Exxon Valdez **Oil Spill Trustee Council**

Long-Term Research and Monitoring, Mariculture, Education and Outreach

Annual Project Reporting Form

Project Number: 22120114-O

Project Title: Long-term monitoring of humpback whale predation on Pacific herring in PWS

Principal Investigator(s): John R. Moran, Auke Bay Laboratories, National Marine Fisheries Service, and Janice M. Straley, University of Alaska Southeast Sitka Campus

Reporting Period: February 1, 2022 – January 31, 2023

Submission Date (Due March 1 immediately following the reporting period): March 1, 2023

Project Website: https://gulfwatchalaska.org/

Please check all the boxes that apply to the current reporting period.

☒ **Project progress is on schedule.**

☐ **Project progress is delayed.**

☐ **Budget reallocation request.**

☒ **Personnel changes.**

Lauren Wild will replace Jan Straley as PI in Year 2 (FY23). Her CV was included with the FY22-31 proposal.

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1. Summary of Work Performed:

The humpback whale monitoring project is part of the Gulf Watch Alaska-Long-Term Research and Monitoring (GWA-LTRM) program Pelagic Component and the integrated predator-prey (IPP) 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 in PWS declined dramatically, and calf production fell. In 2020, we saw a decoupling of whale numbers from herring abundance and an increase in herring biomass while whale numbers have remained low through 2022. 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 (*Exxon Valdez* Oil Spill Trustee Council [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. This project is one of only two long-term humpback whale projects funded in Alaska. As this study continues, we will continue to inform the Herring Research and Monitoring component of the GWA-LTRM program, as well as state and federal managers assessing potential recovery limitations for PWS herring.

The goal of the project is to continue estimating the impacts of humpback whale predation on herring in PWS over the next 10 years.

The objectives are to:

1) Estimate trends in humpback whale abundance, diet and distribution and identify the causes for the decline.

2) Evaluate prey quality and trophic position through bomb calorimetry and stable isotopes.

3) Estimate the impact of humpback whale predation on herring.

Trends in humpback whale abundance, diet, and distribution

The April and September 2022 GWA-LTRM humpback whale surveys in PWS were completed. All samples from both surveys have been processed or submitted for analysis. Completed data has been archived with the Alaska Ocean Observing System. Although herring appear to be recovering in PWS, humpback whale numbers remain low (Figs. 1 and 2). During the spring survey, weather ranged from calm clear skies to whiteout blizzards. Whale numbers were up slightly from recent years but are still nowhere close to pre-heatwave abundance. Prey was abundant with spawning herring being the main target of whales followed by euphausiids. The distribution of killer whales (AT 73, 80, 81 and the AK18 and 10 matriline), porpoise and sea lions were also recorded. Our general impression was that the ecosystem was starting to get back to pre-heatwave conditions except humpback whales.

We completed the humpback whale component of the IPP survey in September with the forage fish (22120114-C) project. Whale numbers remain low within the Sound. Large concentrations of prey were located in Whale Bay (euphausiids) and near Glacier Island (adult herring). Juvenile herring schools were scattered throughout the Sound with a few humpbacks targeting these schools. Prey schools with marine birds foraging on them were targeted by whales near

Fox Farm and McCleod Bay. Killer whales (AE5 matriline) were photographed in Port Gravina. Dall's porpoise sightings were up from last year. Kelp greenling as well as black, widow, and copper rockfish were more abundant than we have seen in previous years where we sampled herring.

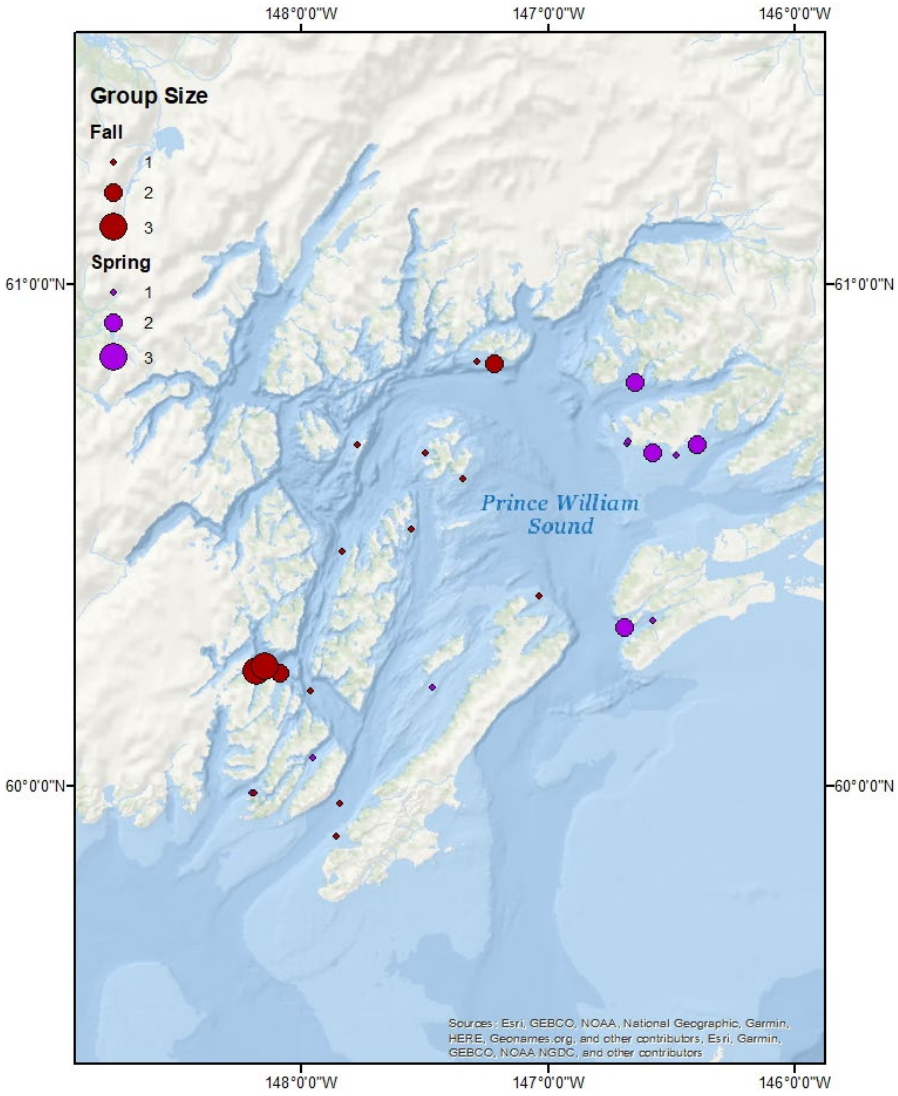

Figure 1. Map of humpback whale sightings in April (Spring, purple) and September (Fall, red) of 2022 during Exxon Valdez Oil Spill Trustee Council and National Oceanic and Atmospheric Administration funded surveys in Prince William Sound.

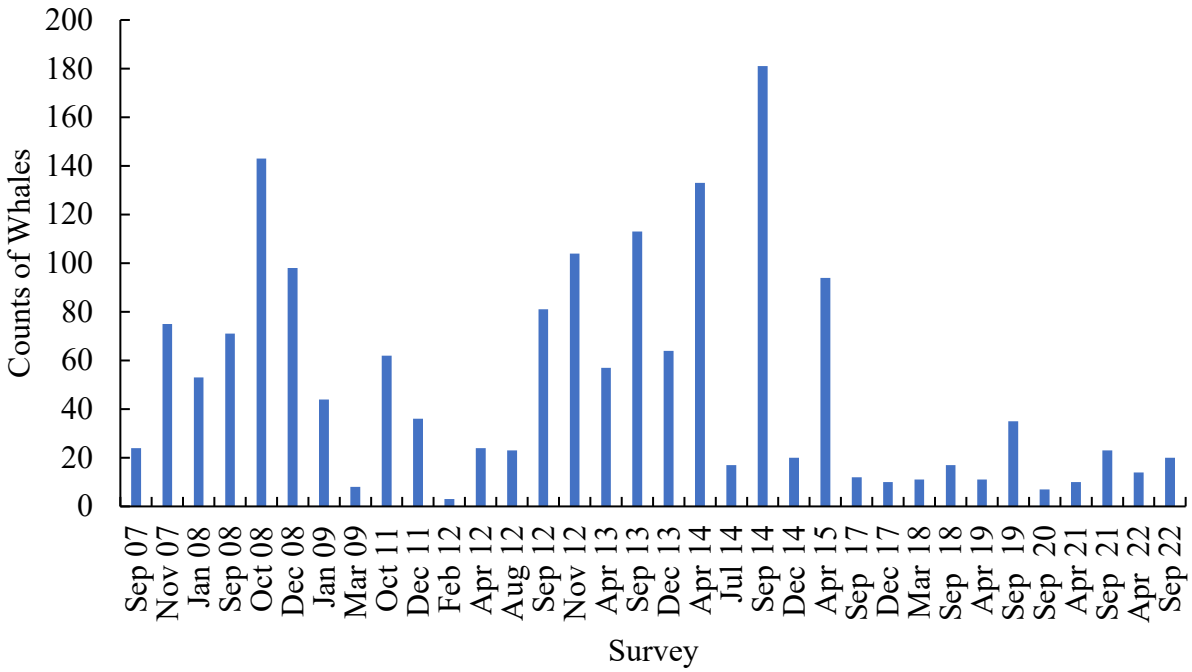

Figure 2. Counts of humpback whales during Exxon Valdez Oil Spill Trustee Council and National Oceanic and Atmospheric Administration funded surveys in Prince William Sound.

Humpback whale numbers have failed to rebound in PWS following a decline associated with the 2014-2016 marine heatwave in the Gulf of Alaska. Encounter rates for humpback whales during the 2022 fall surveys remained much lower than the pre-heatwave years, with the initial reduction possibly related to a decline in the biomass of herring in PWS or lingering whale population effects from the marine heatwave. Fall surveys are consistent in the area searched, allowing for comparisons between years to establish trends (Table 1).

Table 1. Encounter rates of humpback whales in Prince William Sound during fall surveys. Gulf Watch Alaska sampling began in 2012, no surveys were conducted in 2015-16, but resumed in 2017 and will continue annually as funding allows.

Year	Counts of whales	Counts of calves	Nautical miles surveyed	Encounter rate whales/NM
2008	71	17	412	0.17
2011	62	2	441	0.14
2012	81	5	444	0.18
2013	113	6	355	0.32
2014	181	1	427	0.42
2017	12	0	543	0.02
2018	17	1	541	0.03
2019	35	0	573	0.06
2020	14	2	331	0.04
2021	23	0	525	0.04
2022	19	1	504	0.04

Evaluate prey quality and trophic position through bomb calorimetry and stable isotopes

Prey quality and relative trophic position was consistent with previous years. Field observations and chemical analysis indicated that humpback whales in PWS feed primarily on herring with some euphausiids (Fig. 3).

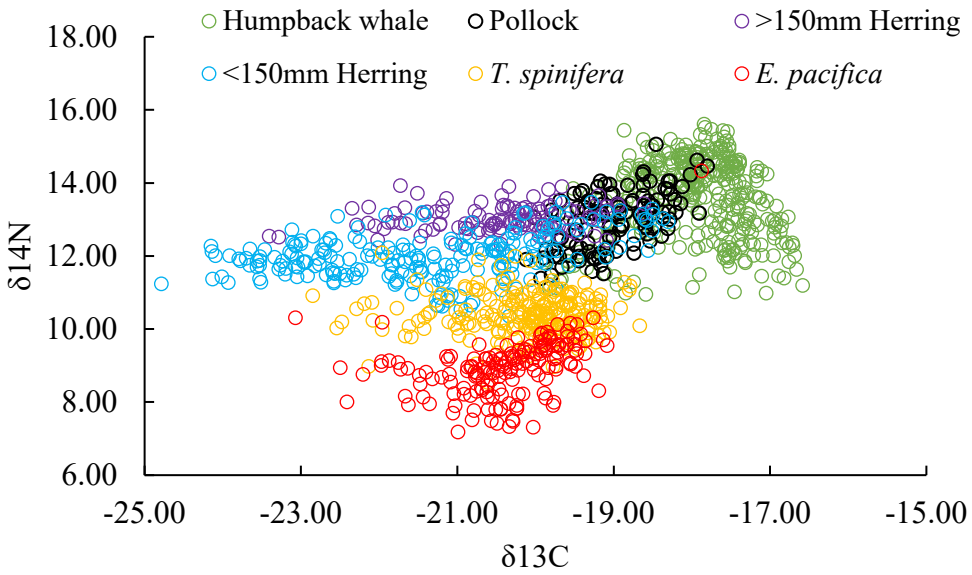

Figure 3. The relative trophic position of humpback whales, and common forage species in Prince William Sound, Alaska from 2007-2022.

Estimate the impact of humpback whale predation on herring

The abundance of suitable whale prey in PWS seems to be increasing post-heatwave, but the abundance of humpback whales is not. The factors limiting the return of humpback whales to the Sound remains uncertain, however, prey availability seems to be less of an issue. Our mark-recapture abundance estimate for humpback whales in 2022 requires sampling in 2023; however, given the increase in herring biomass and the availability of alternative prey, we believe that the consumption rate on the spawning biomass will be lower than 2021, probably less than 5%. We are uncertain as to why humpback whales have failed to return to PWS following the marine heatwave, but their absence may provide some reprieve from predation pressure to local herring stocks (Fig 4).

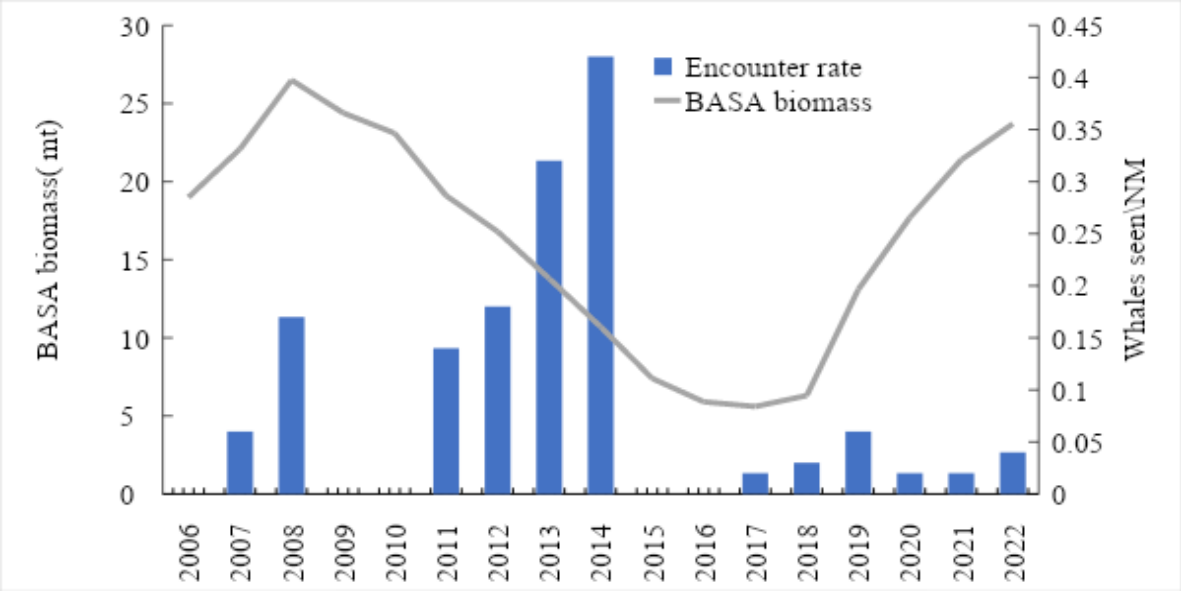

Figure 4. Herring biomass from the Bayesian age-structured assessment (BASA) model and humpback whale encounter rates from fall surveys in Prince William Sound Alaska.

2. Products:

Peer-reviewed publications:

Atkinson, S., T. A. Branch, A. A. Pack, J. M. Straley, J. R. Moran, C. Gabriele, K. L. Mashburn, K. Cates, and S. Yin. 2023. Pregnancy rate and reproductive hormones in humpback whale blubber: Dominant form of progesterone differs during pregnancy. General and Comparative Endocrinology 330:114151.

Wild, L. A., H. E. Riley, H. C. Pearson, C. M. Gabriele, J. L. Neilson, A. Szabo, J. R. Moran, J. M. Straley, and S. DeLand. Submitted. Biologically Important Areas II for Cetaceans in US Waters - Gulf of Alaska Region. Frontiers in Marine Science.

Cheeseman, T. et al. In review. All the humpback whales of the North Pacific: A collaborative and comprehensive North Pacific humpback whale photo-ID dataset.

Reports:

Moran, J., and J. Straley. 2022. Fall surveys of humpback whales in Prince William Sound. In B. E. Ferriss, and S. Zador, editors, Ecosystem Status Report for the Gulf of Alaska, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, AK 99501.

Popular articles:

South Florida PBS. 2022. Episode 1401: Vanishing Whales. Changing Seas. https://www.changingseas.tv/season-14/1401/

Conferences and workshops:

Arimitsu, M., D. Cushing, J. Durban, S. Hatch, R Kaler, K. Kuletz, L. Labunski, C. Matkin, J. Moran, D. Olsen, S. Pegau, J. Piatt, J. Straley, and S Whelan. 2023. Changes in marine predator and prey populations in the Northern Gulf of Alaska: Gulf Watch Alaska Pelagic update 2022. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Cheeseman, T., K. Audley, A. Frisch, N. Ransome, J. Urban, P. M. Loustalot, J. Jacobsen, E. Quintana-Rizzo, J. De Weerdt, D. M. Palacios, C. Hayslip, J. Calambokidis, K. Flynn, P. Clapham, C. McMillan, J. Hildering, J. Wray, N. Doe, C. Birdsall1, K. Dracott, J. D. Darling, J. K. Byington, T. Shaw, M. Mallison, J. K. B. Ford, T. Doniol-Valcroze, J. Neilson, J. Straley, S. Teerlink, J. Cedarleaf, A. Szabo, F. Sharpe, J. Moran, H. Pearson, O. von Ziegesar, B. Witteveen, D. Zwiefelhofer, C. Matkin, R. Cartwright, S. Stack, J. Currie, M. Jones, E. Lyman, R. Finn, C. Gabriele, A. Pack, B. Goodwin, K. Yano, L Bejder , M. van Aswegen, M. Hil, J. M. Acebes, O. Filatova, O. Titova, E. Mamaev, G. Donovan, J. Moore, J. Barlow, M. Olio, H. Newell, and K. Southerland. 2022. Happy collaboration: Basin-scale, high-throughput, AI-assisted photo-ID matching for North Pacific humpback whales. 24th Biennial Conference on the Biology of Marine Mammal, Palm Beach, Florida, August.

DeMaster, S. A., A Pack, H. Pearson, V. Melica, K. Mashburn, M. Lammers, J. Moran, S. Teerlink, L. Bejder, J. Currie, S Stack, A Szabo, K. Cates, and M. van Aswegen. 2022. Seasonally stressed? Varying metabolic biomarkers in humpback whales (*Megaptera novaeangliae*) in Alaska and Hawaii. 24th Biennial Conference on the Biology of Marine Mammal, Palm Beach, Florida, August.

Demaster, S. A., H. Pearson, S. Teerlink, J. Moran, K. Mashburn, and V. Melica. 2023. Pregnancy rates and reproductive hormones in humpback whales. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Lettrich, M., J. Baker, D Dick, C. Fahy, P. Fiedler, N. Friday, K. Graham, R. Griffis, D. Noren, P. Thomas, S. Wright, R. Baird, L. T. Ballance, L. Bejder, S. J. Bograd, C. Boyd, A. Bradford, L. Divine, C. Emmons, B. Fadely, E. Falcone, M. Ferguson, D. Hauser, E. L. Hazen, J. Jahncke, S. Jeffries, M. Lander, C. Littnan, J. London, L. Loseto, S. Melin, D. Monson, J Moran, E. Oleson, H. Pearson, L. Quakenbush, K. Raum-Suryan, J. Roletto, B. Rone, G. Schorr, J. Scordino, K. Shelden, S. Steingass, J. Sterling, R Stimmelmayr, S. Teerlink, T. Tinker, D. Weller, M. Williams, A. Zerbini, D. Bowen, L. Carswell, and D. Lynch. 2022. Vulnerability of U.S. marine mammal stocks in the Pacific and Arctic to climate change. 24th Biennial Conference on the Biology of Marine Mammal, Palm Beach, Florida, August.

Moran, J., J. Straley, and O. von Ziegesar. The decline of humpback whales in Prince William Sound, Alaska following the 2014– 2016 Northeast Pacific marine heatwave. 24th Biennial Conference on the Biology of Marine Mammal, Palm Beach, Florida, August.

Parsons, K., S. May, Z. Gold, K. Goetz, A. Zerbini, C. Gabriele, J. Straley, J. Moran, M. Dahlheim, L. Park, and P. Morin. 2022. In the wake of small cetaceans: Can targeted eDNA sampling support stock structure analysis for small or elusive cetaceans? 24th Biennial Conference on the Biology of Marine Mammal, Palm Beach, Florida, August.

Pearson, H., S. A. DeMaster, V. Melica, J. Moran, and S. Teerlink. 2022. Humpback whales (*Megaptera novaeangliae*) and tourism in Juneau, AK: Establishing baseline measurements during the COVID-19 pandemic. 24th Biennial Conference on the Biology of Marine Mammal, Palm Beach, Florida, August.

Public presentations:

Moran, J. 2022. What's happening with Prince William Sound humpback whales? Large whale entanglement response training, Cordova, AK, June.

Moran, J. 2022. What's happening with Prince William Sound humpback whales? Large whale entanglement response training, Gustavus, AK, June.

Moran, J. 2022. Whales in the time of COVID. Maui Whale Tales, Maui, Kapalua, March.

Data and/or information products developed during the reporting period:

Cheeseman, T., K. Southerland, J. M. Acebes, K. Audley, J. Barlow, L. Bejder, C. Birdsall, A. Bradford, J. Byington, J. Calambokidis, and R. Cartwright. 2023. (Almost) all the humpback whales of the North Pacific: A collaborative and comprehensive photo-ID dataset.

Data sets and associated metadata:

Straley, J., and J. Moran. 2022. Pelagic: Humpback whale predation on herring. Gulf of Alaska Data Portal: https://gulf-of-alaska.portal.aoos.org/#metadata/54adceab-74cb-4419-b02c-bacb6d2acb8b/project.

The Prince William Sound Fluke Catalog has been updated through September of 2022.

Additional Products not listed above:

Humpback whale genetics sent to Scott Baker at Oregon State University and blubber samples sent to Shannon Atkinson at University of Alaska Fairbanks for stress and reproduction hormone assays.

3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

The humpback whale team collaborates with Prince William Sound Science Center (PWSSC) at a programmatic level because members of the GWA-LTRM program management team work for PWSSC and PWSSC is the fiscal agent for the University of Alaska's grant through the National Oceanic and Atmospheric Administration (NOAA). Principal investigators (PIs) have also contributed to PWSSC Field Notes series regarding PWS humpback whales.

EVOSTC Long-Term Research and Monitoring Projects

The humpback whale project is part of the Pelagic Component of the GWA-LTRM program. We collaborate regularly with other pelagic projects. In particular, we conduct the IPP surveys with the forage fish project (22120114-C) and exchange killer whale and humpback whale sighting data with the killer whale project (22120114-N). We also work closely with HRM Component projects regarding herring predation by humpback whales, including contributing data to the herring modeling (22120111-C) project for their Bayesian age-structured assessment model.

EVOSTC Mariculture Projects

None

EVOSTC Education and Outreach Projects

The humpback whale project team has participated in meetings with members of the CORaL network funded by EVOSTC to evaluate ways the programs can work together on outreach activities.

Individual EVOSTC Projects

The humpback whale project works with the Data Management program to ensure data collected in the nearshore ecosystem are properly reviewed, have current metadata, and are posted to the Gulf of Alaska data portal within required timeframes. We will work with other individually funded EVOSTC projects if collaborative efforts make sense based on data collected.

Trustee or Management Agencies

In addition to PI Moran being a NOAA employee, the project makes numerous contributions to NOAA reports and databases, including the following:

- Humpback whale abundance indicator to the NOAA Gulf of Alaska Ecosystem Status Report for the North Pacific Fishery Management Council
- eDNA data to the Marine Mammal Lab's porpoise program
- Data and advise to the NOAA Protected Resources Division's tanker collision workshop
- Internal review for NOAA's Draft Recovery Status Review for the Central America, Mexico, and Western North Pacific Distinct Population Segments of Humpback Whales (*Megaptera novaeangliae*)
- Humpback whale data to a model of the North Pacific humpback whale abundance, based on public efforts and the North Pacific Humpback Whale Photo-ID collaboration with the potential for an International Whaling Commission report
- Input into the Vulnerability of US Marine Mammal Stocks in the Pacific and Arctic to Climate Change

The project also provides photographs of sea lion haulouts and brands to the Alaska Department of Fish and Game.

Native and Local Communities

PI Moran has participated in large whale entanglement response training in Gustavus, Cordova, and Eyak.

4. Response to EVOSTC Review, Recommendations and Comments:

May 2021 EVOSTC Science Panel Comment: The goal of the project is to continue estimating the impacts of humpback whale predation on herring in Prince William Sound over the next 10 years. The objectives are to 1) estimate trends in humpback whale abundance, diet and distribution and identify the causes for the decline, 2) evaluate prey quality and trophic position through bomb calorimetry and stable isotopes and 3) estimate the impact of humpback whale predation on herring. The objectives, sampling protocol and personnel remain the same. 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 to assess the impact of recovering humpback whale populations on the Prince William Sound ecosystem.

The PIs noted that whale numbers dropped dramatically following the recent heatwave while there was an uptick in herring in 2020. If whale numbers remain low, then it is more likely that whales are depressing herring populations than bottom-up environmental drivers are responsible for the declines. The PIs suggest that the decline in whales indicates that the whales either moved to different feeding grounds or died. We suggest a third possibility that herring were avoiding the high numbers of whales in Prince William Sound in 2020. The PIs should consider this hypothesis.

PI Response: The PIs have considered this hypothesis and agree that whales can influence prey behavior but there needs to be sufficient predators and prey to evaluate this concept. The numbers of whales in PWS in 2020 was still low (see figure below) and not synchronized with herring. The PIs believe (speculate) that there was a change in herring biomass and behavior that made PWS herring less energetically profitable as prey for whales. This ties in with the 'whales moved somewhere else' hypothesis. The following two observations support this idea:

1) The absence of winter aggregations of herring that were present prior to the heatwave. These shoals were temporally and spatially predictable with energetically rich herring. Good prey for whales.

2) Herring staging in deeper water before spawning doesn't seem to be happening anymore. The acoustic surveys are having a hard time finding schools. It seems the herring move fast into shallow water, spawn, and leave. A good strategy for avoiding whales and boats.

It would be difficult to quantify the avoidance hypothesis suggested by the Science Panel. The PIs will look at changes in the density and distribution of whales in relation to herring which may shed light on this topic. For example, if whales were present in a small area, feeding on

herring implies easy feeding (minimal search time). We could look at school size for prey species as well and maybe come up with a prey energy density map.

We are using the Happywhale algorithm to match individually identifiable fluke photographs from throughout their range and see if the missing PWS whales have turned up on the breeding grounds or other feeding areas.

May 2021 EVOSTC Science Panel Comment: We recognize the value of monitoring the potential impact of humpback whales on herring. We also appreciate the outreach that the PIs have conducted by giving talks. We suggest that the PIs increase the presence of this project through online platforms to expand outreach opportunities.

PI Response: We will work with our own agency's media teams, the GWA Outreach Coordinator, and any projects funded under the EVOSTC's Education and Outreach Focus Area to increase this project's online presence and outreach opportunities over the next 10 years.

September 2021 EVOSTC Science Panel Comment: The goal is to continue estimating the impacts of humpback whale predation on herring in Prince William Sound over the next 10 years. The objectives, sampling protocol and personnel remain the same. The PIs have been productive and agreed to increase their online presence and outreach. We recommend that the work be continued.

PI Response: Thank you for your comments.

5. Budget:

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
PROGRAM BUDGET PROPOSAL AND REPORTING FORM

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	$46,764
Travel	$15,394	$14,320	$14,488	$18,083	$14,852	$77,137	$4,580
Contractual	$50,000	$50,000	$50,000	$52,000	$52,000	$254,000	$51,309
Commodities	$4,000	$7,000	$7,000	$2,300	$2,300	$22,600	$2,758
Equipment & F&A Exempt	$24,000	$18,900	$19,845	$20,837	$21,879	$105,461	$18,000
Indirect Costs (varies by proposer)	$14,255	$14,897	$13,887	$14,379	$13,846	$71,265	$5,549
SUBTOTAL	$187,806	$186,633	$183,260	$187,465	$186,616	$931,779	$128,960
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	

COMMENTS:
This is the combined budget for the individual Moran and Straley budgets that follow. Moran is affiliated with NOAA, a Trustee Agency, and Straley is affiliated with the University of Alaska Southeast, a Non-Trustee Agency. The budgets have been combined by using a Non-Trustee Agency budget reporting form. This form contains the summary information only. Detail by year for each PI can be found in the following two worksheets.

UAS spending for FY22 is behind schedule because of the delay in the release of funds by EVOSTC and the issuance of the NOAA grant.

FY22-26	Project Number: 22120114-O Project Title: Humpback Whale Monitoring PI(s): Moran (NOAA) & Straley (UAS)	SUMMARY TABLE

The proposed budget was written for funding to begin February 1, 2022; however, the NOAA grant was not issued until late spring with a start date of June 1, 2022, and University of Alaska Southeast's (PI J. Straley) subaward contract with PWSSC was not signed until June. The NOAA grant cycle now runs June 1 - May 31. The University of Alaska Southeast did not receive funds until August 2022, which has caused our personnel funds line item to be much lower than expected as we are about 6 months off this budget period. Additionally, there was a delay in hiring our research associate, who was supposed to start in August 2022, but will instead have a hiring date of January 31, 2023.

Spending for the NOAA portion of the budget is on track.