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

Does this proposal contain confidential information? ☐Yes ☒No

Project Number and Title

Gulf Watch Alaska Long-Term Research and Monitoring Program: Pelagic Ecosystem Monitoring Component

22120114-O—Long-term Monitoring of Humpback Whale Predation on Pacific Herring in Prince William Sound

Primary Investigator(s) and Affiliation(s)

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Project Abstract (maximum 300 words)

The humpback whale monitoring project is part of the Gulf Watch Alaska (GWA) Pelagic Component and the integrated predator-prey survey. Humpback whale predation has been identified as a significant source of mortality on over-wintering Pacific herring in Prince William Sound (PWS) and a likely top-down force constraining their recovery from the *Exxon Valdez* oil spill (EVOS). Humpback whales in PWS have a higher percentage of herring in their diet and forage longer on herring during non-summer months than their counterparts in Southeast Alaska. Following the Pacific marine heatwave of 2014-2016, humpback whale numbers declined dramatically and calf production fell within PWS. In 2020, we saw a decoupling of whale numbers from herring abundance and an increase in herring biomass while whale numbers remained low. The cause of the decline in PWS whales remains unknown, but the reduction of predators may provide some relief for struggling herring populations. We will continue to evaluate the impact by humpback whales foraging on Pacific herring populations in PWS following protocols established during 2007/08 and 2008/09 (EVOSTC project PJ090804). Prey selection by humpback whales is determined through acoustic surveys, visual observation, scat analysis, and prey sampling. Chemical analyses of skin and blubber biopsy samples provide a longer-term perspective on shifts in prey type and quality. These data will be combined in an updated bioenergetic model that will allow us to assess the impact of recovering humpback whale populations on the PWS ecosystem. By integrating with the forage fish and fall/winter marine bird components, we will contribute to a comprehensive understanding of bottom-up influences and top-down controls on the PWS herring population. This project is one of only two long-term humpback whale projects funded in Alaska, we will continue to inform the Herring Research and Monitoring component of the GWA Long-Term Research and Monitoring program as well as state and federal managers.

EVOSTC Funding Requested* (round to the nearest hundred, must include 9% GA)

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$204,709	$203,430	$199,754	$204,337	$203,411	$1,015,639
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$220,317	$212,893	$217,019	$224,018	$228,436	$1,102,683
				FY22-31 Total	*$2,118,322*

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

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

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$140,000	$140,000	$140,000	$140,000	$140,000	$700,00
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$140,000	$140,000	$140,000	$140,000	$140,000	$700,000
				FY22-31 Total	*$1,400,000*

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

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

Pelagic Component Background

In the aftermath of the 1989 *Exxon Valdez* oil spill (EVOS) it was difficult to distinguish between the impacts of the spill and background variability in pelagic populations such as whales, marine birds, and forage fish. The main problem was that long-term baseline data for these species groups were largely absent. As a result, managers struggled to make informed decisions in their assessment of damages and recommendations for recovery. Ten years after the spill it was widely recognized that there had been a major climatic regime shift that altered the marine ecosystem prior to the spill. Recently, marine heatwaves of unprecedented spatial and temporal scale have led to a large-scale disruption in the pelagic marine food web. Ongoing monitoring is essential for understanding the impacts of natural and anthropogenic stressors on the pelagic marine ecosystem.

The Gulf Watch Alaska (GWA) - Long-Term Research and Monitoring (LTRM) program's Pelagic Component contains five projects focused on species that play a pivotal role in the pelagic ecosystem as trophic indicators for short and long-term ecosystem change: killer whales, humpback whales, marine birds, and forage fish. The overall goals of the Pelagic Component are to (1) determine the population trends of key pelagic species groups in Prince William Sound (PWS) and their abundance in adjacent shelf waters, and (2) improve our understanding of predator – prey relationships and their response to ecosystem changes. The following questions will shape the research of the pelagic team over the next decade:

1. What are the population trends of key pelagic species groups in PWS - killer whales, humpback whales, marine birds, and forage fish?

2. What are indicators of ecosystem flux in these middle- and upper-level predators (e.g., population changes, shifts in distribution or abundance, variation in condition of individuals, changes in predator/prey relationships)?

3. How do these indicators interface with environmental drivers and with indicators in nearshore coastal and shelf environments to inform a larger picture of ecosystem change?

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 (Straley et al. 2018, Moran et al. 2018), 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 (Barlow et al. 2011). Parallel increases in whale abundance have been documented in PWS (Teerlink 2015). This recovery has coincided with major natural and anthropogenic perturbations in the marine ecosystem (regime shift, Pacific Decadal Oscillation, EVOS). Following EVOS and concurrent with the increase in humpback whale, the abundance of the dominant forage fish, Pacific herring, shifted from an abundant state to a diminished state. The lack of a 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 (EVOS Trustee Council [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 (Rice et al. 2011). In PWS humpback whales during 2007 to 2015 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. 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 Gulf of Alaska for over 50 years.

Warmer water temperatures combined with seabird and marine mammal die-offs and large changes in abundance and quality of krill and forage fish (Arimitsu et al. 2021), emphasize that the Gulf of Alaska is still undergoing major perturbations that impact species at the population level. In PWS, we have failed to see a recovery in humpback whale numbers following the recent marine heatwaves (Fig. 1).

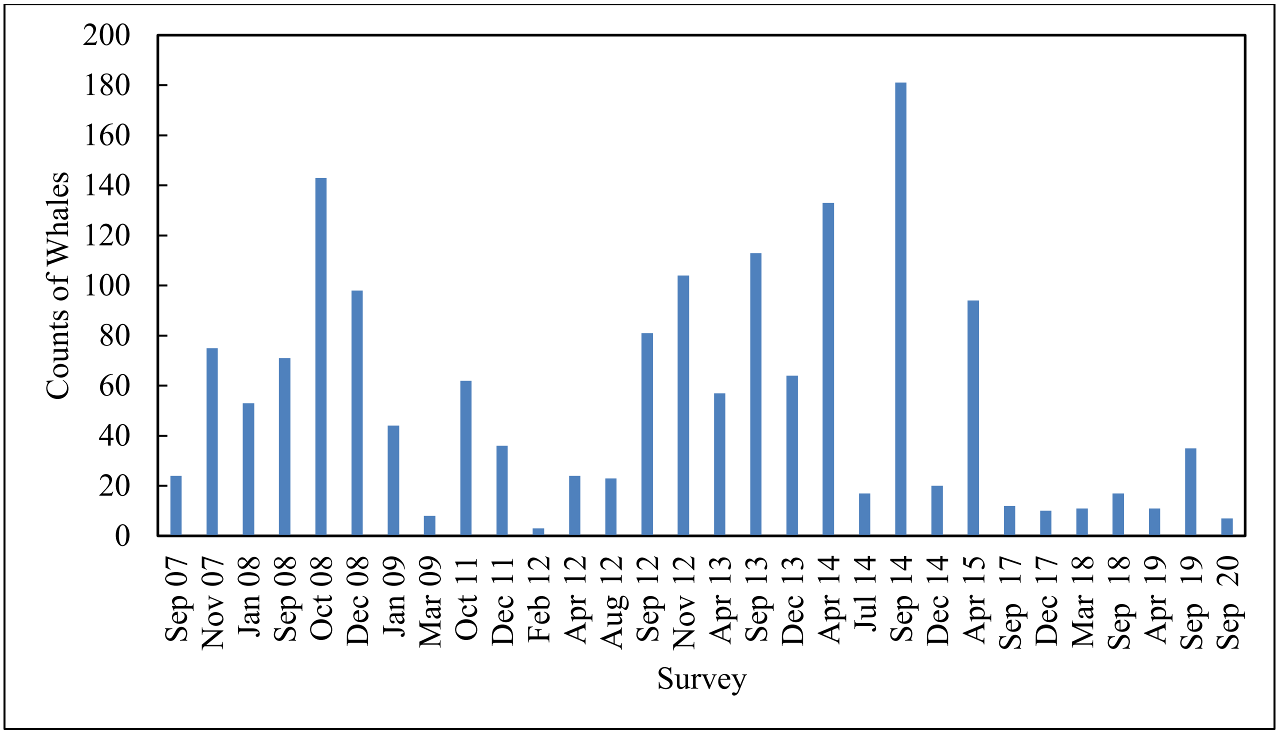

Figure 1. Counts of humpback whales during Exxon Valdez Oil Spill Trustee Council and National Oceanic and Atmospheric Administration funded surveys in Prince William Sound.

In the past we found a correlation between the numbers of individual whales identified each year in PWS (this includes data from both standardized surveys and opportunistic efforts) and the mile-days of milt as reported by Alaska Department of Fish and Game (ADF&G) surveys (Haught and Moffitt pers. comm.) and the Herring Research and Monitoring (HRM) program (Fig. 2). However, 2020 proved to be an exception because whale numbers did not increase with the increase with the mile-days of milt (Fig. 2). We are uncertain as to why humpback whales have failed to return to PWS following the marine heatwave of 2014-2016, but their absence may provide some reprieve from predation pressure to local herring stocks.

The cause of the decline in the number of whales foraging in PWS remains unknown. This presents an added challenge for the project, what is the fate of the missing whales? What is the recovery time for humpback whales within PWS? Will the reduction of predators provide some relief for struggling herring populations? This appears to be an important ecological time period to continue long term monitoring efforts to document changes to the ecosystem and explore the mechanisms behind those changes. Shifts in prey, predators, and environmental drivers identified through this collaborative effort will be instrumental in interpreting these changes in humpback whale predation on herring in PWS.

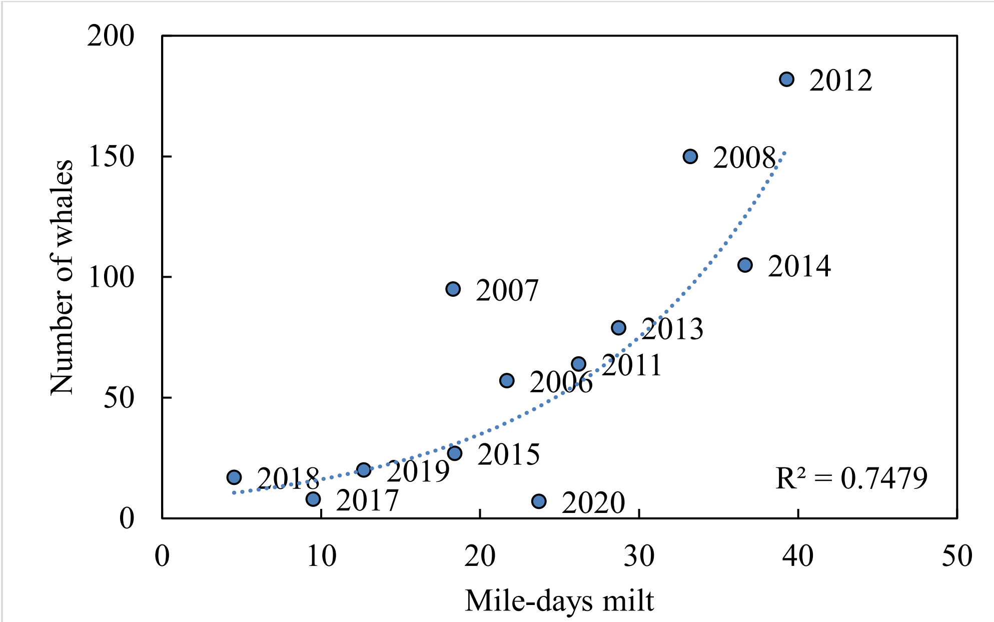

Figure 2. The number of individually identified humpback whales and mile-days of milt for Prince William Sound, 2007-2020. Herring data are courtesy of Scott Pegau (Prince William Sound Science Center) and Stormy Haught (Alaska Department of Fish and Game).

2. RELEVANCE TO THE INVITATION (maximum 300 words)

Humpback whales both prey upon and compete with forage fish. Long-term monitoring of humpback whales and their diet is relevant to the invitation because it ties a key upper trophic level predator to the Pelagic Component as described in the invitation. These data will contribute to the long-term baseline allowing us to not only address recovery of herring in PWS but to identify changes due to long-term oceanographic change, climate change or sudden perturbations. Information provided by this project will also be crucial to National Oceanographic and Atmospheric Administration (NOAA) Protected Resource managers in the implementation of the De-Listing Monitoring Plan for humpback whales, Critical Habitat Designation, Biologically Important Areas, and the Marine Mammal Climate Variability Analysis.

This project specifically addresses the following Areas of interest for the LTRM Focus Area:

(b) Pelagic Monitoring Component.

1. Projects, including monitoring in the Spill Area, covering pelagic species such as killer whale, humpback whale, seabirds, pollock, pink salmon and forage fish. Over the years, Council-funded projects have provided information on population trends of pelagic species to better understand how underlying predator-prey interactions influence recovering species and pelagic ecology within PWS and the Gulf of Alaska.

(e) Herring Research and Monitoring Component.

9. The continued examination of the role of humpback whale population dynamics and changes in whale foraging behavior on herring mortality and the potential limitation of herring recovery.

3. PROJECT HISTORY (maximum 400 words)

This project is a continuation of a long-term humpback whale monitoring project (070804 / Significance of Whale Predation on Natural Mortality Rate of Pacific Herring in PWS), initiated in 2007 under the direction of co-principal investigators (PIs) Rice, Moran, Straley, and Quinn. In 2012, the methodology and results from that (project 070804) and a subsequent project (project 10100804) were used to develop the long-term humpback whale monitoring project under the umbrella of the GWA-LTRM program (projects 16120114-N and 21120114-O). In 2017, the project was improved by a collaboration with the GWA marine birds and forage fish projects and further enhanced in 2019 by collaboration with the GWA monitoring ocean conditions in PWS project (PI Campbell, 22120114-G). Table 1 lists our project's accomplishments to date.

Table 1. Summary of accomplishments of this project since its initiation in 2007 by the Exxon Valdez *Oil Spill Trustee Council (EVOSTC). Reference Literature Cited section for details on accomplishments.*

Accomplishment	Number	Details
Total data collection seasons	14	2007-2009, 2011-2015, 2017-2021.
Total surveys since project initiation	31	September 2007-April 2021 in PWS (Fig. 1).
Peer-reviewed project publications	9	See Literature Cited, Project accomplishments, Publications
Peer-reviewed synthesis publications	2	Arimitsu et al. 2021, Suryan et al. 2021.
EVOSTC final reports	3	Rice et al. 2011, Moran and Straley 2013, Moran and Straley 2018
EVOSTC syntheses	3	Arimitsu et al. 2020, Moran and Straley 2015, Suryan et al. 2020
Other reports	6	See Literature Cited, Project accomplishments, Reports
Professional conference oral presentations	34	See Literature Cited, Project accomplishments, Presentations
Professional conference poster presentations	28	See Literature Cited, Project accomplishments, Posters
Other outreach	11	See Literature Cited, Project accomplishments, Other

4. PROJECT DESIGN

A. Objectives and Hypotheses

Long-term monitoring has proven to be crucial in separating acute and chronic anthropogenic impacts from natural variation when interpreting trends in populations of marine organisms. This project's original goal was to estimate the impacts of humpback whale predation on herring stocks in PWS. Since its inception, we have seen the rise and fall of humpback whale within PWS. Prior to the marine heatwave of 2014 - 2016 we estimated 15%-20% of the pre-spawning herring biomass was consumed by whales (Straley et al. 2018, Moran et al. 2018). Following the heatwave, whale numbers dropped dramatically (Fig. 1). In 2020 there was an uptick in herring biomass while whale numbers remained low (Fig. 2). If whale numbers remain low into the future, we will have a natural experiment to evaluate the top-down forcing hypothesis by whales on herring. While evaluating humpback whale predation on herring will remain the primary focus of this project, the decline in whales raises the question "Where did they go?". This leads to two hypotheses on their fate: 1) they moved to different feeding grounds; 2) they died. Determining the fate of the missing PWS humpbacks will help us understand future herring population trends within PWS.

This project will directly address the following objectives:

1. Estimate trends in humpback whale abundance, diet, and distribution; identify the causes for the decline in humpback whales within PWS

2. Evaluate prey quality and trophic position through chemical analysis (using bomb calorimetry and stable isotopes)

3. Estimate the impact of humpback whale predation on herring

B. Procedural and Scientific Methods

Integrated Predator-Prey Surveys 2022-2031: Humpback Whales, Marine Birds, Forage Fish

To meet the goals of the program we will use an integrated survey design that brings together predator and prey components of the pelagic ecosystem with project collaborators (Integrated Predator-Prey [IPP] survey with 22120114-C PI M. Arimitsu and 22120114-E PI M. Bishop). The IPP surveys include an annual fall (September) hydroacoustic-trawl survey that targets persistent humpback whale feeding locations in Montague Strait, Bainbridge passage and Port Gravina (22120114-C PI M. Arimitsu). In addition, we conduct an annual winter/spring survey that determines humpback whale abundance around the herring spawning season in March or April of each year. These surveys focus on locations where whales are observed foraging in PWS during the fall and winter. In September, this location is where herring can be found entering Montague Strait, as well as Bainbridge Passage and Port Gravina. The basic structure of the survey is for a vessel to conduct acoustic estimates along fixed transect lines, the locations of which are based on recent historical data on whale foraging locations. While the acoustic vessel is conducting transects a second "whale" vessel will be used to assess whale abundance to meet project objectives on this proposal. The whale vessel will depart from the acoustic vessel and work independently in the area where the acoustic data are being collected. This gives the whale vessel the ability to census and sample whales and scout for whales along a standard route outside the fixed areas. At the end of the day the two vessels will join and share information. Data collected by the whale vessel include photograph the flukes of individual whales for identification, blubber and skin biopsies, observations of whale diets, and samples of tissues left by whales (e.g., stunned fish, scats, scales etc.). Onboard GPS and acoustics on the whale vessel will be used to identify layers to which whales may be diving and locations. These data will be compared with data from the acoustic vessel. During the March/April survey, there will be one vessel only, focusing on humpback whale abundance and distribution.

Hydroacoustic-trawl. (Forage Fish Project) The fixed transect layout was chosen to sample areas of persistent humpback whale habitat use identified in surveys conducted in 2006-2014. To estimate depth distribution and biomass of prey in the water column a calibrated SIMRAD 38-120 kHz split beam EK60 system will be towed beside the boat along pre-determined transects, and each transect will serve as a sample to estimate the abundance using the area each subregion (Fig. 3).

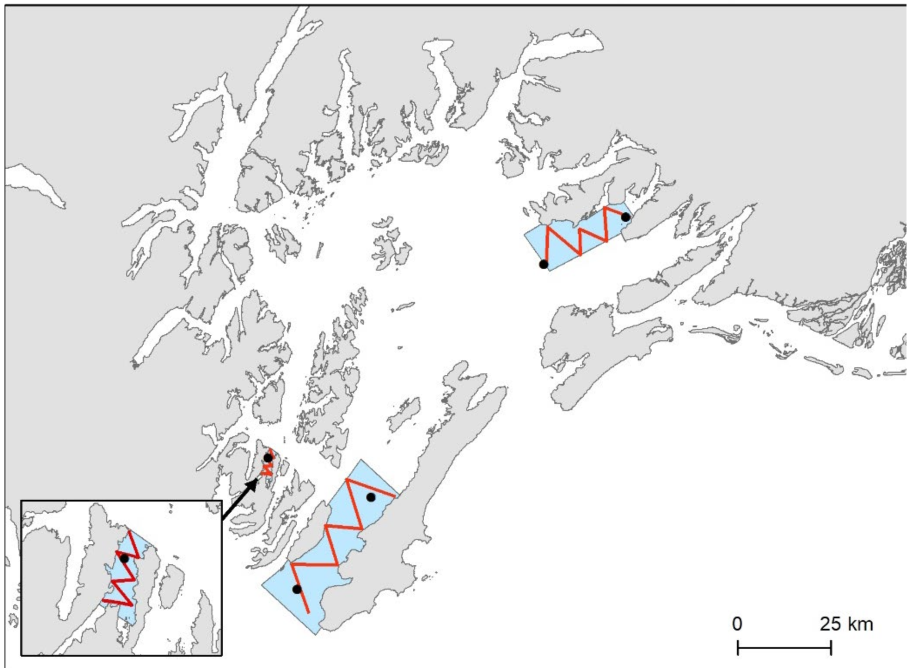

Figure 3. Integrated Predator-Prey survey transect layout (red lines) and persistent humpback whale foraging areas (blue shaded regions). Marine bird and whale density will be assessed in conjunction with hydroacoustic transects for fish and krill. We will also assess changes in associated marine habitat at stations (black circles) within each subregion using zooplankton tows and conductivity-temperature-depth profiles.

We will use a midwater trawl and other means as necessary to verify species and size (length in mm, weight to 0.01 g) of organisms (krill and schooling fish) that contribute to hydroacoustic backscatter in each subregion. The net has an approximately 154 m_2 mouth (14 m x 11m) and is 22 m long. Mesh size diminishes from 38 mm at the mouth to 12 mm at the cod end (Innovative Net Systems, Inc.). The net is held open by two 0.4 m_2, series 2000 steel mid-water trawl doors (Nor 'Eastern, Inc.); each weighing approximately 76 lbs. The net will be towed at approximately 1.8 kt, trawl duration will depend on the vertical and horizontal distribution of acoustic targets. Depth of the headrope will be managed with a TrawlMaster system. Although we will try to accomplish ground-truthing of acoustic sign on daytime transects, logistical constraints (daylight hours, trawl depth limitations, etc.) may require that trawls occur at night when the scattering layer ascends in the water column. We will also attempt to ground truth untrawlable (e.g., shallow nearshore areas) acoustic backscatter with other means (e.g., underwater video, jigs, dipnets, cast nets).

Trawl catches will be enumerated, lengthed (TL and FL, mm), and weighed (0.01 g) by species. Fish samples will be taken for sex, diet, energetics, and isotope analysis. A subsample of the euphausiid catch will be preserved in 3-5% formaldehyde solution for laboratory analysis of species proportion and weight. Krill samples will also be analyzed for energetics.

In addition to fixed transects in persistent predator aggregation areas, we will also characterize prey density more closely associated with individual or groups of whales in each subregion (Montague, Bainbridge and Gravina). This will involve focal follows of individual whales, or prey mapping near groups of feeding whales.

Marine habitat. At six fixed stations in the study area (Fig. 3) we will measure oceanographic variables with a SBE19 plus v2 conductivity-temperature depth profiler (CTD). After each CTD cast we will also collect zooplankton samples with a 100 m vertical haul of a 150 µ-mesh zooplankton net. Concurrent sampling of ocean and zooplankton indices will provide spatial and temporal overlap of environmental and predator-prey indices. During each cruise we will sample 80 km of transects, with associated trawls (max depth 100 m) to collect fish and krill and 6 CTD/zooplankton stations.

We anticipate a typical survey schedule will occur as follows (subject to changes as necessary for logistics and weather conditions):

Day 1. load, travel, calibrate hydroacoustics, passive noise test
Day 2. Montague (82 km tx, 2 trawl, 2 CTD/zoop)
Day 3. Montague (82 km, 2 trawl, 2 CTD/zoop)
Day 4. Finish Montague, focal follows or adaptive tx. Transit.
Day 5. Bainbridge (18 km tx, 1 trawl, 1 CTD/zoop, 1-2 hour focal/adaptive). Transit.
Day 6. Knowles/Gravina (57 km tx , 1-2 trawls, 2 CTD/zoop)
Day 7. Knowles/Gravina (57 km tx, 1-2 trawls, 2 CTD/zoop, 2-3 hour focal/adaptive)
Day 8. Weather or focal/adaptive effort
Day 9. Weather or focal/adaptive effort
Day 10. Weather or focal/adaptive effort. Transit. Unload.

Humpback Whales: Long-term monitoring of predation on Pacific herring in Prince William Sound

(*Objective 1*) The decline in humpback whales during recent years present a unique challenge to estimating abundance and trends. Tradition line transects are not appropriate for the bays and passages of PWS because convoluted shorelines, poor visibility, limited survey time, combined with highly aggregated and mobile whales are not practical for this type of survey. Counts of whales can be accurate when whales are widely distributed but may be underestimate the true number when whales are in large shoals. When groups of whales are located and determined to be feeding, effort will be made to determine the identities of the whales and what they are eating. Whales will be identified from the patterns on the ventral sides of their flukes. The patterns will be recorded using Nikon (model D-800, D-300, D-850 or similar) cameras with 80-200 mm zoom or fixed 300mm lenses to capture digital images. The photos will be compared with the PWS catalog and sighting history database that includes 511 whales previously sighted in PWS and managed by PI Straley at the University of Alaska Southeast (UAS). Direct observations of prey being consumed, remains after feeding, and sonar mapping of the prey fields observed on a dual 38/120 kHz frequency echosounder will be used to determine presumed target prey of humpback whales (see Arimitsu and Piatt forage fish proposal, 22120114-C, for details). Confirmation of target prey will be accomplished using herring jigs, trawls, zooplankton tows, and cast nets to collect surface fish near feeding whales. Scales and zooplankton will be collected behind whales feeding at the surface with a skim net. Fecal samples will be collected when possible. Certainty of identification of the target prey will be recorded as certain, probable, or undetermined. Only cases where the identification is certain or probable will be used to identify specific prey.

Observers will conduct conventional focal follows by recording the position and behavior of whales in conjunction with hydroacoustic measurements of prey. Position relative to the boat's heading will be recorded by estimating the angle and line of sight distance to the animal upon surfacing. Behavioral observations will include initial surface and terminal dive times, swim direction relative to the observation vessel, and general behavior (slow/fast travel, milling, feeding, tail slap, breach, etc.).

Biopsies of whale skin will be collected for isotopic analysis to independently derive estimates of whale diets from the trophic level. Direct observation of diets provides only a “point-in-time” estimate and does not provide information on periods when whales are not being observed. Stable isotope analysis can provide a more time-integrated measure of whale diet. In addition, stable isotope analysis can be used to estimate the trophic position of organisms. If whales in PWS consume large amounts of herring they should occupy a higher trophic position than herring, as has been shown previously for humpbacks in and around PWS (Witteveen et al. 2011). We will use both methods to better describe the impact of whales on forage fish including herring. Biopsies will be collected using a crossbow bolt with a coring tip. Samples will be recovered immediately, labeled, and placed in an ice chest. At the end of the day the contents of the ice chest will be transferred to a freezer on the acoustic vessel. At the end of the survey the biopsy samples will be transported to Auke Bay and stored at -80 °C until they are processed. Primary consumers will be collected and analyzed to establish an isotopic baseline for inter-annual trophic comparisons.

(*Objective 2*) Isotopic analysis of whale and prey samples will be conducted using a Thermo Delta V gas chromatograph/isotope ratio mass spectrometer. Prior to stable isotope analysis, tissues will be archived at - 80 °C in freezers at NOAA Auke Bay Laboratories Juneau, Alaska. Pilot analyses has shown that lipid content in tissues can influence $\delta^{13}C$ values; therefore, tissues will be lipid-extracted prior to quantification of stable isotope ratios. Stable isotope values (expressed in δ notation) will be generated for samples using the methods described in Seymour et al. (2014). The isotope ratio mass spectrometer will be calibrated using certified standards from the International Atomic Energy Agency and US Geological Survey, which produce the international reference materials (reference standard for carbon is VPD and air for nitrogen) All sample analyses will be conducted with certified quality control standards for precision and accuracy interspersed throughout the analytical run. If the quality assurance standard results differ from certified values by more than the known standard deviation of the reference material, the sample will be re-analyzed until results of quality assurance standards are within the expected tolerances.

The energy content of prey will be measured from each survey to estimate the number of prey (or volume) consumed by humpback whales. Energy content will be measured using calorimetric methods as outlined in by Siddon et al. (2013). Putative prey will be obtained from trawls conducted on the acoustic vessel and samples collected by the whale vessel. Samples of prey will be weighed, dried, and the homogenized tissue will be pressed into pellets. The pellets will be combusted in a Parr Instrument 6725 Semimicro Bomb Calorimeter to measure the energy released. Quality assurance (QA) procedures include the use of duplicate samples to evaluate precision, reference materials to evaluate accuracy and blanks (benzoic acid) to evaluate cleanliness. Predetermined limits for variation observed in QA samples were set, where precision estimates from duplicate tissue and reference samples must not vary by more 15% CV.

(Objective 3) See section C. Data Analysis and Statistical Methods.

C. Data Analysis and Statistical Methods

Analysis of the data collected during the surveys is aimed at fulfilling objectives 1, 2 and 3 listed under the heading *Long-term monitoring of humpback whale predation on Pacific herring in Prince William Sound*. This includes assessing trends in the abundance and spatial distribution of whales, evaluating their diets and assessing their impact on PWS herring populations.

Estimating humpback trends in humpback whale abundance, diet, and distribution (Obj. 1)

Whale abundance will be estimated using mark-recapture techniques using the black and white pattern on the ventral surface of each whale's flukes as natural marks. The first photograph of a particular whale is treated as the "mark", and subsequent photographs of the same whale are "recaptures". Both closed and open population models will be examined. However, we will likely employ the Huggins closed-capture model (White and Burnham 1999) using the program MARK. This is the approach employed in our previous efforts (Moran et al. 2018) and those used by Teerlink et al. (2015). Photographs will be quality ranked for percent of flukes visible, angle of the flukes to the water surface and to the camera, clarity of the image and other attributes to reduce sampling bias. Some whale's flukes are very distinctive; that is the black and white pattern or shape can identify the whale in blurry photo. Other whales are not distinguishable with poor quality photography; hence this quality control makes all patterns on the flukes equally available for capture. Photographs deemed poor or of insufficient quality will be excluded from the mark-recapture analysis to avoid this bias. Further, photographs of humpback whale calf flukes will also be excluded, because the capture probability for a calf is complicated by their co-occurrence with their mothers (and is therefore not independent), and the probability of recapture in later years can be difficult as calf flukes tend to change more than adult flukes. Abundance estimates will represent the number of whales present in PWS in a given winter. Whale distributions will be examined by plotting whale observations on maps for each survey to identify locations where whales were most abundant and evaluate seasonal movements. These maps can be overlaid with maps derived from the forage fish survey to relate whale distributions to prey availability. Determining the number of humpback whales foraging in PWS a will require the full suite of sighting histories and covariates. Thus, estimates of abundance will be made on during years 3, 5, 8, and 10; however, we will be able to provide preliminary abundance estimates that may be useful in determining whale population trends.

To address the fate of the missing whales in PWS we will be collaborating with Ted Cheeseman (Happywhale fluke matching technology). This basin-wide database contains whale fluke photographs from multiple research groups and the general public throughout the world. If missing PWS whales are documented on the breeding grounds or in another feeding area, we can rule out mortality as the cause of the decline.

Evaluate whale diets, prey quality and trophic position (Obj. 1 & 2)

Direct observations of whale diets will be summarized to estimate whale diets for each winter. The proportion of prey type in the diet of observed feeding groups of whales will be determined for each survey. The survey design calls for identifying groups of foraging whales. Consequently, diets will be summarized for individual groups. Multiple groups are likely to be seen on a given day. Each group of whales associating together on a given day will be tallied across a survey to determine the total number of groups observed. The number observed eating a particular prey item (e.g., herring, krill, unknown) will be tallied for each survey to estimate the proportional contribution of each prey type to whale diets during a given survey. Pearson chi-square tests will be used to identify differences among the diets of groups in different parts of PWS during a survey (where there are sufficient data) and between surveys. Stable isotope data from whale tissue and prey will be used to estimate the contribution of various prey to whale diets using isotopic mixing models and trophic niche partitioning methods (Jackson et al. 2011, Parnell et al. 2013).

Estimating the impact of humpback whale predation on herring (Obj. 3)

Estimates of the number of herring consumed by whales over winter will be compared with estimates of the herring abundance to evaluate the impact of whale predation on PWS herring. Estimates of herring abundance will be taken from the pre-spawning biomass as estimated by the age-structured stock assessment to be produced by the Herring Research and Monitoring Component (22120111-C, PI T. Branch). Estimates of herring consumption by humpback whales will combine estimates of the averaged daily metabolic demand by humpback whales with estimates of the number of whales present, the proportion of herring in their diet, and the average energy content of the herring to determine the number of herring consumed (eq. 1, Moran et al. 2018).

Eq.1:

$$C = \sum_{t=1}^{182} \frac{p_t \sum_{i=1}^{100} K\left(\frac{n_t}{100} w_i\right)^{\beta}}{ED_t}$$

Where C is the total biomass removed by whales over the course of the winter (t in days); p_t is the proportion of the whales known to be eating herring on the t^{th} day, n_t is the number of whales foraging on the t^{th} day, w_i is the mass of a whale in the i^{th} size class, K and β are allometric parameters describing the metabolic rate of whales in the i^{th} size class, and ED_t is the energy density of herring on the t^{th} day.

The time step for the model is one day and the duration of winter is estimated to be the time between surveys. We will interpolate the number of whales present on a given day from a whale-day model (Moran et al. 2018). Previous surveys between 2006 and 2020 have provided observations of the number of unique whales present on different days of the winter. We will plot the number of whales present by Julian day and fit a curve describing the whale attendance pattern in PWS. For each winter we will scale the curve upward so that the maximum number of whales present in PWS equals the point estimate from our mark-recapture analysis. This will model the number of whales present on each day, and the integral from day 1 to day n is the number of whale days.

Statistical Robustness

Coefficients of variation (CV) among Chapman mark recapture estimates for PWS humpbacks have varied over the years between 2007 and 2019, with a step change between CVs before (2007-2013) and after (2014-2019) the marine heatwave years (Table 2). Chapman estimates show a strong and significant decline in whale abundance since 2007 (80 ± 16 whales per year, $R^2 = 0.73$, $f\,[1,8] = 24.99$, $p = 0.001$), demonstrating a clear ability of the methods employed to identify significant trends in PWS humpback whale abundance over time.

We conducted a power analysis to identify the effect size for a linear trend over time given the CVs in low and high abundance years following Gerrodette (1987). If we assume an CVs of 0.53 for low abundance years (2015-2019) and 0.26 for high abundance years (2007 – 2014), and $\alpha = \beta = 0.05$, at the end of 21 years of sampling we will be able to detect a significant effect size of 0.07 and 0.03, respectively (Fig. 4; Gerrodette 1987).

Overestimation may be an issue with counts if whales move across the Sound and are recounted. We have relied on the unique marking of the flukes to use mark-recapture models for a robust estimate abundance. However, as the number of marked animals and recaptures drop, the coefficient of variation increases making estimates questionable (Table 2.). It is unlikely that increasing effort will increase the number of whales identified when abundance is extremely low (we can't identify more whales if they are not there). Reports from other researchers and the public confirm our observations, there were significantly fewer whales using PWS following the marine heatwave. If numbers remain low, it is likely we will have to use a combination of techniques to determine how many whales are foraging within PWS.

Table 2. Chapman estimates of adult humpback whale abundance and coefficients of variation (CV) in Prince William Sound. Note these preliminary estimates are used here to illustrate the changes in the CV.

	2007	2008	2011	2012	2013	2014	2015	2017	2018	2019	2020
Whales IDed	217	316	76	224	123	192	29	9	20	18	7
Chapman Estimator	1096	625	618	753	824	578	149	52	99	50	*
CV	9%	10%	14%	12%	15%	24%	50%	32%	36%	37%	*

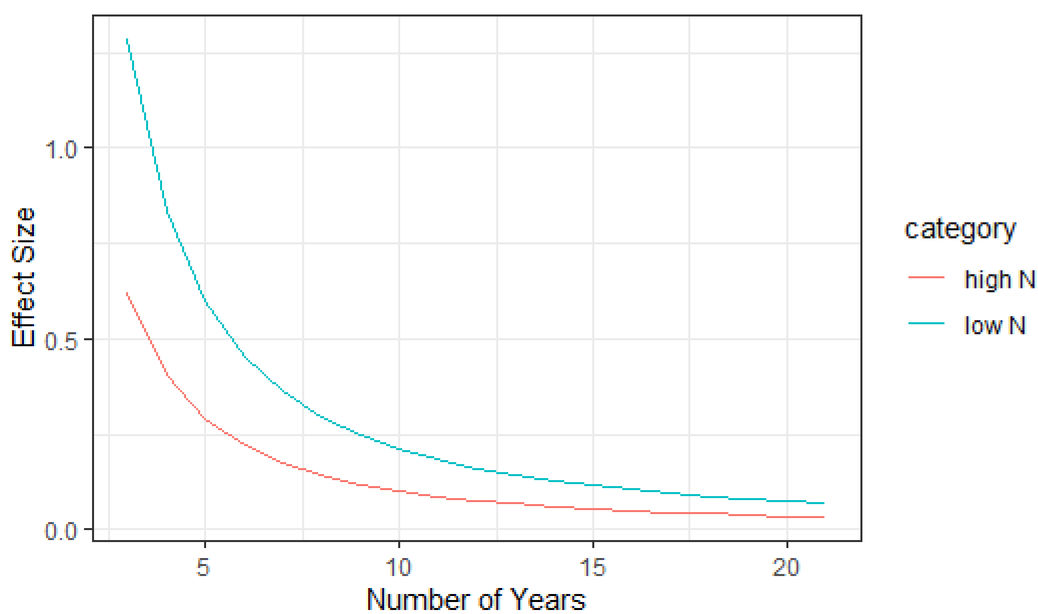

Figure 4. Power analysis to identify the minimum statistically significant effect size detectable based on the anticipated number of years sampled at the end of this project and coefficients of variation for high and low abundance categories (color). For this analysis we set $\alpha = \beta = 0.05$.

D. Description of Study Area

This study will occur in the waters of PWS (bounding coordinates: 61.292, -148.74; 61.168, -146.057; 60.273, -145.677; 59.662, -148.238 (Fig. 3). The seasonal distribution of humpback whales served as a guide in establishing these transects. While the acoustic survey vessel focusses on IPP survey transects, the whale survey vessels ranges broadly throughout PWS to locate as many whales as possible. If whale numbers remain low, we will expand our surveys to the waters adjacent to PWS.

5. COORDINATION AND COLLABORATION

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

The humpback whale project has shared vessels with the Prince William Sound Science Center (PWSSC) fall and wintering marine bird project (PIs Bishop and Schaefer, 22120114-E) since 2007, this collaboration continues as the GWA-LTRM Integrated Predator Prey Survey. We share information with the PWSSC HRM and Environmental Drivers Components as well.

B. Within the EVOSTC LTRM Program

Environmental Drivers Component

The PWSSC research vessel (R/V New Wave) with the Monitoring of Oceanographic Conditions in PWS project (PI Campbell, 22120114-G), provides us with whale observations.

Pelagic Monitoring Component

This study is part of the Pelagic Component of the GWA-LTRM program. The GWA-LTRM pelagic projects share research platforms and common goals of the Integrated Predator-Prey surveys that include this project, the fall and wintering marine bird project (PIs Bishop and Schaefer, project 22120114-E), and the forage fish project (PIs Arimitsu and Piatt, project 22120114-C). Our project also collects data for the killer whale project (PIs Matkin et al., project 22120114-N). The objectives of the Integrated Predator-Prey surveys are summarized in Table 3.

Table 3. Integrated Predator-Prey sampling objectives.

Objective	Index	Task	PI
1. Estimate humpback whale abundance, diet, and distribution			
	Whale counts by subregion	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)
2. 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 - hydroacoustic transects, whale focal follows**	**Bishop - Schaefer (PWSSC), Arimitsu-Piatt (USGS)/ Moran (NOAA)/ Straley (UAS)**
3. Estimate index of forage fish and euphausiid abundance in seasonally predictable predator foraging areas			
	Species composition and acoustic biomass indices within persistent predator foraging areas	Integrated Surveys: hydroacoustic-trawl data, whale focal follows	Arimitsu-Piatt (USGS)/ Moran (NOAA)/ Straley (UAS)
	Forage fish density and depth distribution	Integrated Surveys: hydroacoustic-trawl data, whale focal follows	Arimitsu-Piatt (USGS)/ Moran (NOAA)/ Straley (UAS)
	Diet, energy density	Sample Analysis: herring, sand lance, capelin, juvenile pollock, euphausiids	Moran (NOAA)/ Arimitsu-Piatt (USGS)

Objective	Index	Task	PI
4. Measure local conditions of marine habitat in seasonally predictable predator foraging areas			
	Oceanographic parameters and zooplankton biomass	Integrated Surveys: CTD, nutrients, and zooplankton samples	Arimitsu-Piatt (USGS)

Nearshore Monitoring Component

Our data would be available to share if needed to examine correlations with the nearshore team.

Lingering Oil Monitoring Component

Because lingering oil data are collected once in a 5-year period and the oil is not currently bioavailable, we do not anticipate incorporating these data into our project. We look forward to status reports from the Lingering Oil Component. Our data would be available to share if needed to examine correlations with impacts of lingering oil.

Herring Research and Monitoring component

Our project relies on herring biomass estimates from HRM. We share information on herring and whale distribution (and other predators). The combining of the HRM and GWA under the LTRM will help facilitate future collaboration.

Synthesis and Modeling Component

We will contribute data as needed for synthesis and modeling efforts undertaken during FY22-31. In the past, we have contributed data to and assisted with development of three synthesis efforts: Arimitsu et al. 2021, Suryan et al. 2021, and Moran and Straley 2015.

Data Management Project

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.

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

Current EVOSTC-funded projects not within the LTRM focus area have not intersected with this project so far. As the EVOSTC funds future projects outside the GWA-LTRM program we will evaluate their applicability to our project and coordinate as appropriate. 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.

D. With Proposed EVOSTC Mariculture Focus Area Projects

We look forward to working with the EVOSTC's Mariculture Program and projects they embark on. We anticipate they will be interested in GWA-LTRM datasets and we expect there will be opportunities for coordination and collaboration. Understanding the seasonal movements and distribution of humpback whales is critical to avoiding whale entanglements with mariculture gear. Our data would be available to share if needed to mitigate conflicts between marine mammals and mariculture operations. Due to the lack of Alaska-based research, ADF&G Marine Mammal Program has requested assistance from PIs Moran and Straley in responding to mariculture operation permits with regard to wildlife impacts.

E. With Proposed EVOSTC Education and Outreach Focus Area Projects

The GWA-LTRM program will develop an outreach plan that includes coordination and collaboration with the Trustee's Education and Outreach Program and projects. We look forward to participating in education and outreach opportunities where our project findings can contribute to a better understanding of the Gulf of Alaska ecosystem by the general public. This project has an extensive outreach history (Table 1). We will work with the Education and Outreach focus area program and GWA-LTRM to develop and deliver marine mammal informational products to students and the public. We are developing and seeking funds for a project to establish coastal monitoring sites around the Gulf of Alaska in collaboration with local schools. This project will build on the existing RASOR (Rural Alaska Students in One-Health Research) Program.

F. 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 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. NOAA's Protected Resource Division (Aleria Jensen, NOAA Fisheries Alaska Regional Office) is funding the Survey of Population Level Indices for Southeast Alaska (SPLISH), a collaborative survey of humpback whales in northern Southeast Alaska. The objectives of this study were to establish baseline conditions for indices that are slated to be monitored for the 10-year post-delisting period. SPLISH builds on work conducted during *Exxon Valdez* Oil Spill Restoration Project 100804 and compliments our GWA surveys. Data from the GWA surveys and SPLISH were provided to the Humpback Whale Critical Habitat Review Team (Lisa Manning, NOAA Fisheries/ Endangered Species Division) and are included in the North Pacific Fishery Management Council's annual forage fish stock assessment.

During our surveys we will collect eDNA from harbor porpoise to identify stock structure for the Marine Mammal Laboratory (Kim Parsons, NOAA Fisheries).

This project will continue to report a humpback whale index as an indicator in ecosystem assessments for reports to the North Pacific Fisheries Management Council (Stephani Zador, NOAA Fisheries Alaska Fisheries Science Center) (Ferriss and Zador 2020). Collections of juvenile forage fish, particularly age-0 pollock, are of direct interest to the NOAA Alaska Fisheries Science Center, which is actively engaged in understanding how winter influences pollock survival (Recruitment Processes Alliance – Fisheries-Oceanography Coordinated Investigations, Ecosystem Monitoring and Assessment, Recruitment Energetics and Coastal Assessment, Resource Ecology and Fisheries Management programs). We anticipate working with the NOAA 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. We will also collect data (location, number, species, and behavior) on all cetacean species sighted in PWS (Sadie Wright, NOAA Fisheries/Alaska Regional Office).

G. With Native and Local Communities

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

In addition, this project will continue engaging with local communities as we have during the first 10 years of the program, including talks at the Chenega School and discussions with the Sitka Tribe of Alaska on herring issues.

6. DELIVERABLES

This project has met expectations for deliverables consistently and will continue to be responsive to the EVOSTC. Deliverables are summarized in Table 4.

Table 4. Project Deliverables for FY22-31.

Deliverable	Description
Progress reports	Submit annually
Final report	Submit within required timeframe
Data & metadata	Upload data to Research Workspace annually. Publish data to DataONE as required; Contribute data to North Pacific Pelagic Seabird Database on regular basis
Synthesis & modeling efforts	Continue modeling the humpback whale abundance distribution and predation rates on herring; for syntheses: contribute data and assist with analyses and interpretation as needed
Peer-reviewed publications	We will publish scientific papers to peer-reviewed journals. Topics may include the decline of humpback whales in PWS and the response of humpback whales to a marine heatwave.
Professional presentations	Prepare and deliver oral and poster presentations on a regular basis for professional meetings such as the Alaska Marine Science Symposium and Biennial Marine Mammal Conference
Public outreach	Regularly contribute to *Delta Sound Connections*, National Oceanic and Atmospheric Administration websites, Whale Fest, and other educational and public forums.
Website	Maintain up-to-date project description on the Gulf Watch Alaska website

7. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

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

	FY22				**FY23**				**FY24**				**FY25**				**FY26**			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone 1: Surveys																				
Integrated predator-prey surveys			X				X				X				X				X	
Spring survey	X				X				X				X				X			
Milestone 2: Data processing																				
Photographic analysis		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Chemical analysis		X		X		X		X		X		X		X		X		X		X
Statistical Analysis												X								X
Reporting																				
Annual reports				X				X				X				X				X
Deliverables																				
Peer reviewed paper																				X
Data posted online				X	X			X	X			X	X			X	X			X
Annual PI meeting			X				X								X				X	

	FY27				**FY28**				**FY29**				**FY30**				**FY31**			
Milestone/Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestone 1: Surveys																				
Integrated predator-prey surveys			X				X				X				X				X	
Spring survey	X				X				X				X				X			
Milestone 2: Data processing																				
Photographic analysis		X	X	X		X	X	X		X	X	X		X	X	X		X	X	X
Chemical analysis		X		X		X		X		X		X		X		X		X		X
Statistical Analysis												X								X
Reporting																				
Annual reports				X				X				X				X				X
Final report																				X
Deliverables																				
Peer reviewed paper																				X
Data posted online				X	X			X	X			X	X			X	X			X
Annual PI meeting			X				X				X				X				X	

8. BUDGET

A. Budget Forms (Attach)

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

Budget Category:	Proposed FY 22	Proposed FY 23	Proposed FY 24	Proposed FY 25	Proposed FY 26	5-YR TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$80,157	$81,515	$78,040	$79,866	$81,739	$401,316	
Travel	$15,394	$14,320	$14,488	$18,083	$14,852	$77,137	
Contractual	$50,000	$50,000	$50,000	$52,000	$52,000	$254,000	
Commodities	$4,000	$7,000	$7,000	$2,300	$2,300	$22,600	
Equipment & F&A Exempt	$24,000	$18,900	$19,845	$20,837	$21,879	$105,461	
Indirect Costs (varies by proposer)	$14,255	$14,897	$13,887	$14,379	$13,846	$71,265	
SUBTOTAL	$187,806	$186,633	$183,260	$187,465	$186,616	$931,779	
General Administration (9% of subtotal)	$16,903	$16,797	$16,493	$16,872	$16,795	$83,860	N/A
PROJECT TOTAL	**$204,709**	**$203,430**	**$199,754**	**$204,337**	**$203,411**	**$1,015,639**	
Other Resources (In-Kind Funds)	**$140,000**	**$140,000**	**$140,000**	**$140,000**	**$140,000**	**$700,000**	

Budget Category:	Proposed FY 27	Proposed FY 28	Proposed FY 29	Proposed FY 30	Proposed FY 31	5-YR TOTAL PROPOSED	ACTUAL CUMULATIVE	TEN YEAR TOTAL
Personnel	$83,655	$85,623	$87,637	$89,705	$91,820	$438,439		$839,755
Travel	$18,627	$15,253	$15,468	$15,695	$15,933	$80,976		$158,113
Contractual	$54,000	$54,000	$54,000	$56,000	$56,000	$274,000		$528,000
Commodities	$2,300	$2,300	$2,300	$2,300	$2,300	$11,500		$34,100
Equipment & F&A Exempt	$28,973	$24,122	$25,328	$26,594	$27,924	$132,941		$238,402
Indirect Costs (report rate here)	$14,571	$14,017	$14,367	$15,227	$15,597	$73,780		$145,045
SUBTOTAL	$202,126	$195,315	$199,100	$205,521	$209,574	$1,011,635		$1,943,415
General Administration (9% of subtotal)	$18,191	$17,578	$17,919	$18,497	$18,862	$91,047	N/A	$174,907
PROJECT TOTAL	**$220,317**	**$212,893**	**$217,019**	**$224,018**	**$228,436**	**$1,102,683**		**$2,118,322**
Other Resources (In-Kind Funds)	**$140,000**	**$140,000**	**$140,000**	**$140,000**	**$140,000**	**$700,000**		**$1,400,000**

This project is a collaborative effort among co-PIs from NOAA ABL (a Trustee Agency) and UAS (a Non-Trustee Organization). Over the course of the 10-year funding period, each organization requests the following amounts (not including GA):

- NOAA ABL (PI Moran): $991,790
- UAS (PI Straley): $951,625

B. Sources of Additional Funding

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

FY22	FY23	FY24	FY25	FY26	FY22-26 Total
$140,000	$140,000	$140,000	$140,000	$140,000	$700,000
FY27	**FY28**	**FY29**	**FY30**	**FY31**	**FY27-31 Total**
$140,000	$140,000	$140,000	$140,000	$140,000	$700,000
				FY22-31 Total	*$1,400,000*

Non-EVOSTC funds are agency in-kind, representing salary contributions of permanent Primary Investigators and use of existing equipment including boats and other specialized gear. Over the 10-year period, NOAA will make the following in-kind contributions: salary ($90 K) for PI Moran (7 mos. GS-12), and all field and laboratory equipment required ($50 K) for an annual total of $140K/year.

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

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Moran, J. 2016. Invited Speaker Hawaii's Humpbacks: What are they doing in Alaska? Oral Presentation. Maui Whale Tales Kapalua, HI. February.

Moran, J. 2016. Impacts of a recovering humpback whale population. Oral Presentation. University of Alaska Southeast, Juneau, Alaska. February.

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Moran, J.R. 2012. Invited speaker. 154th meeting of the Western Pacific Fishery Management Council, Honolulu, HI. 25-28 June.

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10. PROJECT PERSONNEL

PRINCIPAL INVESTIGATOR: Pelagic Component
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RELEVANT PROFESSIONAL EXPERIENCE

Research Fisheries Biologist, *U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Auke Bay Laboratory*, *Juneau AK. August 2006- present*
Research Associate, *University of Alaska Southeast, Juneau, AK.* September 2003- August 2006
Research Assistant, *University of Alaska Fairbanks, Juneau, AK*. January 2002-May 2003
Weir Crew Leader, *SWCA, Salt Lake City, UT.* September 2001-November 2001
Graduate Intern, *Alaska Department of Fish and Game, Juneau, AK.* April 2000-April 2001
Teaching Assistant, *University of Alaska Fairbanks, Juneau, AK.* September 1999-December 2000
Biological Technician (Fisheries), *U.S. Fish and Wildlife Service, Togiak NWR, Dillingham, AK***.** April 1998-August 1999
Biological Science Technician (Wildlife), *U.S. Fish and Wildlife Service, Togiak NWR, Dillingham, AK*
Fisheries Technician/Tagger/Diver, *Prince William Sound Aquaculture, Cordova, AK.* February 1992-April 1993

MOST RELEVANT PUBLICATIONS

Taylor L.F., C.M. Gabriele, K. Burek Huntington, C.L Buck, K.E. Hunt, C. Lockyer, C. Low, **J.R. Moran**, A. Murphy, S. Raverty, and M.C. Rogers. *In review*. Humpback Whale #441 (Festus): Life, Death, Necropsy, and Pathology. Natural Resource Report NPS/GLBA/NRR.

Rogers, M.C., **J. Moran,** C.M. Gabriele, J. Nielson, C. Weiss, A. Masterman, and J. Straley, *In review*. Isotopic analysis of Northeast Pacific humpback whale baleen: dynamic foraging habits and evidence of starvation in response to a marine heatwave. Deep Sea Research II

Suryan, R.M., M.L. Arimitsu, H.A. Coletti, R.R. Hopcroft, M. R. Lindeberg, S.J. Barbeaux, S.D. Batten, W.J. Burt, M.A. Bishop, J. L. Bodkin, R. Brenner, R.W. Campbell, D.A. Cushing, S.L. Danielson, M.W. Dorn, B. Drummond, D. Esler, T. Gelatt, D.H. Hanselman, S.A. Hatch, S. Haught, K.Holderied, K. Iken, D.B. Irons, A. Kettle, D.G. Kimmel, B. Konar, K.J. Kuletz, B.J. Laurel, J. M. Maniscalco, C. Matkin, C.A.E. McKinstry, D.H. Monson, **J.R. Moran**, D. Olsen, W.A. Palsson, W.S. Pegau, J.F. Piatt, L.A. Rogers, N.Rojek, A.Schaefer, I.B. Spies, J.M. Straley, S.L. Strom, K.L. Sweeney,M. Szymkowiak, B.P. Weitzman, E.M. Yasumiishi, and S.G. Zador. *Accepted.* Ecosystem response persists after a prolonged marine heatwave. Scientific reports.

Arimitsu, M., J. Piatt, S. Hatch, R.M. Suryan, S. Batten, M.A. Bishop, R.W. Campbell, H. Coletti, D. Cushing, K. Gorman and R.R. Hopcroft, K.J. Kuletz, C. Marsteller, C.A. McKinstry, D. McGowan, **J.R. Moran**, W.S. Pegau, A. Schaefer, S. Schoen, J.M. Straley, and V.R. von Biela. 2021. Heatwave-induced synchrony within forage fish portfolio disrupts energy flow to top pelagic predators. Global Change Biology.

Moran, J., and J. Straley. 2019. Summer survey of population level indices for Southeast Alaska humpback whales and fall surveys of humpback whales in Prince William Sound in Zador, S. G., and E. M. Yasumishi. 2018. Ecosystem Status Report 2018: Gulf of Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301.

Moran, J.R., R.A Heintz, J.M. Straley, and J.J. Vollenweider. 2018. Regional variation in the intensity of humpback whale predation on Pacific herring in the Gulf of Alaska. Deep Sea Research II 147:187-195.

Moran, J.R., M.B O'Dell, M.L Arimitsu, J.M. Straley, and D.M. Dickson. 2018. Seasonal distribution of Dall's porpoise in Prince William Sound, Alaska. Deep Sea Research II 147:64-172.

Straley, J.M., **J.R. Moran,** K.M. Boswell, J.J. Vollenweider, R.A., Heintz, T.J. Quinn II, B.H. Witteveen, and S.D. Rice, 2018. Seasonal presence and potential influence of humpback whales on wintering Pacific herring populations in the Gulf of Alaska Deep Sea Research II 147:173-186.

Boswell, K.M., G. Rieucau, J.J. Vollenweider, **J.R. Moran,** R.A. Heintz, J.K. Blackburn and D.J. Csepp. 2016. Are spatial and temporal patterns in Lynn Canal overwintering Pacific herring related to top predator activity?. Canadian Journal of Fisheries and Aquatic Sciences 73:1307-1318.

Heintz, R.A., **J.R. Moran**, J.J. Vollenweider, J.M. Straley, K.M. Boswell, and S. D. Rice. 2010."Humpback whale predation and the case for top-down control of local herring populations in the Gulf of Alaska." Alaska Fisheries Science Center Quarterly Report October/November (2010):1-6.

OTHER SIGNIFICANT PUBLICATIONS

Barton, M.B., J.R Moran, J.J., Vollenweider, R.A. Heintz, and K.M Boswell. 2017. Latitudinal dependence of body condition, growth rate, and stable isotopes of juvenile capelin (*Mallotus villosus*) in the Bering and Chukchi Seas. Polar Biology 40:1451-1463.

Carls, M.G., L. Holland, E. Pihl, M.A. Zaleski, **J. Moran,** and S.D. Rice. 2016. Polynuclear aromatic hydrocarbons in Port Valdez shrimp and sediment. Archives of environmental contamination and toxicology 71:48-59.

Wright, S.K. and **J.R. Moran**, 2011. Ocean-going vessels: a possible conduit for the introduction of white-nose syndrome fungus (*Geomyces destructans*) into bats in Alaska. Northwestern Naturalist 92:133-135.

Kelly, B.P., O.H. Badajos, M. Kunnasranta, **J.R Moran**, M. Martinez-Bakker, D. Wartzok, and P. Boveng. 2010. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology:1095-1109.

Swanson, B. J., B.P. Kelly, C.K. Maddox, and **J.R. Moran.** 2006. "Shed skin as a source of DNA for genotyping seals." Molecular Ecology Notes 6 no. 4: 1006-1009.

EDUCATION

2003 M.Sc. Fisheries. University of Alaska Fairbank**s**, Juneau, Alaska, USA .

1989 B.Sc. Zoology/Marine Biology. University of New Hampshire, Durham, New Hampshire, USA.

COLLABORATIONS

Mayumi Arimitsu (USGS), Shannon Atkinson (UAF), Mary Anne Bishop (PWSSC), Ted Cheeseman (tNorth Pacific humpback whale photo ID study group), Louise Copeman (Oregon State University), Chris Gabrielle (U.S. Park Service), Kristen Gorman (PWSSC), Lauri Jemison (ADF&G), Aleria Jensen (NMFS/Protected Resources Division), Ed Lyman (Hawaiian Islands Humpback Whale National Marine Sanctuary), Lisa Manning (NMFS/Humpback Whale Critical Habitat Review Team), Craig Matkin (NGOS), Dave McGowan (NMFS), Dan Olsen Kim Parsons (NMFS/Marine Mammal Laboratory), Heidi Pearson (UAS), Scott Pegau (OSRI), Matt Rogers (NMFS/AFSC), Kate Savage (NMFS/Protected Resources Division), Anne Shaefer (PWSSC), Jan Straley (UAS) Rob Suryan (NMFS/AFSC), Andy Szabo (Alaska Whale Foundation), Suzie Teerlink (NMFS/Protected Resources Division), Johanna Vollenweider (NMFS/AFSC), Bree Witteveen (UAF), Stephanie Zador (NMFS/AFSC), Alex Zerbini (NMFS/AFSC)

PRINCIPAL INVESTIGATOR: Pelagic Component
JAN STRALEY

University of Alaska Southeast
1332 Seward Ave
Sitka, AK 99835

907.747.7779
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RELEVANT PROFESSIONAL EXPERIENCE:

Ms. Straley has conducted research in Alaskan waters on large whales since 1979. Her skills and experience include photo-id, fecal sample collection, biopsy, suction-cup and dart tagging, acoustic data collection, underwater video and prey sampling. She has all permits necessary for this research.

TEN PEER REVIEWED RECENT PUBLICATIONS:

Arimitsu, M., J. Piatt, S. Hatch, R. Suryan, S. Batten, M. A. Bishop, R. Campbell, H. Coletti, D. Cushing, K. Gorman, R. Hopcroft, K. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, S. Pegau, A. Schaefer, S. Schoen, S. K., J. Straley, and V. von Biela. 2021. Heatwave-induced synchrony within forage fish portfolio disrupts energy flow to top pelagic predators. *Global Change Biology.* https://doi.org/https://doi.org/10.1111/gcb.15556

Suryan, R. M., M. L. Arimitsu, …., J. M. Straley, S. L. Strom, K. L. Sweeney, M. Szymkowiak, B. P. Weitzman, E. M. Yasumiishi, and S. G. Zador. 2021. Ecosystem response persists after a prolonged marine heatwave. *Scientific Reports*. https://doi.org/10.1038/s41598-021-83818-5.

Kosma, M.M., Werth, A.J., Szabo, A.R. and Straley, J.M., 2019. Pectoral herding: An innovative tactic for humpback whale foraging. *Royal Society open science*, *6*(10), p.191104.

Wild, L.A., E.M. Chenoweth, F.J. Mueter, and J.M. Straley. 2018. Evidence for dietary time series in layers of cetacean skin using stable carbon and nitrogen isotope ratios. Rapid Communications in Mass Spectrometry 32(16): 1425–1438.https://doi.org/10.1002/rcm.8168

Burrows, J., Johnston, D., Straley, J., Chenoweth, E., Ware, C., Curtice, C. 2017. Prey density and depth affect the fine-scale foraging behavior of humpback whales Megaptera novaeangliae in Sitka Sound, Alaska, USA. Marine Ecology Progress Series 561, 245-260 ‘

Straley, J., Moran, J., Boswell, K., Vollenweider, J, Heintz, Quinn,T., Witteeveen, B., Rice. S. 2017. Seasonal presence and potential influence of humpback whales on wintering Pacific herring populations in the Gulf of Alaska. Deep Sea Research Part II: Topical Studies in Oceanography http://dx.doi.org/10.1016/j.dsr2.2017.08.008

Moran, J., Heintz, R., Straley, J., Vollenweider. 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. https://doi .org/10.1016/j.dsr2.2017.07.010

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

Teerlink, S.F., von Ziegesar, O., Straley, J.M., Quinn II, T.J., Matkin, C.O. and Saulitis, E.L., 2015. First time series of estimated humpback whale (*Megaptera novaeangliae*) abundance in Prince William Sound. Environ. Ecol. Stat. 22(2):345-368.

FIVE RELATED PUBLICATIONS:

Straley, J., Schorr, G., Calambokidis, J., Thode, A., Lunsford, C., Chenoweth, E., O'Connell, V. and Andrews, R. 2014. Depredating sperm whales in the GOA: local habitat use and long distance movements across putative population boundaries. Endangered Species Research V34:125-135.

Baker, C.S., Steel, D., Calambokidis, J., Falcone, E., González-Peral, U., Barlow, J., Burdin, A.M., Clapham, P.J., Ford, J.K Gabriele, C.M. , Straley J.M., 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Mar. Ecol. Prog. Ser. 494:291-306

Hendrix, A., Straley, J., Gabriele, C. and Gende, S. 2012. Bayesian estimation of humpback whale (*Megaptera novaeangliae*) population abundance and movement patterns in southeastern Alaska. Can. J. Fish. Aquat. Sci. 69(11):1783-1797.

Straley, J., T. J. I. Quinn and C. M. Gabriele. 2009. Assessment of mark-recapture models to estimate the abundance of a humpback whale feeding aggregation in Southeast Alaska. *Journal of Biogeography* 36.

Straley, J.M. 1990. Fall and winter occurrence of humpback whales *(Megaptera novaeangliae)* in southeastern Alaska. Rep. Int. Whaling Comm. (Special Issue 12):319-24.

ACHIEVEMENTS:

Books

Straley, J. 2020 Revised. Ed Ricketts from Cannery Row to Sitka, Alaska science, history and reflections along the Pacific Coast. Old Sitka Rocks Press, Sitka, Alaska.

Patents

Hagelin, J.C. and Straley, J.M., 2015. Method of using biologically-relevant chemical attractants for marine predators. U.S. Patent 9,167,802.

PROFESSIONAL PREPARATION-EDUCATION:

University of Washington, Seattle, WA	BS	Fisheries and Wildlife	1975
University of Alaska Fairbanks, Fairbanks, AK	MS	Biological Oceanography	1994

APPOINTMENTS:

2018	University of Alaska Southeast Researcher of the Year
2018	Sitka Woman of the Year
2013	University of Alaska Board of Regents Meritorious Service Award
2012	Ocean Leadership Award for Excellence in Marine Science, Alaska SeaLife Center
2015-P	Professor of Marine Biology, University of Alaska Southeast-Sitka Campus
2010-2015	Associate Professor of Marine Biology, University of Alaska Southeast-Sitka Campus

COLLABORATORS:

Andrews, Russel (Marine Ecology & Telemetry), Behnken, Linda (Alaska Longline Fishermen’s Association), Cates, Kelly (UAF), Chenoweth, Ellen (UAF), Falvey, Dan (Alaska Longline Fishermen’s Association), Gabriele, Christine (NPS), Gordon, Jonathan (University of St. Andrews), Kosma, Madison (NOAA), Lunsford, Chris (NOAA), Moran, John (NOAA), Neilson, Janet (NPS), O’Connell, Tory (Sitka Sound Science Center), Thode, Aaron (Scripps Institution of Oceanography), Wild, Lauren (UAS), Witteveen, Bree (UAF).

RESEARCH ASSOCIATE: Pelagic Component
LAUREN WILD

Assistant Professor of Fisheries & Research Biologist
University of Alaska Southeast
1332 Seward Ave, Sitka, Alaska 99835
(907) 738-5315; lauren.a.wild@gmail.com

RELEVANT PROFESSIONAL EXPERIENCE

Co-Investigator, Southeast Alaska Sperm Whale Avoidance Project (SEASWAP). My research investigates sperm whale interactions with longline fisheries in the Gulf of Alaska, with a dual focus on foraging ecology, acoustics, and population dynamics of sperm whales (May 2009 – Present).

Region Lead - Gulf of Alaska, NOAA's Biologically Important Areas for Cetaceans (BIA), NMFS, US. I lead the GOA group to summarize data (reports, unpublished data, published data, observations, etc.) on migratory, feeding, and reproductive BIAs of large whales as part of a national project by NMFS. (September 2020 – Present).

University Assistant Professor, Department of Fisheries Technology, University of Alaska Southeast, Sitka, Alaska. I teach fisheries classes to undergraduate students (August 2020 – Present).

Research Biologist, Whale Research Lab, UAS Sitka. My research under Jan Straley at UAS Sitka involves humpback, gray, and killer whale research, including my participation in fieldwork on the EVOS GulfWatch Alaska project in Prince William Sound. Additionally, I am responsible for NMFS marine mammal research permit reports and applications, IACUC protocols and reports, and whale research equipment maintenance and upkeep. (November 2013 – present).

MOST RELEVANT PUBLICATIONS

Wild, LA, Straley, JM, Andrews, RD, and Mueter, FJ. [In Review]. Movement and diving behavior of satellite-tagged sperm whales in the Gulf of Alaska. Deep Sea Res II.

Wild, LA, Straley JM, Witteveen, B, Mueter, FJ. 2020. Exploring variability in depredating sperm whale diets in the Gulf of Alaska through stable isotope analysis. Royal Soc. Open Sci. 7: 191110.

Wild, LA, Chenoweth, EM, Straley, JM, Mueter, FJ. 2018. Evidence of dietary time series in cetacean skin using stable carbon and nitrogen isotope ratios. Rapid Comm. Mass Spec. 32: 1425-1428.

Wild, LA, Thode, AM, Straley, JM, Rhoads, S, Falvey, D, Liddle, J. 2017. Field trials of an acoustic decoy to attract sperm whales away from commercial longline fishing vessels in the western Gulf of Alaska. Fish. Res. 196: 141-150.

Thode, AM, **Wild, LA**, Straley, JM, Barnes, D, Bayless, A, O'Connell, V, Oleson, E, Sarkar, J, Martin, S, Falvey, D, Behnken, L 2016. Using line acceleration to measure false killer whale (Pseudorca crassidens) click and whistle source levels during pelagic longline depredation. J. Acoust. Soc. Am. 140: 3941.

Thode, AM, Straley, JM, O'Connell, V, Behnken, L, Falvey, D, Mathias, DK, **Wild, LA**, Calambokidis, J, Schorr, GS, Andrews, RD, Liddle, JB, Lunsford, C. 2015. Cues, creaks, and decoys: using passive acoustic monitoring as a tool for studying sperm whale depredation. ICES J. Mar. Sci. 72(5): 1621-1637.

O'Connell, V, Straley, JM, Liddle, JB, **Wild, LA**, Behnken, L, Falvey, D, Thode, AM 2015. Testing a passive acoustic deterrent on longlines to reduce sperm whale depredation in the Gulf of Alaska. ICES J. Mar. Sci. 72(5): 1667-1672.

Straley, JM, Thode, AM, O'Connell, V, Behnken, L, Falvey, D, Liddle, JB, **Wild, LA** 2015. Southeast Alaska Sperm whale Avoidance Project (SEASWAP): A successful collaboration among scientists and industry to study depredation in Alaskan waters. ICES J. Mar. Sci. 72(5): 1598-1609.

Thode, AM, **Wild, LA**, Mathias, DK, Straley, JM, Lunsford, C 2014. A comparison of acoustic and visual metrics of sperm whale longline depredation. J. Acoust. Soc. Am. 135(5): 3086-3100.

Wild, LA, Gabriele, CM 2014. Putative contact calls made by humpback whales (Megaptera novaeangliae) in southeastern Alaska. Can. Bioacoust. 42: 23-31.

EDUCATION

2020 Ph.D. Fisheries. University of Alaska Fairbanks, Fairbanks, Alaska, USA.
2013 M.Sc. Marine Mammal Science. University of St. Andrews, St. Andrews, Scotland, UK.
2009 B.A. International & Global Studies. Brandeis University, Boston, Massachusetts, USA.

COLLABORATIONS

Andrews, Russel (Marine Ecology & Telemetry), Behnken, Linda (Alaska Longline Fishermen's Association), Chenoweth, Ellen (UAF), Falvey, Dan (Alaska Longline Fishermen's Association), Gabriele, Chris (NPS Glacier Bay National Park), Craig George (North Slope Burough), Gordon, Jonathan (University of St. Andrews), Kosma, Madison (NOAA), Lunsford, Chris (NOAA), Moran, John (NOAA), Mueter, Franz (UAF), Neilson, Janet (NPS Glacier Bay National Park), Straley, Jan (UAS), Szabo, Andy (Alaska Whale Foundation), Thode, Aaron (Scripps Institution of Oceanography), Witteveen, Bree (UAF), Wooler, Mat (UAF).

MADISON KOSMA

Coordinator, Alaska Beluga Monitoring Partnership
Contractor with Pacific States Marine Fisheries Commission
In support of NMFS AKR, Protected Resources Division
Anchorage, Alaska |(231) 282-0061 | madison.kosma@gmail.com

RELEVANT PROFESSIONAL EXPERIENCE

Coordinator, Alaska Beluga Monitoring Partnership, Contractor with Pacific States Marine Fisheries Commission in support of National Marine Fisheries Service, Alaska Protected Resources Division. I lead the citizen scientist beluga monitoring programs and am the lead biologist for the monitoring protocol, database management and analysis (September 2020 – Present). Research Biologist, Cetacean-Human Interaction Lab, UAS Sitka. My research under Jan Straley at the University of Alaska Southeast, Sitka Campus involved humpback whales, gray, sperm, and killer whales. I participated in and managed fieldwork (including participating in EVOS Gulf Watch Alaska project in Prince William Sound) and data analysis, conducted laboratory work, maintained field equipment, and assisted with NMFS marine mammal research permit reporting and was responsible for IACUC protocols and reports (August 2014 – Present). Alaska Sea Grant Fellow, National Marine Fisheries Service, Alaska Protected Resources Division. I assisted with Cook Inlet beluga research, data compilation, participated in aerial, boat, and shore-based surveys in Cook Inlet, and worked with staff on Endangered Species Act Section 7 consultations (September 2019 – September 2020). Sitka WhaleFest Director and Science Outreach Coordinator, Sitka Sound Science Center. I was responsible for securing programmatic funding, writing grant proposals and reporting, was the Marine Mammal Stranding Coordinator for the Science Center, supervised staff members, and developed and lead science outreach programs (August 2013 – January 2016).

MOST RELEVANT PUBLICATIONS

Kosma, MM, MV McPhee, MJ Wooller, AR Szabo, JM Straley. [In Prep]. Individual specialization among humpback whales in Southeast Alaska.

Kosma, MM, AJ Werth, AR Szabo, JM Straley. 2019. Pectoral herding: an innovative humpback whale foraging strategy. Royal Society Open Science. 6: 191104. DOI: http://doi.org/10.1098/rsos.191104

Werth, AJ, **MM Kosma**, EM Chenoweth, JM Straley. 2019. New views of humpback whale flow dynamics and oral morphology during prey engulfment. Marine Mammal Science. 35(4): 1556-1578 DOI: 10.1111/mms.12614

EDUCATION

2019 M.S. Fisheries. University of Alaska Fairbanks, Fairbanks, Alaska, USA.
2012 B.S. Marine Biology. University of Hawai'i at Manoa, Honolulu, Hawai'i, USA.

COLLABORATIONS

Bejder, Lars (University of Hawai'i at Manoa), Burek Huntington, Kathy (Alaska Veterinary Pathology Services), Chenoweth, Ellen (UAF), Gabriele, Chris (Glacier Bay National Park and Preserve), George, Craig (North Slope Borough, Department of Wildlife Management), Gill, Verena (NOAA), Laidre, Kristin (University of Washington), McGuire, Tamara (Cook Inlet Beluga Photo-ID Project), McPhee, Megan (UAF), Moran, John (NOAA), Neilson, Janet (Glacier Bay National Park and Preserve), Savage, Kate (NOAA), Sharpe, Fred (Alaska Whale Foundation), Stephens, Amber (Cook Inlet Beluga Photo-ID Project), Straley, Jan (UAS), Szabo, Andy (Alaska Whale Foundation), Tobin, Debbie (UAA, Kachemak Bay Campus), Werth, Alex (Hampden-Sydney College), Wooller, Matthew (UAF).

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

July 7, 2021

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

Dear Ms. Wang,

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

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

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

Sincerely,

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

UNIVERSITY
of ALASKA
SOUTHEAST

11066 Auke Lake Way
Juneau, Alaska 99801
Tel: (907) 796-6100
uas.alaska.edu

August 2, 2021

To: Mandy Lindeberg - NOAA, GWA-LTRM Program Lead
Katrina Hoffman - PWSSC, President and CEO
Shiway Wang, EVOSTC Executive Director

Re: Letter of Commitment

We are pleased to provide this letter of commitment for the proposed project "Long-term monitoring of humpback whale predation on Pacific herring in Prince William Sound" led by principal investigator (PI), Jan Straley. This proposal was drafted by the PI in response to the EVOSTC's FY22-31 Invitation for Proposals and subsequent request for final submission on August 13, 2021. The cost for this project over a ten-year period will be $951,625 (without EVOSTC GA).

This project proposal is part of the larger multi-agency Gulf Watch Alaska Long-Term Research and Monitoring (GWA-LTRM) program proposal package. This package represents a continued commitment of the successful long-term research and monitoring projects supported by the EVOSTC and various agencies and organizational investments since 2006.

Indirect costs have been included at the negotiated F&A rate for State of Alaska-sponsored research at 25.0% of Modified Total Direct Costs.

Sincerely,

Julie L. Vigil Digitally signed by Julie L. Vigil Date: 2021.07.19 10:11:42 -08'00'

Julie Vigil
Director, Budget, Grants and Contracts
Authorized Organizational Representative
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(907) 796-6494