

1. EXECUTIVE SUMMARY

Pelagic Component

The pelagic component research team proposed for FY18-21 to continue monitoring key pelagic species groups in Prince William Sound (PWS) using the same five projects focused on killer whales, humpback whales, forage fish, and marine birds. However, modifications have been made to some projects for greater integration, increased precision of information, and achieving new goals. Ultimately, this will provide more information to the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC), agency resource managers, non-governmental organizations, and the public.

Thus, the two over-arching questions for the pelagic component to answer during this 5-year period are:

1. What are the population trends of key upper trophic level pelagic species groups in PWS – killer whales, humpback whales, marine birds, and forage fish?
2. How do predator-prey interactions, including interannual changes in prey availability, contribute to underlying changes in the populations of pelagic predators in PWS and Middleton Island?

Humpback Whale Predation on Herring Surveys in PWS

Monitoring humpback whales and their diets is important to understanding predator prey interactions in the pelagic waters of PWS. Because humpback whales are significant predators in the ecosystem, they may have the potential to control the distribution and abundance of forage fish. The humpback whale population in the North Pacific has rebounded from near extinction in the late 1960s to over 22,000 individuals, and parallel increases in whale abundance have been documented in PWS. This rapid recovery has coincided with major natural and anthropogenic perturbations in the marine ecosystem (regime shift, Pacific Decadal Oscillation, and the *Exxon Valdez* oil spill [EVOS]). Over much of the same period the abundance of the dominant forage fish, Pacific herring, shifted from an abundant to a diminished state. The lack of commercial fishery has not restored this population to their former abundance. Pacific herring were identified as an injured species following the EVOS. Understanding the mechanisms behind their failed recovery requires a comprehensive understanding of both top-down and bottom-up processes in the context of a changing ecosystem. Our previous work in PWS (EVOSTC project PJ090804) estimates that humpback whales are consuming 15% to 20% of the pre-spawning biomass of adult herring, roughly equivalent to the percentage of herring removed during the final years of the commercial herring fishery. In PWS humpback whales during 2007 to 2009 had a higher percentage of herring in their diet during the winter months and foraged longer on wintering herring shoals than their counterparts in Southeast Alaska, suggesting that top-down forcing may be limiting the recovery of herring in PWS.

Humpback whales continue to have an impact on PWS herring (Figure 1). Warmer water temperatures over the past two years combined with seabird and marine mammal die-offs, emphasize that the Gulf of Alaska is still undergoing major perturbations that impact species at the population level. There is a need to continue evaluating predation pressure on herring stocks in PWS and to understand the ecosystem impacts of a humpback whale population that has been functionally absent from the Gulf of Alaska for over 50 years.

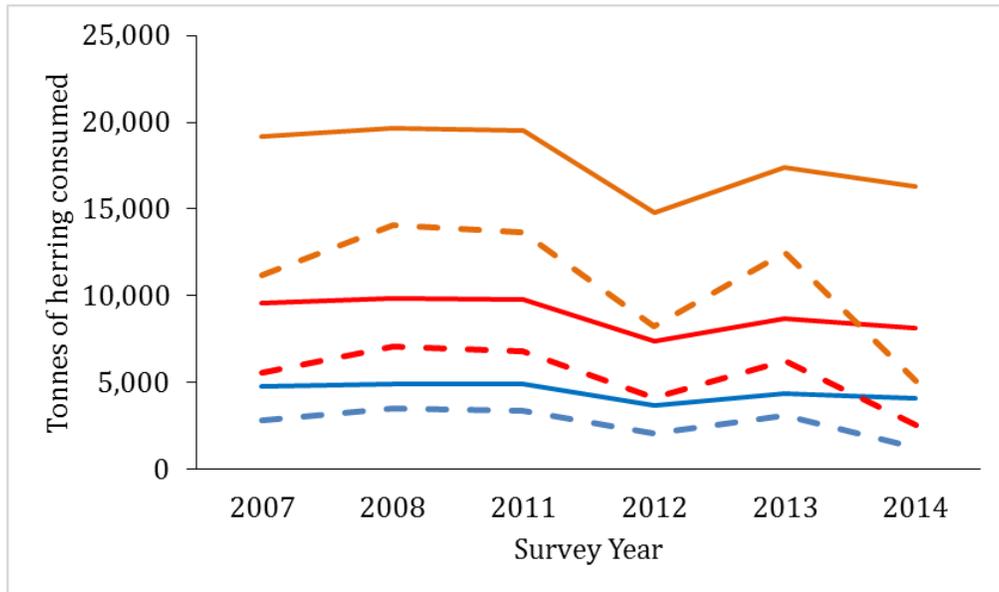


Figure 1. Modeled consumption of herring in Prince William Sound, Alaska based on the observed diet composition for 50 (blue), 100 (red), and 200 (orange) whales. Low estimates (dashed lines) exclude other fish and use Witteveen’s consumption value of 338 kg/whale/day (Witteveen et al. 2006). High estimates (solid lines) treat other fish as herring and use Roman’s daily consumption value of 471kg/whale/day (Roman and McCarthy 2010).

This project specifically addresses a “project of interest” identified in the EVOSTC FY17-21 Invitation for Proposals. However, we believe by integrating the humpback whale component with the forage fish and winter bird survey we can provide a more cost effective and scientifically sound survey, while still achieving the goals of the individual projects. We are not proposing any major changes to this project for FY18.

2. COORDINATION AND COLLABORATION

A. Within an EVOSTC-funded Program

Gulf Watch Alaska

This study is part of the pelagic component of the integrated Gulf Watch Alaska (GWA)-Long-term Monitoring of Marine Conditions and Injured Resources and Services as. The GWA pelagic projects share research platforms and common goals of the integrated predator-prey surveys that include our project (humpback whale; Moran and Straley), marine bird (Bishop), and forage fish (Arimitsu/Piatt) (Table 1).

Table 1. Integrated predator-prey collaborations by objective. Bolded text highlights humpback whale objectives.

Objective	Index	Task	PI
a. Estimate humpback whale abundance, diet, and distribution			
	Whale counts by sub-region	Integrated Surveys: whale counts, biopsies	Moran (NOAA)/ Straley (UAS)
	Whale Identification	Integrated Surveys: Photo ID	Moran (NOAA)/ Straley (UAS)
	Whale Diet	Integrated Surveys: scales, scat, biopsies, visual observations, hydroacoustics	Moran (NOAA)/ Straley (UAS)/ Arimitsu & Piatt (USGS)
b. Estimate marine bird abundance and distribution in seasonally predictable predator aggregation areas			
	Georeferenced marine bird counts, group size, behavior by species	Integrated Surveys: marine bird transects	Bishop (PWSSC)
b.i. Relate marine bird and humpback whale presence to prey fields identified during hydroacoustic surveys.			
	Spatial coherence of bird and whale presence/ absence, acoustic estimates of forage fish and euphausiid biomass	Integrated Surveys: hydroacoustic and marine bird transects, whale focal follows	Arimitsu & Piatt (USGS)/ Bishop (PWSSC)/ Moran (NOAA)/ Straley (UAS)
b.ii. Characterize marine bird-humpback whale foraging dynamics			
	Georeferenced marine bird and whale counts, group size, behavior by species	Integrated Surveys: marine bird transects; whale focal follows	Bishop (PWSSC)/ Moran (NOAA)/ Straley (UAS)/ Arimitsu & Piatt (USGS)
c. Estimate index of forage fish availability in seasonally predictable predator foraging areas			
	Species composition and biomass within persistent predator foraging areas	Integrated Surveys: hydroacoustic-trawl data	Arimitsu & Piatt (USGS)/ Moran (NOAA) Bishop (PWSSC)
	Density and depth distribution	Integrated Surveys: hydroacoustic-trawl data	Arimitsu & Piatt (USGS)
	Diet, energy density	Sample Analysis: forage fish	Moran (NOAA)
d. Estimate an index of euphausiid availability in seasonally predictable predator foraging areas			
	Species composition and biomass within persistent predator foraging areas	Integrated Surveys: hydroacoustic-trawl data	Arimitsu & Piatt (USGS)
	Density and depth distribution	Integrated Surveys: hydroacoustic-trawl data	Arimitsu & Piatt (USGS)
e. Relate whale, marine bird and forage fish indices to marine habitat			
	Oceanographic metrics and zooplankton biomass	Integrated Surveys: CTD and zooplankton samples	Arimitsu & Piatt (USGS)/ Moran (NOAA)/ Straley (UAS)/ Bishop (PWSSC)

Herring Research and Monitoring

As in the past, we will work closely with the Herring Research and Monitoring program, samples will be provided to the HRM for analysis of age at maturity and we are dependent on estimates of herring abundance developed through the age-structured assessment conducted by the Herring Research and Monitoring program.

Data Management

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the timeframes required.

B. With Other EVOSTC-funded Projects

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

C. With Trustee or Management Agencies

The unique timing and focus of this project provides Trustee and Management Agencies with valuable data and platforms for both management and research. Data collected on humpback whale abundance will be of direct value to National Oceanic and Atmospheric Administration (NOAA) Protected Resource Division in the implementation of the De-Listing Monitoring Plan for humpback whales. NOAA is required by statute to evaluate the whale population to ensure that delisting was warranted. Our collaboration within the GWA pelagic component is the only directed whale foraging and prey study in the Gulf of Alaska. These data will be included in the North Pacific Fishery Management Council's annual forage fish stock assessment.

This project is also working with NOAA to develop a humpback whale index as an indicator in ecosystem assessments for reports to the North Pacific Fisheries Management Council (Stephani Zador, NMFS AFSC REFM Division, Resource Ecology and Ecosystem Modeling Program). Collections of juvenile forage fish, particularly age-0 pollock, are of direct interest to the NOAA AFSC, which is actively engaged in understanding how winter influences pollock survival (Recruitment Processes Alliance – FOCI, EMA, RECA, REFM programs). We anticipate working with the Alaska Fisheries Science Center when they conduct winter acoustic surveys in PWS as part of their normal pollock assessment work for the Gulf of Alaska. During our surveys we will also photograph Steller sea lion brands whenever possible for Lauri Jemison (Alaska Department of Fish and Game). These data represent brand re-sights and are of interest to both the Alaska Department of Fish and Game and NOAA and are used in identifying movements and survival rates of Steller sea lions.

3. PROJECT DESIGN – PLAN FOR FY18

A. Objectives for FY18

This project will directly address the following integrated predator-prey survey objectives:

1. Estimating trends in humpback whale abundance, diet, and distribution
2. Evaluate prey quality and trophic position through chemical analysis (using bomb calorimetry and stable isotopes)
3. Estimating the impact of humpback whale predation on herring

B. Changes to Project Design

There are no changes to this project's design.

4. SCHEDULE

A. Project Milestones for FY18

• Task 1

Annually prepare for and launch field collection of core project data including: identification photos, observation of predation and sampling of prey. Collect annual biopsy samples for feeding habits.

FY18 will be the 2nd consecutive year for these sampling activities during the FY17-21 funding cycle.

- **Task 2**
Conduct analysis of identification photos, annually update photographic catalogue. Preliminary estimates of whale abundance. Annual report.
These activities are ongoing and updated with each year of data collection.
- **Task 3**
Chemical analysis of skin and blubber, and prey samples. Conducted annually, completion date for all laboratory analysis is February 2022.
These activities are ongoing and updated with each year of data collection.
- **Task 4**
Estimations of the impact of humpback whale predation on herring from all years of the project to be included in final report and/or other publication (draft by April 2022). All required reporting will be completed on an annual basis in addition to final report and publications.
These activities are ongoing with annual evaluation of progress toward end of funding period completion.

B. Measurable Project Tasks for FY18

FY 18, 1st quarter	(February 1, 2018 - April 30, 2018)
<i>February-April:</i>	<i>Data entry QA/QC; data upload to portal; data analysis</i>
March 1:	<i>Annual Report Due to Trustees</i>
<i>March:</i>	<i>Secure vessel charter</i>
<i>March-April</i>	<i>Option: whale survey pending NOAA funding</i>
FY 18, 2nd quarter (May 1, 2018 - July 31, 2018)	
<i>May-July:</i>	<i>Data entry QA/QC</i>
<i>May-July:</i>	<i>Lab work, Chemical analysis</i>
FY 18, 3rd quarter	(August 1, 2018 - October 31, 2018)
August 23:	<i>FY19 Work Plan (DPD)</i>
<i>August-October:</i>	<i>Lab work, Chemical analysis</i>
<i>August</i>	<i>Field logistics</i>
<i>Sept-Oct.:</i>	<i>integrated predator-prey survey (EVOSTC funded)</i>
FY 18, 4th quarter	(November 1, 2018 - January 31, 2019)
<i>Oct.-Nov.:</i>	<i>Annual PI meeting</i>
<i>Dec.-Jan:</i>	<i>Option: whale survey pending NOAA funding</i>
<i>January:</i>	<i>Alaska Marine Science Symposium</i>

5. PROJECT PERSONNEL – CHANGES AND UPDATES

There are no personnel changes or updates.

6. BUDGET

A. Budget Forms (See GWA FY18 Budget Workbook)

Please see project budget forms compiled for the program.

B. Changes from Original Proposal

There are no changes from the original proposal.

C. Sources of Additional Funding

Over the life of this project, NOAA will make a substantial contributions: salary (\$350 K) for PI Moran (7 months, GS-12), all field and laboratory equipment required (\$50 K), and small vessel/charters (\$330 K). Total in-kind by NOAA for this project is \$730 K.

7. RECENT PUBLICATIONS AND PRODUCTS

Publications

- Moran, J.R., Heintz, R.A., Straley, J.M. and Vollenweider, J.J., 2017. Regional variation in the intensity of humpback whale predation on Pacific herring in the Gulf of Alaska. *Deep Sea Research Part II: Topical Studies in Oceanography, Spatial and temporal ecological variability in the northern Gulf of Alaska: what have we learned since the Exxon Valdez oil spill?*
- Moran, J. R., M. B. O'Dell., D. M. S. Dickson, J. M. Straley, and M. L. Arimitsu, *In Review*. Seasonal distribution of Dall's porpoise in Prince William Sound, Alaska. *Deep Sea Research Part II: Topical Studies in Oceanography, Spatial and temporal ecological variability in the northern Gulf of Alaska: what have we learned since the Exxon Valdez oil spill?*
- Moran, J. R., and J. M. Straley. 2017. Long-term monitoring of humpback whale predation on Pacific herring in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project: 16120114-N), National Marine Fisheries Service, Juneau, Alaska.
- Straley, J. M., J. R. Moran, K. M. Kevin Boswell, R. A. Heintz, T. J. Quinn II, B. Witteveen, and S. D. Rice. (2017). Seasonal presence and potential influence of foraging humpback whales upon Pacific herring wintering in the Gulf of Alaska. *Deep Sea Research Part II: Topical Studies in Oceanography, Spatial and temporal ecological variability in the northern Gulf of Alaska: what have we learned since the Exxon Valdez oil spill?*

Published datasets

- Moran, J. R. and J. M. Straley, 2017. Lipid Analyses for Pacific Herring, Invertebrates and Humpback Whales in the Gulf of Alaska, 2012-2015, Gulf Watch Alaska Pelagic Component. Dataset. *Exxon Valdez Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.* <https://doi.org/10.24431/rw1k1q>.
- Moran, J. R. and J. M. Straley, 2017. Significance of Whale Predation On Natural Mortality Rate of Pacific Herring in Prince William Sound, Alaska: 2006 - 2009, 2011-2015, Gulf Watch Alaska Pelagic Component. Dataset. *Exxon Valdez Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.* <https://doi.org/10.24431/rw1k1n>.
- Moran, J. R. and J. M. Straley, 2017. Dall's and Harbor Porpoise Survey Data, Prince William Sound, Alaska: 2007 - 2008, 2011-2015, Gulf Watch Alaska Pelagic Component. Dataset. *Exxon Valdez Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.* <https://doi.org/10.24431/rw1k1p>.

Presentations

- Moran, J. R., M.B. O'Dell, D. Dickson, J.M. Straley and M. L. Arimitsu. 2017. Seasonal distribution of Dall's porpoise in Prince William Sound, Alaska. Poster. 2017 Alaska Marine Science Symposium, Anchorage, AK. Jan 23-27, 2017.
- Moran, J. K. Boswell and J. M. Straley, 2017. Humpback whales ruin a perfectly good overwintering strategy for Pacific herring in Alaska. Presentation. PICES - Drivers of Dynamics of Small Pelagic Fish Resources, Victoria, British Columbia, CA, March 2017.

LITERATURE CITED

- Teerlink, S. F., von Ziegesar, O., Straley, J. M., Quinn II, T. J., Matkin, C. O., and Saulitis, E. L. 2014. First time series of estimated humpback whale (*Megaptera novaeangliae*) abundance in Prince William Sound. *Env. Ecol. Stat.* 22: 345-368.
- Rice, S. D., Moran J. R., Straley, J. M., Boswell, K. M., and Heintz. R. A. (2011) Significance of whale predation on natural mortality rate of Pacific herring in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project: 100804). National Marine Fisheries Service, Juneau, Alaska.