ATTACHMENT C ***EVOSTC Annual Project Report Form***

Form Rev. 9.14.17

1. Project Number:

17120114-O

2. Project Title:

Long-term Monitoring of Humpback Whale Predation on Pacific Herring in Prince William Sound

3. Principal Investigator(s) Names:

John Moran, NMFS/Auke Bay Laboratories

Jan Straley, University of Alaska Southeast

4. Time Period Covered by the Report:

February 1, 2017-January 31, 2018 (Year 6)

5. Date of Report:

March 2018

6. Project Website (if applicable):

www.gulfwatchalaska.org

7. Summary of Work Performed:

The objectives of the long-term monitoring of humpback whale predation on herring in Prince William Sound (PWS) project include the following:

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

During this reporting period we secured National Oceanic and Atmospheric Administration (NOAA) funds to cover vessel cost for additional surveys in December of 2017, March of 2018, and December of 2018. These surveys will allow us to continue our winter monitoring efforts within PWS and maintain the time series of humpback whale abundance and prey which began in 2007. All sampling and analysis occurred according to plan during FY17 and we did not propose any changes to this project for FY18.

Trends in humpback whale abundance, diet, and distribution

We completed the fall Integrated Marine Predator-Prey Survey (IMPPS) with the Marine Bird and Forage Fish projects and a winter whale-prey survey in early December. Several findings from these surveys differed with our previous observation in PWS. Lower numbers of

humpback whales (Table 1) and marine birds were observed along with low numbers of other forage fish and krill relative to previous years.

Table 1. Counts of whales in PWS during fall surveys. * The 2007 survey did not cover Montague Entrance, an area known for the highest concentration of whales and herring during early fall. Gulf Watch Alaska sampling began in 2012, no surveys were conducted in 2015-16, but resumed in 2017 and will continue annually.

Month/year	Counts of whales	Nautical miles surveyed	Encounter rate Whale/NM
Sep 2007*	24	370	0.06
Sep 2008	71	412	0.17
Oct 2011	62	441	0.14
Sep 2012	81	444	0.18
Sep 2013	113	355	0.32
Sep 2014	181	427	0.42
Sep 2017	12	543	0.02

September of 2017 was our 7th fall survey, with the lowest number of whales since the project began. Despite increased effort and excellent conditions while surveying, historical whale/herring hot spots failed to locate any concentrations of humpbacks or prey (Fig. 1) and no new prey aggregations were located. Anecdotal reports and other research groups also noted the lack of humpback whales in PWS during the summer and fall of 2017.

We expanded our coverage to include the waters outside of Montague Entrance but failed to locate any whales. The US Fish and Wildlife Service vessel, *R/V Tiglax*, was contacted as it was transiting from Kodiak to PWS. They did not report any humpbacks in offshore waters west of PWS.

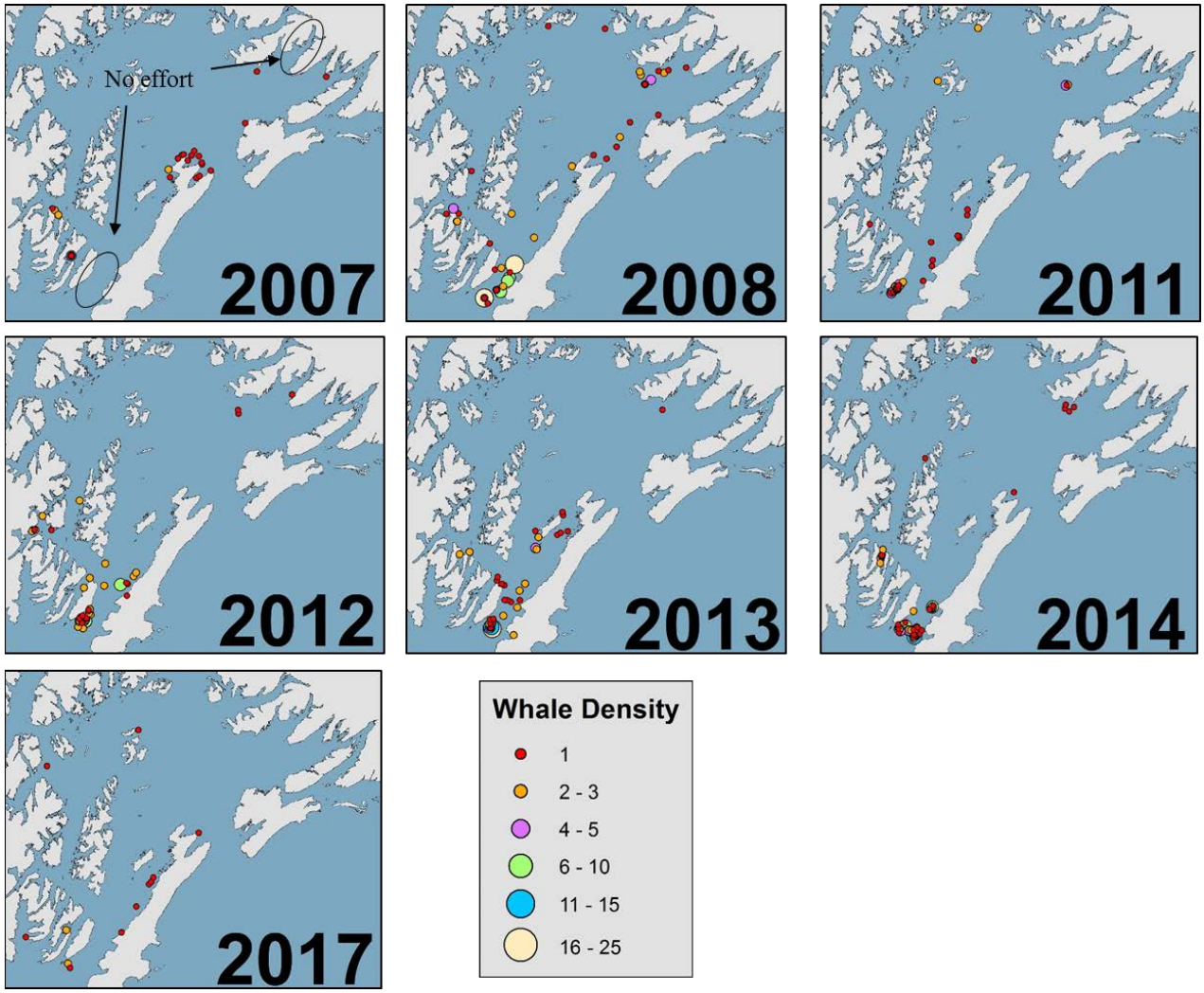

Figure 1. The distribution and abundance of humpback whales in PWS during September/October surveys. Note that Montague Entrance and Port Gravina were not surveyed in 2007.

The December 2017 survey was hampered by high winds and heavy rain. The low whale counts reported during this survey may have been biased by poor sightability (Fig. 2). Port Gravina and Bainbridge passage were surveyed for forage fish and euphausiids using hydroacoustics, and no whales or aggregations of prey were found in either location. One whale was seen south of Gravina Point. The whale lunged through foraging bird flocks and small scattered schools of fish were identified on the hydroacoustics, suggesting juvenile herring were being targeted. On December 6th, 8 to 12 whales were encountered feeding on a shoal of adult herring off Graveyard Point near the north end of Montague Island. Sea state and lighting were not favorable for photo identification or biopsy, but the area was surveyed using hydroacoustics. In collaboration with the forage fish project (17120114-C), we estimate herring biomass at 7,435 (95% CI: 5845-9025) metric tonnes, within a 2.5 nmi^2 area. Fish density of 18 schools measured was 40.7 (11.1 SD) million fish/nmi^2. This shoal was concentrated near the 100 m bathymetric contour roughly 0.8 nmi offshore (Fig. 3). We have not observed large shoals of overwintering herring and whales in this area during our previous surveys.

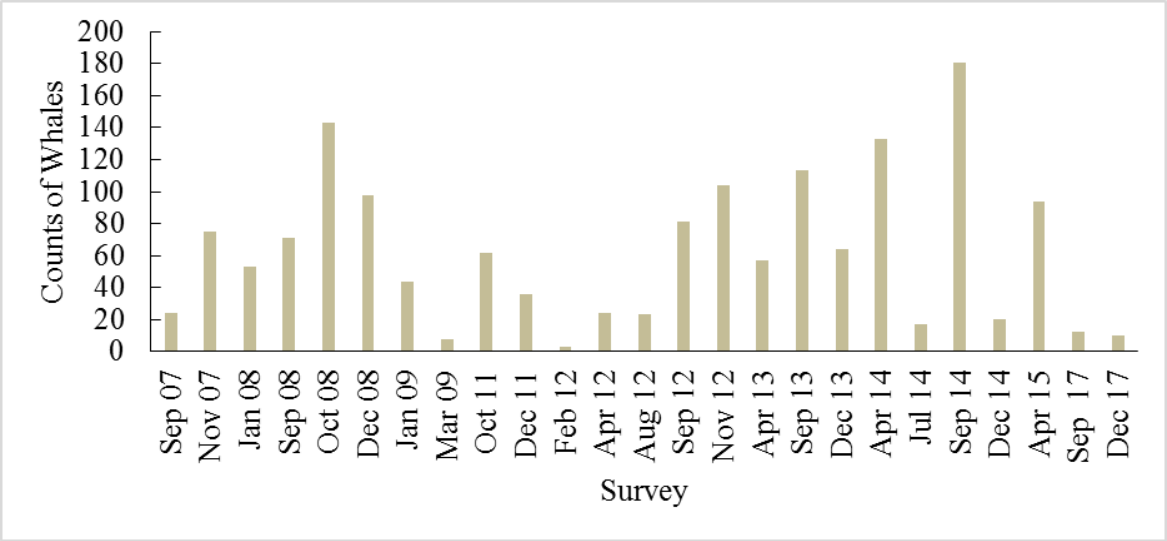

Fig. 2. Counts of humpback whales during EVOSTC-funded surveys in Prince William Sound.

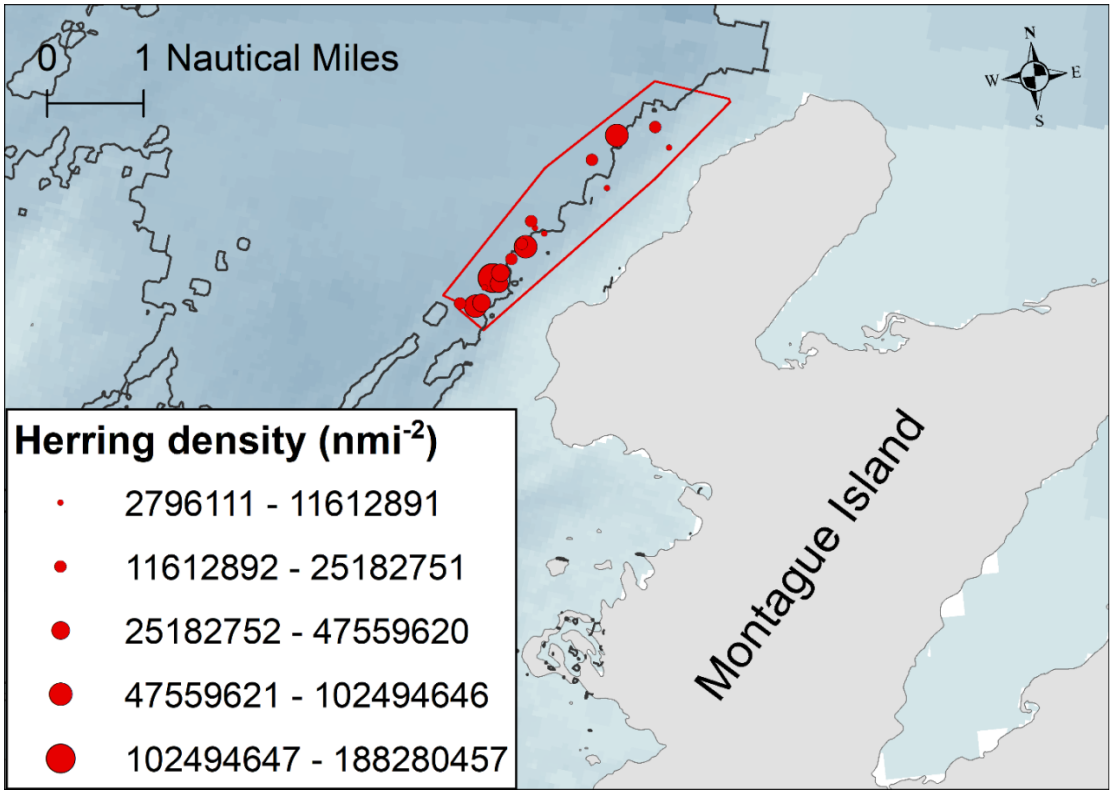

Figure 3. Map of herring schools encountered in Prince William Sound on Dec. 6, 2017. Biomass density of each school was derived from acoustic survey data conducted within the area delineated by a red box, which was approximately 2.5 nmi² in area. The black line denotes the 100 m bathymetric contour.

Prey quality and trophic position through chemical analysis (using bomb calorimetry and stable isotopes)

Euphausiids

We reported a potential increase in humpback whale trophic position in PWS during 2014. Coincidently, humpback whale abundance decreased during the following years. To help understand potential processes explaining these observations, we initiated an analysis of euphausiid trophic ecology and bioenergetics. We found that there may have been a shift it the species composition. *T. spinifera* and *E. pacificia* dominated catches during the September 2017 survey, whereas the typical common species (*T. longipes, T. inermis, and T. raschii*), were scarce. This shift in composition is possibly the result of higher water temperatures or the advection of *E. pacifica* into the PWS from offshore waters. The trophic position of the two dominant species caught in 2017differed from each other (Fig. 4), as has been seen it other studies. This implies that shifts in the species composition of euphausiids could influence the trophic signature of their predators and higher trophic levels.

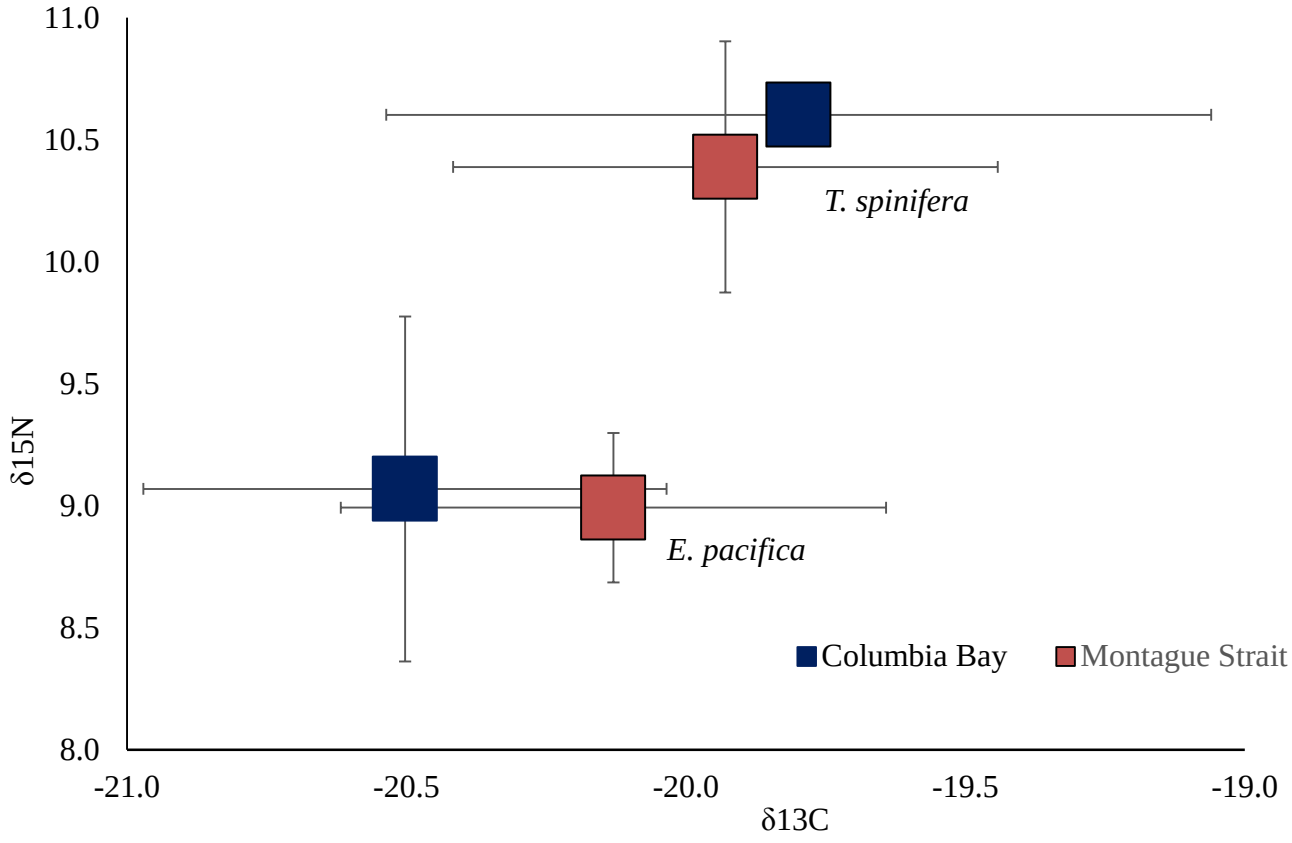

Figure 4. $\delta^{13}C$ and $\delta^{15}N$ of *T. spinifera* and *E. pacifica* at Montague Strait and Columbia Bay in September 2017. Trophic positions differ among euphausiids species but not among sites.

Herring

Herring and pollock were collected from PWS and will be analyzed for stable isotopes and energy content during spring 2018.

Baleen

In May of 2017 there were 5 reports of stranded humpback whales in the waters in and around PWS. Although the cause of their deaths was not determined for these animals due to advance decomposition and logistical difficulties, we were able to collect baleen from three of the whales and compare them to samples from Southeast Alaska. Baleen plates were sampled at 1 cm intervals following the axis of the longest individual baleen filament for carbon and nitrogen stable isotope analysis (Fig. 5.). Previous studies in other baleen whale populations have shown an oscillating pattern of nitrogen isotope (^{15}N) enrichment and depletion along the length of individual baleen plates corresponding to the fasting and feeding states or changes in resource use associated with whales' migratory and reproductive feeding behavior. All of the baleen plates analyzed in this study had a general oscillating pattern of ^{15}N enrichment and depletion occurring at roughly 12-20 cm intervals, within the bounds of previous estimates of annual baleen growth rates. There were slight deviations in this pattern which may result from individual whales' foraging or migratory behavior. All whales sampled from PWS were near the peak of the enrichment phase of ^{15}N oscillation, which likely means that they had not resumed substantial feeding upon their return to PWS. This may be due to stress from migration leading to changed foraging behavior, lack of prey resources being present, or other unknown factors.

Estimating the impact of humpback whale predation on herring

Our September PWS observations parallel the trend seen in northern Southeast Alaska, low whale numbers and few calves (Fig. 6). Whales in both areas appear to target scattered prey (in many cases age 0 herring) rather than the large, dense aggregations of krill and herring that we have seen in the past. There were reports of increased numbers of whales offshore and in southern SEAK that we have not been able to verify. It seems likely that the missing whales from PWS whales have moved to new feeding grounds, possibly providing temporary relief to some struggling herring populations in PWS and northern Southeast Alaska.

Predation rates by whales on herring observed in PWS during December were slightly less than what we have seen in the past. Although we have no data on the duration of the feeding event at Graveyard Point, if we assume that 12 whales feeding for three months on the shoal, they would consume 4% to 9% of the herring biomass.

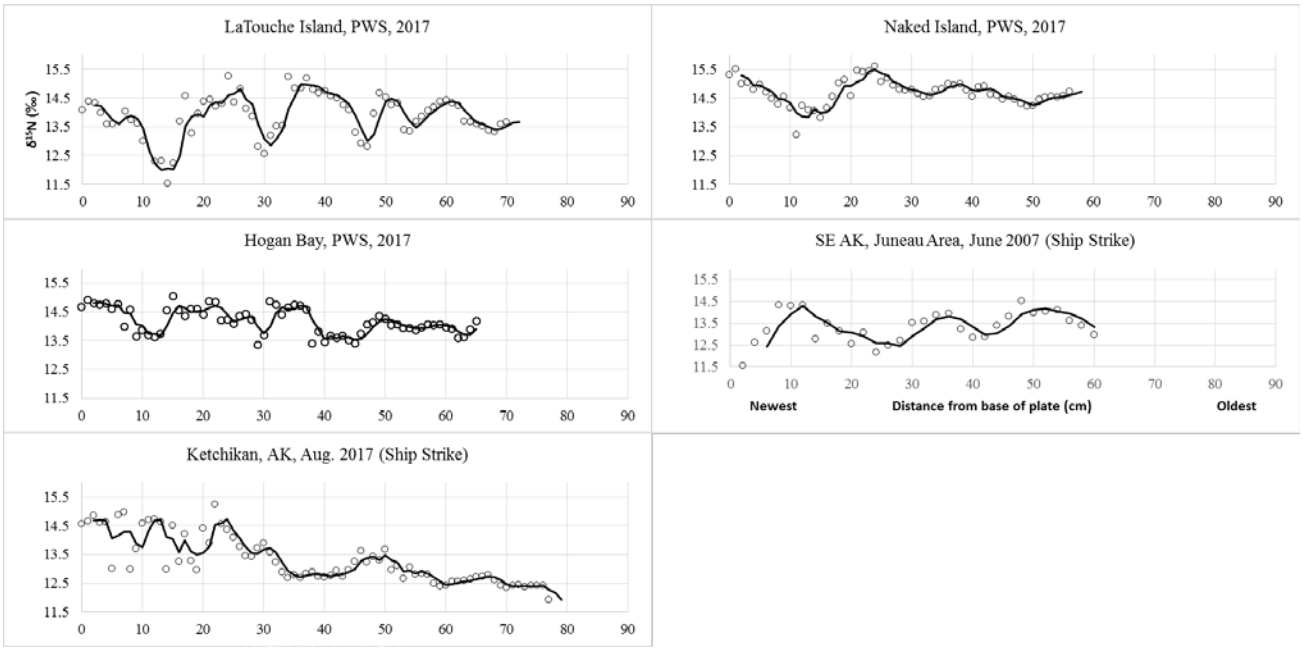

Figure 5. Stable nitrogen isotope measurements from baleen plates of humpback whales that stranded in PWS and Southeast Alaska during spring and summer 2017. Sampling distance from proximal end (base) of baleen plate is shown on the x-axis. Trendlines are 3-point moving averages.

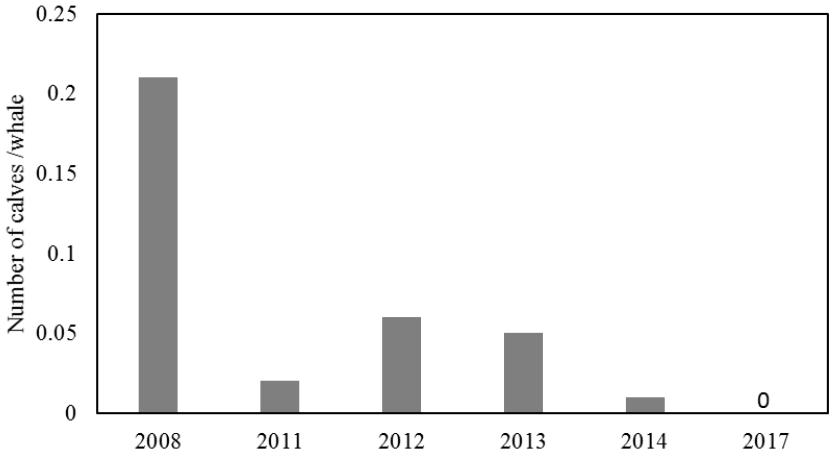

Figure 6. Crude birth rates (number of calves seen/number of whales identified) for humpback whales in PWS.

In additional to reduced abundance of humpback whales, their body condition in both Southeast Alaska and PWS appears to have declined in recent years. Prior to Sept 2017, our last PWS survey was April of 2015 when we noticed that whale and herring abundance was reduced, but there were no clear observations of "skinny" whales. We first notice skinny whales in Southeast Alaska during our August 2016 survey. The proportion of skinny whales (Fig. 7) increased in 2017. Shifts to lower quality and less dense prey associated with "The Blob" and El Niño are the likely explanation for nutritionally stressed whales. Whale behavior and prey observations support this hypothesis. We are initiating a project to quantify whale

body condition by reviewing past photos. We will start with Glacier Bay, since they have the most comprehensive dataset.

Figure 7. A "skinny" whale (left) photographed in 2017 versus a "fat" whale (right) from 2007. Note the "keel shaped" back and lack of fat behind the blowhole on the skinny whale as compared to the broad, flat back of the fat whale.

8. Coordination/Collaboration:

A. Projects Within a Trustee Council-funded program

1. Within the Program

Our September IMPP survey was a collaborative effort with the forage fish (17120114-C) and fall and winter marine bird (17120114-E) projects.

Capelin and sand lance were collected for the forage fish project (17120114-C) in December.

Killer whales were photographed for the killer whale project (17120114-N).

The nearshore component project (17120114-H) collected baleen from stranded humpback whales for our stable isotope analysis.

2. Across Programs

a. Herring Research and Monitoring

The GWA forage fish and humpback whale projects are closely aligned with the Herring Research and Monitoring program through data collection and information sharing. In December 2017 we collected hydroacoustic data on a shoal of herring near feeding whales at Graveyard Point in PWS. M. Arimitsu, J. Vollenweider, and J. Moran provided analyses of these data, including echointegration, mapping, and biomass estimates, to S. Pegau (PWSSC/HRM) and presented this information at the Alaska Marine Science Symposium in January 2018.

Kristen Gorman (project 18170111-D) participated on our September IMPP survey to collect herring.

An opportunistic collaboration was provide to Ben Gray (PWSSC) who participated on the December survey to tag Pollock for a methods feasibility effort.

b. Data Management

We are coordinating with the Data Management team to upload data to the Research Workspace and make it available on the Gulf of Alaska data portal and review metadata and update for accuracy.

B. Projects not Within a Trustee Council-funded program

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. The opportunity did not arise in FY17.

C. With Trustee or Management Agencies

Additional NOAA funds allowed forage fish acoustic surveys to be completed in Port Gravina and Bainbridge Passage. These additional surveys will allow us to examine season variation in prey availability.

Age 0 pollock were collected for a National Marine Fisheries Service (NMFS) Essential Fish Habitat project.

Trend and abundance data for humpback whales were submitted to the Gulf of Alaska Ecosystem Status Reports for the North Pacific Fishery Management Council.

Dead marine mammals encountered during our surveys were reported to the NMFS Alaska Marine Mammal Stranding Network and appropriate government agencies

Baleen data were provided to the NMFS Alaska Marine Mammal Stranding Network.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

Moran, J. R., R. A. Heintz, J. M. Straley, and J. J. Vollenweider. 2017. Regional variation in the intensity of humpback whale predation on Pacific herring in the Gulf of Alaska. Deep Sea Research Part II. DOI: http://dx.doi.org/10.1016/j.dsr2.2017.07.010.

Moran, J. R., M. B. O'Dell., D. M. S. Dickson, J. M. Straley, and M. L. Arimitsu. 2017. Seasonal distribution of Dall's porpoise in Prince William Sound, Alaska. Deep Sea Research Part II. DOI: https://doi.org/10.1016/j.dsr2.2017.11.002.

Moran, J. R., and J. M. Straley. 2018. 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). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Straley, J. M., J. R. Moran, K. M. 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. DOI: http://dx.doi.org/10.1016/j.dsr2.2017.08.008.

B. Dates and Locations of any Conference or Workshop Presentations where EVOSTC-funded Work was Presented

Arimitsu, M., M.A. Bishop, S. Hatch, R. Kaler, K. Kuletz, C. Matkin, J. Moran, D. Olsen, J. Piatt, A. Schaefer, and J. Straley. 2018. Changes in marine predator and prey populations in the aftermath of the North Pacific Heat Wave: Gulf Watch Alaska Pelagic update 2017. Alaska Marine Science Symposium, Anchorage, January. **Poster Presentation**.

Moran, J., K. Boswell, and J. Straley. 2017. Humpback whales ruin a perfectly good overwintering strategy for Pacific herring in Alaska. ICES/PICES Victoria BC, February. **Poster Presentation**.

Straley, J., and J. Moran. 2018. Have Gulf Of Alaska Humpback Whales Reached Carrying Capacity or has the Blob made the Food Web Screwy? Alaska Marine Science Symposium, Anchorage, January. **Oral Presentation.**

Weiss, C., J. Moran, T. Miller, and M. Rogers. 2018. Fine-scale trophic ecology and bioenergetics of euphausiids in Prince William Sound, Alaska. Alaska Marine Science Symposium, Anchorage, January. **Poster Presentation**.

C. Data and/or Information Products Developed During the Reporting Period, if Applicable

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.

Moran, J. and J. Straley. 2017. Data contributed to the NOAA Ecosystem Considerations Report 2017 for the Gulf of Alaska region. Full reports may be found at the following link: https://access.afsc.noaa.gov/reem/ecoweb/Index.php.

D. Data Sets and Associated Metadata that have been Uploaded to the Program's Data Portal

No data were collected for this project in 2016. Data collection in 2017 fall/winter is outside of the normal spring/summer cycle and therefore will be posted next fall/winter (within 1 year of collection).

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comments and Responses on Revised FY17-21 Proposal, September 2016

In September 2016, the Science Panel had no specific comments.

Science Panel Comments and Responses on FY18 Work Plans, September 2017

In September 2017, the Science Panel commented: The Panel was excited to see the results presented in Figure 1 in the proposal and encourages the PIs to make comparisons to the relevant study conducted by the National Center for Ecological Analysis and Synthesis (NCEAS) working group. Results shown in Figure 1 of the proposal are important and so strikingly incompatible with what was suggested previously by the time series analysis of the NCEAS working group (Ward et al 2017). That working group's model, of necessity, made some quite restrictive assumptions. Can the PIs look at the NCEAS model, and consider whether the new findings invalidate one or more key conclusions from that synthesis work? Additionally, the Panel is concerned that objective #3 may be overly ambitious and suggests re-wording and editing to "predation rate"?

PI Response: Thank you for the close review of project 18120114-O's work plan. Comparisons to Ward et al. (2017) are problematic because these authors depend on summer whale counts from western PWS (Teerlink et al. 2014), while our project focuses on fall/winter and spring time periods when herring form large, dense schools that are most vulnerable to whale predation. Observations of whales and prey when herring are aggregated allow us to study the potential impact of foraging humpback whales on herring as a possible contributor to the lack of herring recovery. The following are three important differences between our approach and the Teerlink et al. (2014) approach to modeling whale predation on herring:

1. The Teerlink et al. (2014) study estimates the number of whales that use PWS in summer, not the number that are present at any given time (for example, 10 whales spending 90 days in the Sound would have the same effect on prey as 900 whales spending one day in the Sound). It is important to know how many whales are feeding on herring for how many days within the Sound and the Ward et al. (2017) paper does not address this.
2. Ward et al. (2017) used whale population estimates from summer surveys, when overall whale abundance is generally low in PWS compared to other seasons. Our work identified adult herring as the preferred prey of humpbacks in PWS, especially when herring are aggregated in the fall, winter, and spring (spawning); thus, whale numbers peaked in the fall and spring, and dropped during the summer months.
3. Neither Ward et al. (2017) nor Teerlink et al. (2014) identify prey consumed by humpback whales.

Therefore, it is not surprising for our study to show different results than Ward et al. (2017). We believe our study is a preferred design to answer questions and test hypotheses relevant to GWA and HRM programs.

With regards to objective #3 being overly ambitious and the Science Panel's suggestion of rewording and editing to "predation rate"? We agree and will change the wording of this objective.

11. Budget:

Please see provided program workbook.

The planned March 2018 survey will use FY17 funds because there is a lag in receiving FY18 funds. NOAA funds were used to secure vessel time for additional surveys (December 2017 and March 2018); however, NOAA funds are exclusively for vessel cost. Cost for logistics (travel, shipping, overtime) and data processing are covered by GWA funds.