced by one day. Samples have been processed and quantified. A report is being drafted. Preliminary results are:
  - The total mass of oil varied from 0 to 3,600 kg per beach; no oil was discovered at Evans Island (EV039A) and one of the Eleanor Island beaches contained the most oil (EL056C; Figure 1). Proportionate oiling ranged from 0 (EV039A) to 40% (EL056C) overall based on the number of oiled pits or 0 to 30% when based on oiled area (Table 1).
  - The amount of oiling was consistent with previous estimates; in general the proportion oiled remains the same (Figure 2). The percent oil discovered increased in one beach (EL058B), declined in another (EV039A) and remained constant in the others. This variance is likely simply statistical noise; on average the amount of oil remaining is roughly the same.
  - Polynuclear aromatic hydrocarbons (PAHs) were not discovered in passive samplers deployed on one beach in 2015; total PAH concentrations were low and modeling revealed no oil. Concentrations in field samples were about the same as in blanks. In sharp contrast, samplers deployed in 2002 in Herring Bay acquired orders of magnitude greater total PAH concentrations and they were petrogenic.

Table 1. Estimates of oil remaining in Prince William Sound beaches in 2015; % oiling is calculated on an area basis (pit area / total area) and % oil is based on the number of oiled pits divided by the total number of pits on that beach. Mmodel is the predicted %oil by a model (Nixon and Michel 2015).

SiteCode	Location	Segment	Length	m	m <sup>2</sup> Site Area	m <sup>2</sup> Oil Area	per area %Oiling	Est. based on n pits % oil	Mmodel
1	Eleanor Is.	EL056C	90		13,212	3,898	29.5%	40%	>30%
2	Eleanor Is.	EL058B	51		9,372	1,698	18.1%	30%	>30%
3	Evans Is.	EV039A	109		26,716	0	0.0%	0%	1-5%
4	Greens Is.	GR103B	100		20,742	802	3.9%	10%	1-5%
5	Herring Bay	KN0114A	68		13,605	1,855	13.6%	23%	>30%
6	Herring Bay Knight	KN0300A-2	52		11,135	267	2.4%	3%	1-5%
7	Island	KN0506A	50		9,171	13	0.1%	3%	0-1%
8	Sleepy Bay	LA018A-1	100		15,722	71	0.5%	4%	5-15%
9	Smith Is.	SM006B	100		28,014	2,504	8.9%	22%	>30%

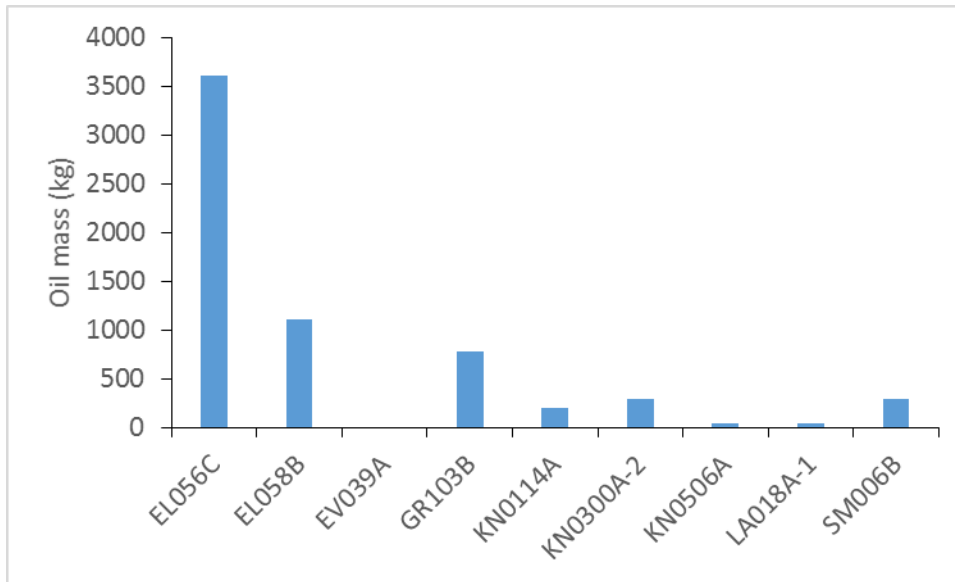


Figure 1. Total oil mass per beach surveyed in Prince William Sound summer of 2015.

#### Project Status for year 4:

Deliverable/Milestone	Status
Objective 1: field work	Field work is complete.
Objective 2: supplemental analyses	No supplemental analyses have been requested by other Gulf Watch researchers.
Objective 3: hydrocarbon database	Maintenance of the hydrocarbon database is up to date through 2015 and available on Ocean Workspace/public.
Objective 4: Reporting	Reports have been submitted as required and publications have been published and drafted.

#### 8. Coordination/Collaboration: *See*, Reporting Policy at III (C) (8).

We continued collaboration with the Prince William Sound Regional Citizens' Advisory Council on long-term environmental monitoring, an Alaska Department of Fish and Game bird study (outside PWS), and hydrocarbon contamination in Cordova Harbor (Ivy Patton, Environmental Coordinator Native Village of Eyak).

#### 9. Information and Data Transfer: *See*, Reporting Policy at III (C) (9).

#### Publications and Reports:

- Carls MG, Larsen ML, Holland LG. 2015. Spilled oils: static mixtures or dynamic weathering and bioavailability? Plos One DOI:10.1371/journal.pone.0134448.
- Carls MG, Holland L, Pihl E, Zaleski MA, Moran J, Rice SD. 2015. Polynuclear aromatic hydrocarbons in Port Valdez shrimp and sediment. Report to Prince William Sound Regional Citizen's Advisory Council. AKC-075.5. 31 pages.
- Carls MG. 2015. Overview, Deepwater Horizon. Report to DOJ lawyers in support of Phase 3 BP trial. 155 pages.
- Carls MG, Holland L, Irvine GV, Mann DH, Lindeberg M. Submitted. Biomarkers as tracers of *Exxon Valdez* oil.
- Carls MG, Holland L, Pihl E, Zaleski MA, Moran J, Rice SD. Submitted. Polynuclear aromatic hydrocarbons in Port Valdez shrimp and sediment. Target Journal: ET&C.
- Carls MG, Vanderhoof L, Shaufler L. Submitted. Carbonate cycling in a north temperate fjord.
- Carls MG, Larry Holland, Corey Fugate, and Mandy Lindeberg. In prep. Review of PAH and alkane retention in sediment oiled by the *Exxon Valdez*.
- Carls MG, Larry Holland, Corey Fugate, and Mandy Lindeberg. In prep. Biomarkers in *Exxon Valdez* oil from Prince William Sound, 2015.
- Incardona JP, Carls MG, Holland L, Linbo TL, Baldwin DH, Myers MS, Peck KA, Tagal M, Rice SD, Scholz NL. 2015. Embryonic crude oil exposure causes cardiac hypertrophy and reduced aerobic performance in juvenile pink salmon and Pacific herring. Nature Scientific Reports DOI: 10.1038/srep13499.
- Nesvacil K, Mark Carls, Larry Holland, Sadie Wright. In prep. Assessment of bioavailable hydrocarbons in Pribilof rock sandpiper overwintering habitat in Cook Inlet, Alaska.
- Payne JR, Driskell WB, Carls MG, Larsen ML, Holland LG. 2015. Long-term environmental monitoring program. Results and interpretations from sampling, 2008-2013. PWSRCAC Contract No. 951.10.01. 109 pp.

### **Presentations and outreach:**

- Carls, MG and RA Heintz. *Persistent Alaska North Slope crude oil: a quarter century of weathering*. Ocean Sciences meeting, New Orleans 2016.
- Lindeberg, M.R. *Seaweeds, Fishes, Monitoring and More!* PWSSC and Cordova Night Lecture Series. December 2015.
- Fugate, C., M.R Lindeberg, J.M. Maselko, L. Holland and M.G. Carls. *Recent Survey Confirms Persistence of Lingering Oil 26 Years after the Exxon Valdez Oil Spill*. Alaska Marine Science Symposium. Anchorage, Alaska. January 2016.

### **Meeting attendance:**

- January 2016, Alaska Marine Science Symposium, Anchorage: Mandy Lindeberg, Corey Fugate.
- November 2015, Gulf Watch Alaska annual principal investigator meeting, Anchorage: Mandy Lindeberg, Ron Heintz.

### **Data and Metadata:**

Ocean Workspace now has:

- 2015 update of the hydrocarbon database and supporting documentation (e.g legacy or data dictionary pdf, macro for filtering GCMS output, and updated metadata). All reports and publications on biomarkers and *Exxon Valdez* oil analyses are based on data in the hydrocarbon database.
- A file on gravimetric samples (raw data for calculating mass of oil in pits) from the summer survey has been added.
- A chain of custody file of all samples collected during the lingering oil survey.
- Site photos from the Prince William Sound lingering oil survey have also be uploaded with metadata file.

**10. Response to EVOSTC Review, Recommendations and Comments:** *See, Reporting Policy at III (C) (10).*

There were no recent comments for this project from EVOS reviews.

**11. Budget:** *See, Reporting Policy at III (C) (11).*

Please see provided program work book.

Our overall budget expenditures are on target with the proposed expenditures. The majority of remaining funds are encumbered in a contract and all funds will be exhausted by the end of the fiscal year.