Exxon Valdez **Oil Spill Trustee Council**

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

Annual Project Reporting Form

Project Number: 24120114-C

Project Title: Monitoring long-term changes in forage fish distribution, relative abundance, and body condition in Prince William Sound and the Northern Gulf of Alaska

Principal Investigator(s): Mayumi Arimitsu U. S. Geological Survey-Alaska Science Center

Reporting Period: February 1, 2024 – January 31, 2025

Submission Date (Due March 1 immediately following the reporting period): March 1, 2025

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.**

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1. Summary of Work Performed:

The Gulf Watch Alaska-Long Term Research and Monitoring (GWA-LTRM) program Forage Fish project has three main components including: 1) continuation of the longest time series on forage fish availability to seabirds in the Gulf of Alaska, i.e., a study that tracks the diets of adult and nestling seabirds at Middleton Island and is conducted in collaboration with Scott Hatch (Institute for Seabird Research and Conservation [ISRC]), 2) ship-based surveys including the Integrated Predator Prey (IPP) survey in Prince William Sound (PWS) conducted in collaboration with the humpback whale study (project 24120114-O, John Moran, National Oceanographic and Atmospheric Administration [NOAA], and Lauren Wild, University of Alaska Southeast) project, and 3) summer forage fish sampling - including aerial survey validation, forage fish sampling for condition in PWS, and juvenile salmon (*Oncorhynchus* spp.) otolith analysis (Fig. 1). In this report we describe work conducted in 2024.

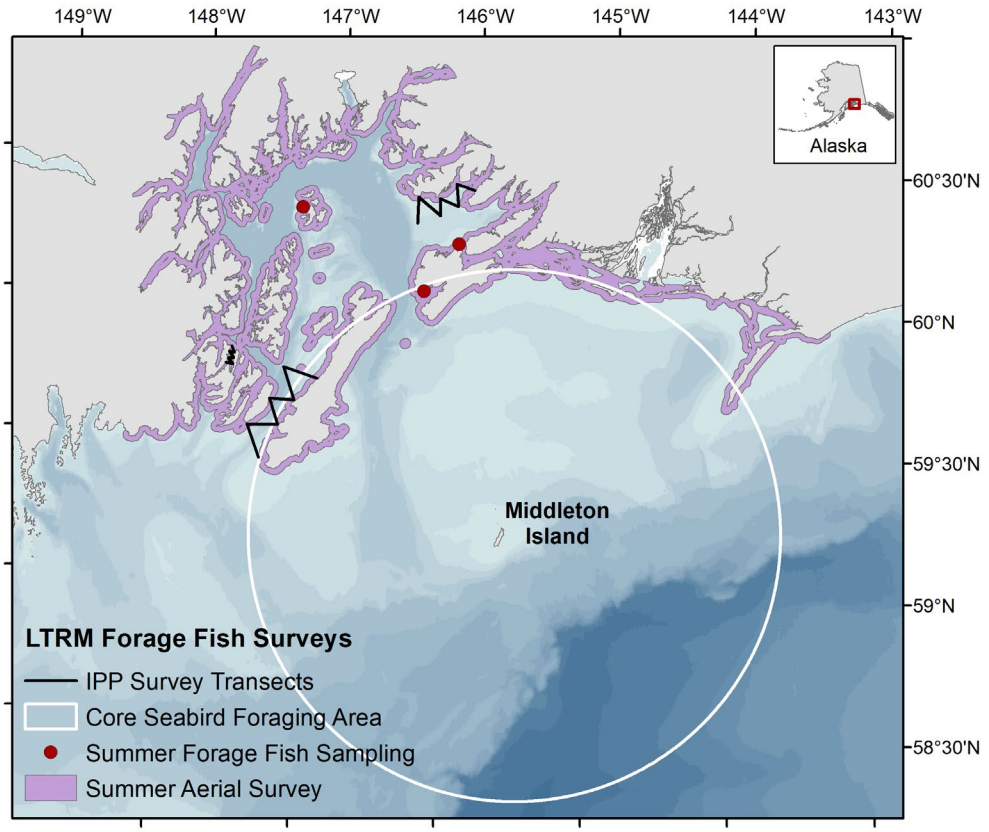

Figure 1. Distribution of Gulf Watch Alaska Long-Term Research and Monitoring (LTRM) seasonal forage fish survey effort in Prince William Sound and Middleton Island. Bathymetry is shown in blue with darker shades indicating deeper seafloor depth; IPP is the Integrated Predator Prey survey.

Seabird Diets

Middleton Island seabird diet sampling was conducted by the ISRC scientific team according to schedule. We provide a brief summary of 2024 seabird diet results below, which were also reported in a contribution to NOAA's 2024 Gulf of Alaska Ecosystem Status Report (Arimitsu et al. 2024) and Alaska sablefish stock assessment (Shotwell and Dame 2024). Seabird diets monitored by the U. S. Fish and Wildlife Service (USFWS) Alaska Maritime National Wildlife Refuge are also incorporated into the Ecosystem Status Report for the Aleutian Islands (Rojek et al. 2024), providing large-scale inference from other seabird diet colony monitoring data including Middleton Island.

Seabird diet information from Middleton Island integrates forage fish species composition and availability over broad areas of the Northern Gulf of Alaska, i.e., across coastal, shelf, and slope regions (Hatch 2013, Arimitsu et al. 2021). An in-depth analysis of rhinoceros auklet (*Cerorhinca monocerata*) diets, supplemented with data from GPS tags attached to foraging birds, showed that the seabirds can detect prey species in foraging areas where other survey types have found the prey to be sparse or absent (Cunningham et al. 2018). Seabird diets, including those from Middleton Island, are useful indicators of spatial and interannual variability in forage species in Alaska (Sydeman et al. 2017, 2021; Piatt et al. 2018; Thompson et al. 2019).

Seabird diet samples at Middleton Island were collected from 6 April to 18 August 2024. This included a total of 1181 diet samples from black-legged kittiwakes (*Rissa tridactyla*) and 311 diet samples from rhinoceros auklets.

Spring kittiwake diets were composed mainly of myctophids (Fig. 2), and spring GPS tracking data (not shown) confirmed that foraging occurred offshore and beyond the shelf break. Pacific capelin (*Mallotus catervarius*, hereafter capelin) occurrence in spring kittiwake diets was much lower than it was in 2023; however, capelin were well represented in summer kittiwake diets in 2024 (Fig. 2). Additionally, capelin indices increased in rhinoceros auklet chick diets during 2024 (Fig. 3), which along with increasing trends in capelin in seabird diets at other colonies around the Gulf of Alaska (Arimitsu et al. 2024) and acoustic surveys in their core area around Kodiak (McGowan et al. 2024) suggest that capelin are currently recovering in the region following population collapse during the marine heatwave.

In contrast, seabird diets at Middleton Island suggest that Pacific sand lance (*Ammodytes personatus*, hereafter, sand lance) indices peaked in the late-1990s and early 2000s, then declined through the marine heatwave (Figs. 2 and 3). Following the heatwave sand lance experienced a short-lived recovery, albeit to a lower level than in the 1990's, owing to a strong cohort in 2016 but have since declined again by 2024 (Figs. 2 and 3). Coherent trends in sand lance are apparent in spring and summer kittiwake diets as well as summer rhinoceros auklet diets at Middleton, as well as in seabird diets at other colonies monitored around the Gulf of Alaska (Arimitsu et al. 2024).

Alternate prey species continue to be well represented in both the auklet and kittiwake diets, Hexagrammid species (i.e., kelp [*Hexagrammos decagrammus*] and rock greenlings [*H. lagocephalus*], lingcod [*Ophiodon elongatus*], and Atka mackerel [*Pleurogrammus*

monopterygius]) increased in 2024 compared to 2023 (Fig. 3). Pacific herring (*Clupea pallasii*) and juvenile salmon indices in rhinoceros auklet diets declined compared to 2023 (Fig. 3).

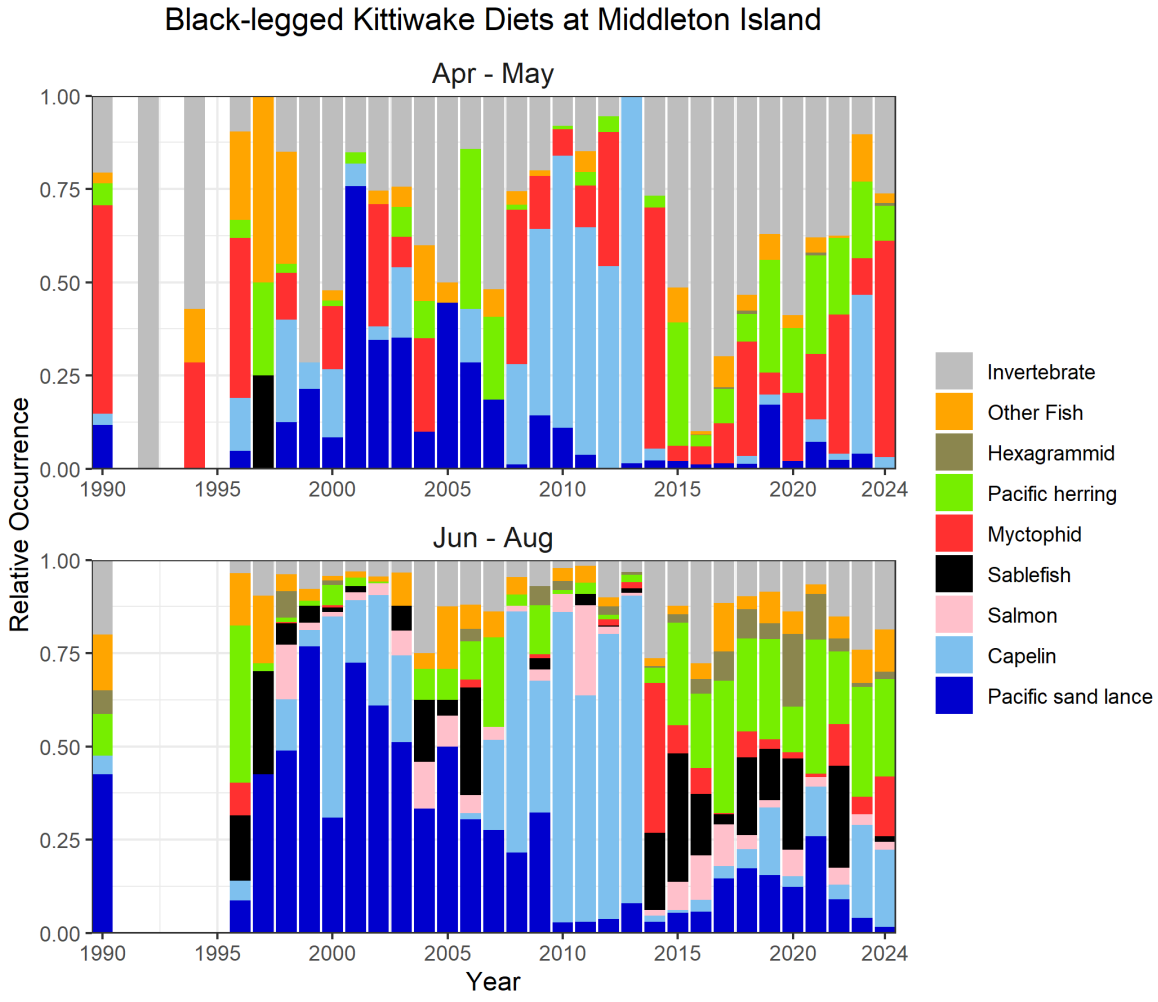

Figure 2. Interannual variation in diet composition of black-legged kittiwakes during spring (top) and summer (bottom) on Middleton Island.

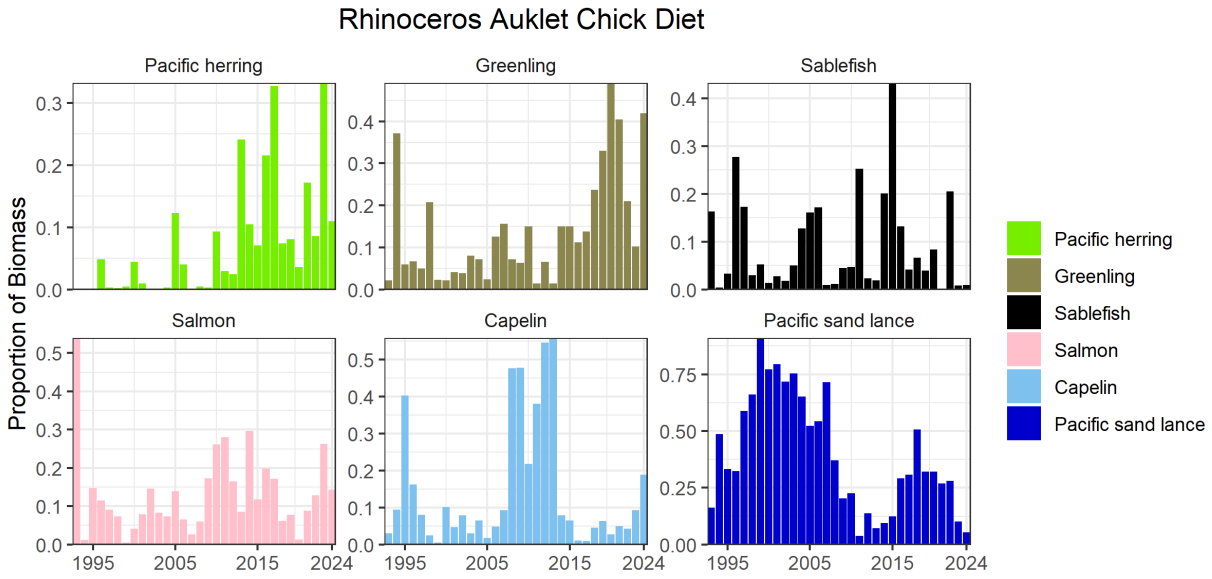

Figure 3. Interannual variation in rhinoceros auklet chick diets by species (color) at Middleton Island.

NOAA Alaska Fishery Science Center has determined that age-0 sablefish (*Anoplopoma fimbria*) growth information from seabird diets at Middleton Island may be relevant for understanding drivers of sablefish recruitment (Shotwell and Dame 2024). NOAA has requested annual updates on these sablefish data for use in the Ecosystem and Socioeconomic Profiles evaluated as part of the sablefish stock assessment process each fall. From samples of age-0 sablefish collected in diets over the chick rearing period, growth rate is calculated using the relationship between mean fish length and Julian date for each year, except in 1994 when data were omitted because of low sample size and effort conducted over only a short period of time (Arimitsu and Hatch 2023). From this relationship we predict length for each year on the median sampling date (July 24).

The 2024 indices are based on measurements of 21 fish sampled on eight different days between June 25 and August 9. A total of 344 bill load samples were collected in 2024. When 2024 data were added to this year's model, we found that the interaction between Julian Day and year explains the majority of variability in age-0 sablefish length (OLS: $F = 27.82$, $p < 0.001$, $R^2 = 0.87$). During 2024 the age-0 sablefish predicted length (90 mm) was below average (-9 mm) on

the median sampling date (Jul 24). In 2024 age-0 sablefish growth (1.9 mm/day) and the growth index anomaly (-0.01 mm/day) was near the long-term average.

Age-0 sablefish are not well sampled by other survey methods, so time series of age-0 sablefish growth derived from seabird diet monitoring at Middleton Island are among the longest available from any Alaska location. Growth (or size) of age-0 sablefish may provide an early indication of recruitment because these indices may be related to survival of the cohort. Size of age-0 sablefish at the end of July is important because frequency of occurrence of age-0 sablefish in seabird diets is positively related to predicted fish length ($p < 0.001$). Seabirds may avoid age-0 sablefish that are too small, either because they can't sense them as easily or because they prefer higher energy food, resulting in lower provisioning rates than would be if the fish were larger in size during the chick rearing stage.

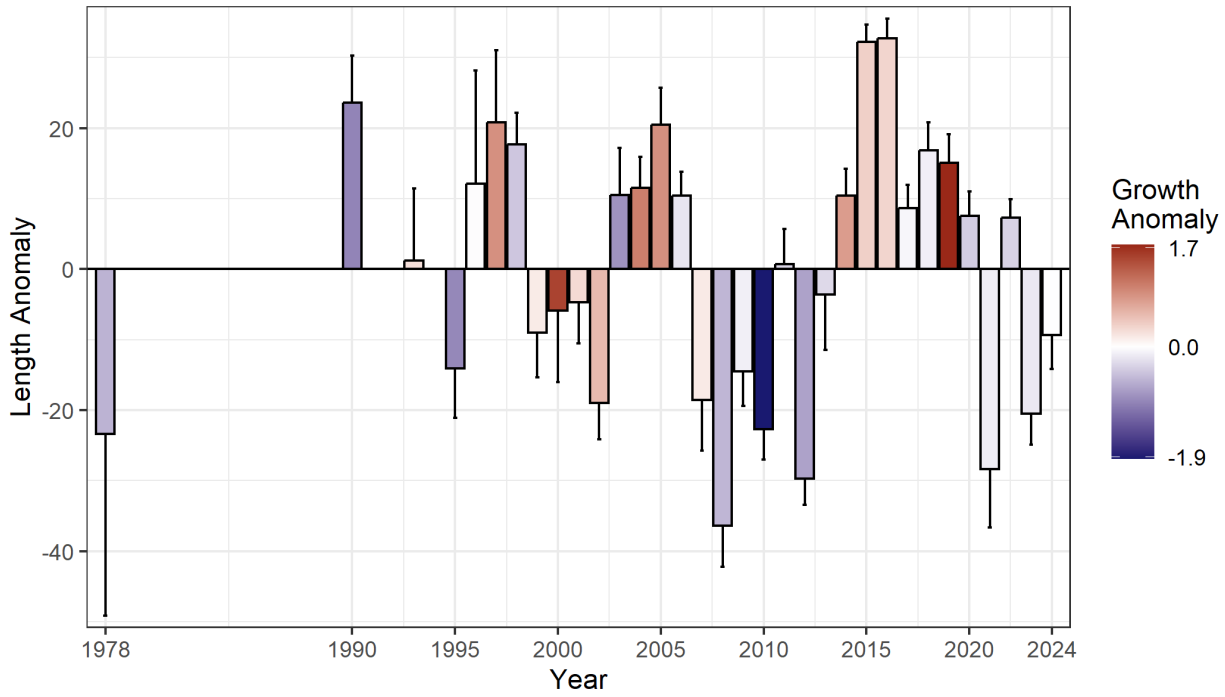

Figure 4. Interannual variability in predicted length anomaly (y-axis) and growth anomaly (color) for age-0 sablefish in seabird diets at Middleton Island, Alaska.

Fall Integrated Predator Prey Survey

The 2024 Fall IPP survey occurred on schedule during the second half of September. We conducted acoustic transects, trawls, marine bird surveys (with Anne Schaeffer, Prince William Sound Science Center [PWSSC]) and habitat sampling in Bainbridge Passage, Montague Strait, and Port Gravina as planned. Acoustic indices of capelin on transects in Montague and Port Gravina increased during 2024 compared to previous years, and in Port Gravina juvenile walleye pollock acoustic indices were higher than usual (Fig. 5). However, acoustic backscatter of euphausiids was lower in 2024 in all regions compared to 2023, juvenile and adult herring biomass indices were lower than previous years. We did not encounter sand lance on surveys in any region during IPP surveys in 2024 (Fig. 5).

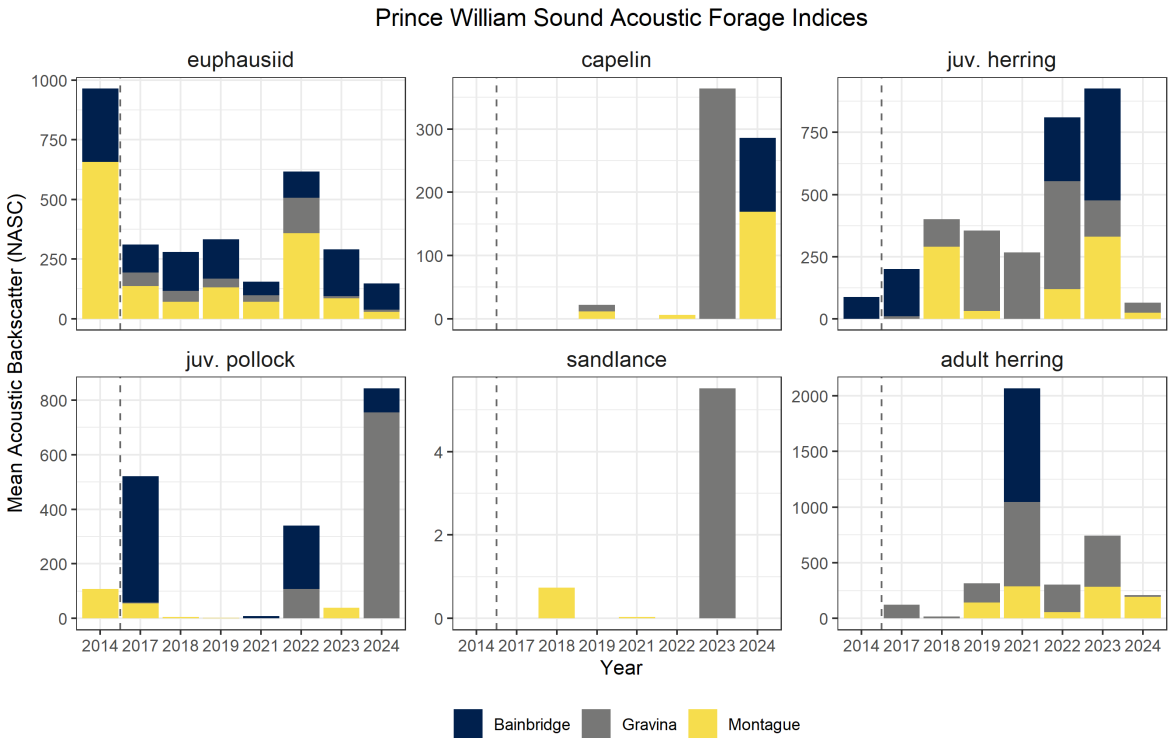

Figure 5. Interannual variability of acoustic backscatter indices by forage species (panels). Acoustic indices derived from Integrated Predator-Prey surveys in three regions (color) within Prince William Sound. In 2014 pilot surveys were conducted over a reduced area in Bainbridge and Montague, but no surveys were conducted in Bainbridge that year (see Arimitsu et al. 2021 for details).

Marine bird surveys conducted in conjunction with the acoustic surveys on IPP surveys in PWS found higher densities of seabirds during 2024 compared to 2023 (Fig. 6), a pattern that was driven by high densities of kittiwakes in Bainbridge and Port Gravina, while average seabird densities were observed in Montague during 2024 (Fig. 6). Despite higher densities of some species on transects, we observed less foraging activity on the IPP survey than in previous years during 2024.

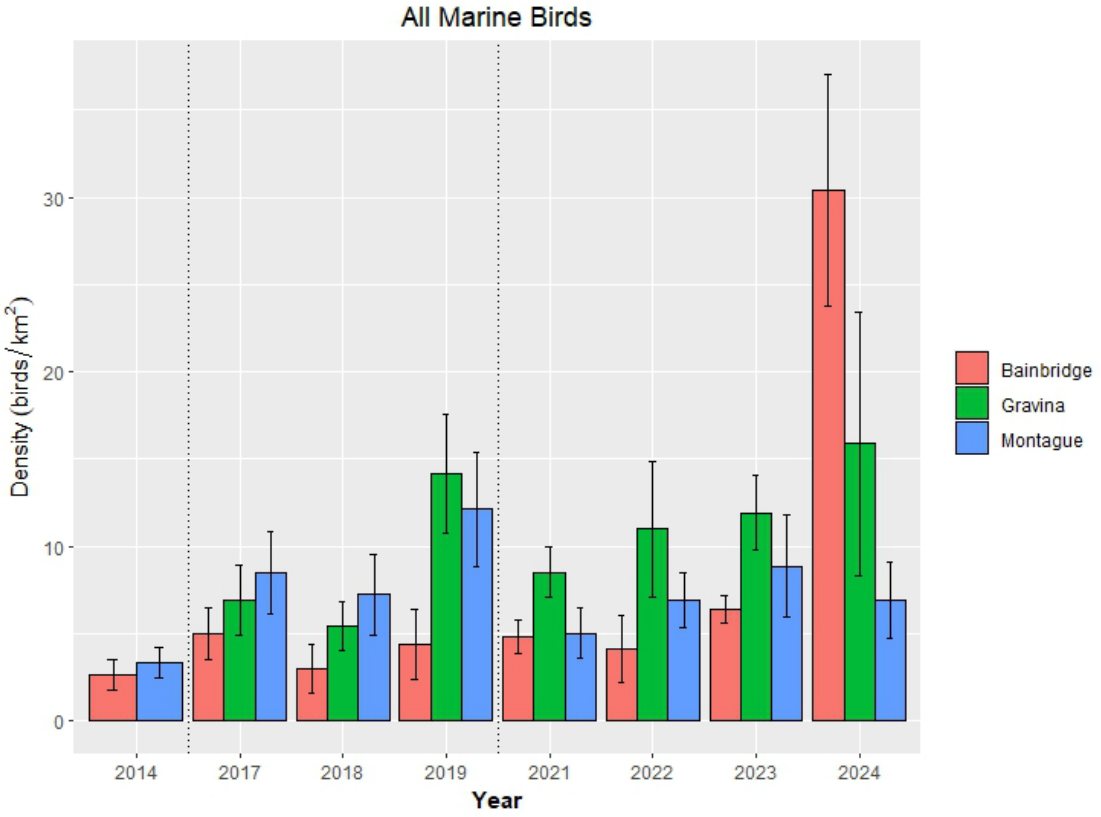

Figure 6. Interannual variability of marine bird densities by region (color) during the Integrated Predator-Prey survey transects in Prince William Sound. Graphic credit: Anne Schaefer, Prince William Sound Science Center.

Summer Forage Fish Sampling

Validation surveys were conducted from Cordova, Alaska in support of the continuing GWA-LTRM aerial forage fish surveys during the second week of June when aerial surveys were conducted by Scott Pegau and Mike Collins. A boat-based team departed from Cordova to the general area identified by aerial observers. When both the aerial spotter plane and boat-based crew were on station, the spotter plane would locate a school of forage fish, make a visual identification of that school, and guide the boat-based crew to the school by giving verbal instructions over marine VHF radio. Once the skiff was over a school, the boat crew would identify fish either by catching fish with jigs, or by visual confirmation of fish at the surface, or below the surface with a drop camera. During 2024, adverse weather conditions resulted in limited opportunities for validation, however, nine herring schools were sampled. Overall, the validation efforts between 2014 and 2024 (102 validated schools) indicate a high level of correct species identification (96% for herring, 74% for sand lance) by the aerial observers. In 2024, relative density of forage fish schools during the June aerial surveys was the lowest since 2019, due mainly to lower numbers of juvenile herring (Fig. 7).

Spatial and temporal variation of forage school densities in PWS between 2010 and 2022 were driven by juvenile herring, which tend to be concentrated in the eastern Sound, and in Knight Island Passage (Donnelly et al. 2024). Sand lance were more restricted to core areas around Middle Ground Shoal, Naked Island, and Perry Island, but school densities in these regions declined after 2010 (Fig. 7). Sand lance declines on aerial surveys are consistent with findings from seabird diets at Middleton Island (Figs. 2 and 3) and other seabirds colonies around the Gulf of Alaska (Arimitsu et al. 2024).

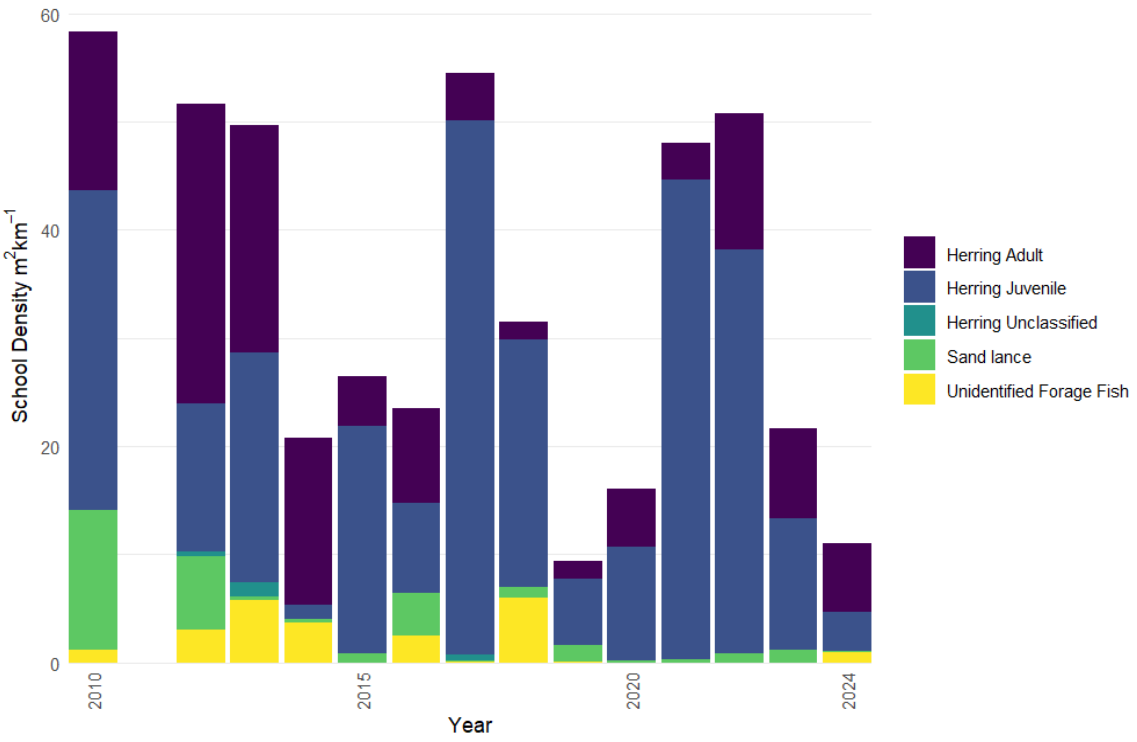

Figure 7. Forage fish school density (median surface area per shoreline km surveyed, m^2km^{-1}) observed June aerial surveys during 2010 to 2023. Species and age (for herring only) classifications are shown in color. Graphic credit: Dan Donnelly, U. S. Geological Survey-Alaska Science Center.

Summer Forage Fish Condition

We collected forage fish in PWS during July 2024. Pacific sand lance samples were collected at Cabin Bay for size, age, and energy measurements. Although we visited Port Etches and looked for spawning capelin over several tidal cycles in July, we did not encounter any spawning capelin activity in the area. We also worked with John Johnson who runs the Nuuciq Spirit Camp, and Rob Campbell (PWSSC) to search for spawning capelin in Port Etches in July but none were observed that summer. We worked with otolith aging experts in Newfoundland to ensure that our methods for aging capelin correspond with those developed for Atlantic populations. We continue to have success with a citizen science project to collect information

about spawning capelin around Alaska (https://www.usgs.gov/media/images/capelin-flyer, accessed 1/31/2025).

From capelin samples collected during beach spawning events and aged by their otoliths, we found that the age structure of summer spawners in PWS shifted from primarily age-2 fish in 2013 (pre-heatwave) to primarily age-1 fish during and following heatwaves (2016, 2019, 2020) (Fig. 8, Arimitsu et al. 2021). In contrast, spawning aggregations in the greater Gulf of Alaska region (2020, 2022, 2023) were composed of primarily age-2 and age-3 fish during spring (Kodiak, Cook Inlet, Glacier Bay) and a mix of age-1 to age-3 fish during fall (Sitka) (Fig. 8). Older age compositions, especially during spring in the core capelin areas correspond with a recovering capelin population in the Gulf of Alaska (Figs. 2 and 3, Arimitsu et al. 2024, McGowan et al. 2024). Spawning capelin age composition data provide important context for understanding plasticity in maturation rates in response to extreme thermal conditions.

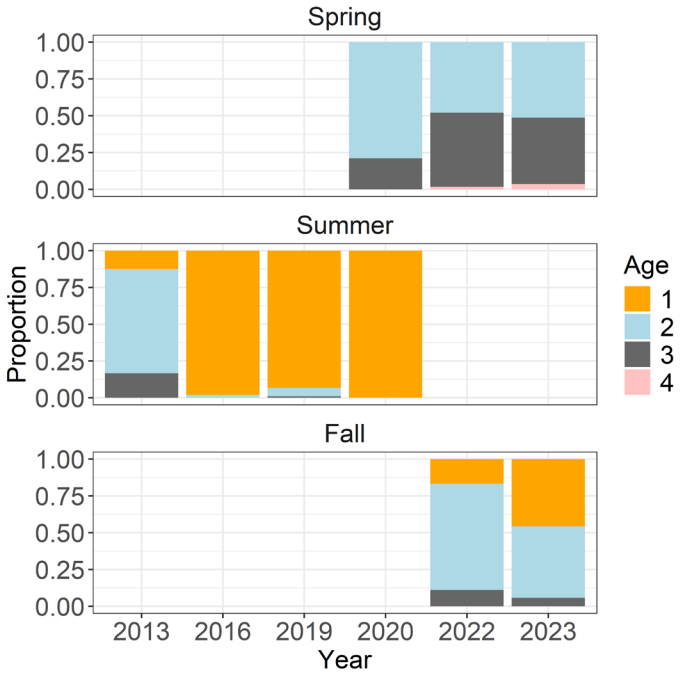

Figure 8. Spawning male capelin age proportions (color) by year and season. Spring sampling events occurred in Kodiak, Cook Inlet, and Glacier Bay, summer sampling events occurred in Prince William Sound, and fall sampling events occurred in Sitka. Graphic credit: Caitlin Marsteller, U. S. Geological Survey-Alaska Science Center.

Juvenile Salmon Otoliths

Rhinoceros auklets at Middleton regularly sample juvenile pink *(O. gorbuscha*) and chum (*O. keta*) salmon (size range = 56 – 190 mm) within their core foraging range (Fig. 1). These fish are from a mix of hatchery and wild origin that have recently out-migrated from streams in the region as smolt and were intercepted by the seabirds as they exited PWS through ocean passages at Hinchinbrook and Montague. Juvenile salmon were removed from archived frozen rhinoceros auklet bill load samples collected at Middleton Island between 2010 and 2024. Otoliths were recovered from individual pink and chum salmon from bill loads, although not all otoliths were recovered because some were missing, damaged, or otherwise unreadable. Preparation and reading of otoliths followed procedures described in the Alaska Department of Fish and Game's Cordova otolith lab procedure manual (Fernandez and Moffitt 2016). The average (standard deviation) proportion of hatchery origin chum and pink salmon in seabird diets was 0.61 (0.31) and 0.53 (0.27), respectively. We applied hatchery vs. wild origin proportions to Middleton Island seabird diet indices (proportion of biomass) for pink and chum salmon over time (Fig. 9). For years between 2019 and 2023, a subset of samples from which otoliths could be recovered (n=100) were randomly selected for analysis of energy density. Whole fish were freeze-dried, then homogenized before being processed for energy density using a Parr 6725 semimicro bomb calorimeter. Mean energy density was not significantly different between hatchery and wild origin salmon (two-tailed *t* test p = 0.9152).

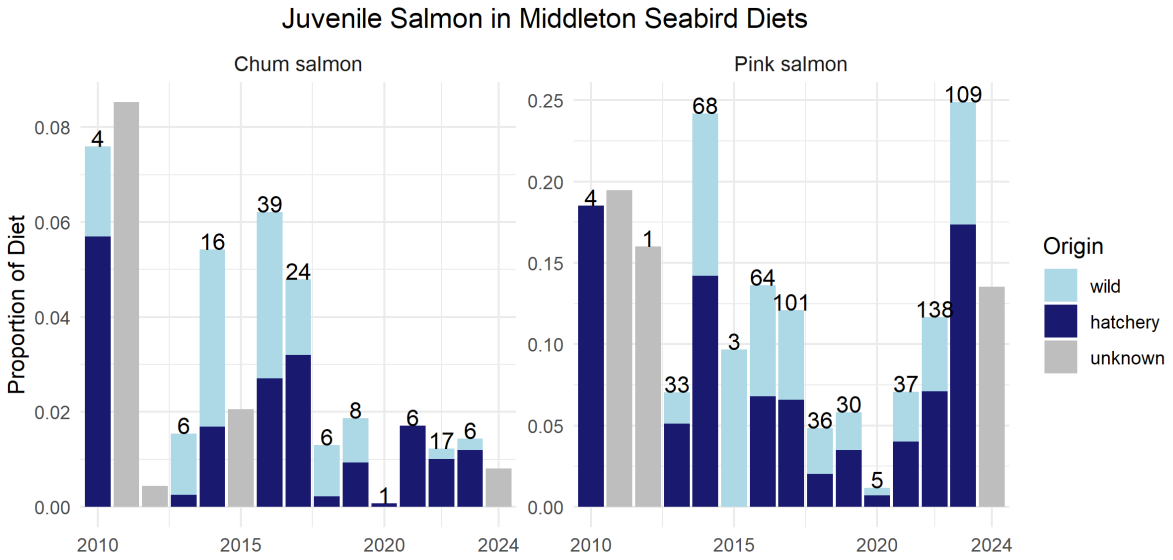

Figure 9. Interannual variation of juvenile salmon indices (proportion of biomass) in rhinoceros auklet diets at Middleton Island during July–August. Bars are colored by the proportion of recovered otoliths that were determined to be wild vs. hatchery origin, and sample sizes are provided above each bar. Grey bars indicate years in which origin could not be determined.

Acknowledgements

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Literature Cited

Arimitsu, M., B. Drummond, S. Hatch, H. Renner, N. Rojek, and S. Whelan. 2024. Seabird diets in the Gulf of Alaska 1978–2024. Pages 96-100 *in* Ferriss, B. E., editor. Ecosystem Status Report 2024: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report. North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501. https://apex.psmfc.org/akfin/r/akfin/151/files/static/v148/2024/GOA_ESR_2024.pdf.

Arimitsu, M., and S. Hatch. 2023. Age-0 Sablefish size and growth indices from seabird diets at Middleton Island, Gulf of Alaska. USGS Open-File Report 2023-1049. doi:10.3133/ofr20231049.

Arimitsu, M. L., J. F. Piatt, S. A. Hatch, R. M. Suryan, S. D. Batten, M. A. Bishop, R. W. Campbell, H. Coletti, D. A. Cushing, K. B. Gorman, R. R. Hopcroft, K. J. Kuletz, C. Marsteller, C. A. E. McKinstry, D. W. McGowan, J. R. Moran, W. S. Pegau, A. L. Schaefer, S. K. 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 27:1859–1878.

Cunningham, J., K. Elliott, K. Cottenie, S. Hatch, and S. Jacobs. 2018. Individual foraging location, but not dietary, specialization: implications for rhinoceros auklets as samplers of forage fish. Marine Ecology Progress Series 605:225–240.

Donnelly, D., M. Arimitsu, S. Pegau, and J. Piatt. 2024. Quantifying spatiotemporal variation of nearshore forage fish schools with aerial surveys in Prince William Sound, Alaska. Marine and Coastal Fisheries Dynamics, Management, and Ecosystem Science 16:e10283, https://doi.org/10.1002/mcf2.10283.

Fernandez, E., and S. Moffitt. 2016. Otolith processing and quality control methods used by the ADF&G Cordova Otolith Laboratory. Alaska Hatchery Research Group Technical Document #12.

Hatch, S. A. 2013. Kittiwake diets and chick production signal a 2008 regime shift in the Northeast Pacific. Marine Ecology Progress Series 477:271–284.

McGowan, D., D. Jones, M. Levine, and K. Williams. 2024. Fisheries-independent survey-based indices of capelin relative abundance. Pages 101-104 *in* Ferriss, B. E., editor. Ecosystem Status Report 2024: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Piatt, J. F., M. L. Arimitsu, W. J. Sydeman, S. A. Thompson, H. M. Renner, S. G. Zador, D. Douglas, S. A. Hatch, A. B. Kettle, and J. Williams. 2018. Biogeography of pelagic food webs in the North Pacific. Fisheries Oceanography 27:366–380.

Rojek, N., S. Zador, M. Arimitsu, J. Lindsey, I. Ortiz, and R. Kaler. 2024 Integrated Seabird Information. Pages 66-75 *in* Ortiz, I., and S. Zador, editors. Ecosystem Status Report 2024: Aleutian Islands, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Shotwell, K., and R. Dame. 2024. Ecosystem and Socioeconomic Profile of sablefish stocks in Alaska – Report Card. North Pacific Fishery Management Council, Anchorage, AK. Available from https://www.npfmc.org/library/safereports/.

Sydeman, W. J., J. F. Piatt, S. A. Thompson, M. García-Reyes, S. A. Hatch, M. L. Arimitsu, L. Slater, J. C. Williams, N. A. Rojek, S. G. Zador, and H. M. Renner. 2017. Puffins reveal contrasting relationships between forage fish and ocean climate in the N. Pacific. Fisheries Oceanography 26:379–395.

Sydeman, W. J., S. A. Thompson, J. F. Piatt, S. G. Zador, and M. W. Dorn. 2021. Integrating seabird dietary and groundfish stock assessment data: Can puffins predict pollock spawning stock biomass in the North Pacific? Fish and Fisheries 23:1–14.

Thompson, S. A., M. García-Reyes, W. J. Sydeman, M. L. Arimitsu, S. A. Hatch, and J. F. Piatt. 2019. Effects of ocean climate on the length and condition of forage fish in the Gulf of Alaska. Fisheries Oceanography 28:658–671.

2. Products:

Peer-reviewed publications:

Donnelly, D., M. Arimitsu, S. Pegau, and J. Piatt. 2024. Aerial surveys to quantify spatiotemporal variation of nearshore forage fish schools in Prince William Sound, Alaska. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 16: e10283. https://afspubs.onlinelibrary.wiley.com/doi/epdf/10.1002/mcf2.10283

Piatt, J., M. Arimitsu, S. A. Thompson, R. Suryan, R. Wilson, and W. J. Sydeman. 2024. HEAT theme section introduction: Mechanisms by which heatwaves impact seabirds. Marine Ecology Progress Series 737:1-8. https://doi.org/10.3354/meps14625

Reports:

Arimitsu, M. L., J. F. Piatt, S. Hatch, C. Marsteller, D. Donnelly, S. Whelan. 2024. Monitoring long-term changes in forage fish distribution, abundance, and body condition in Prince William Sound. *Exxon Valdez* Oil Spill Long-term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 23120114-C), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Arimitsu, M., B. Drummond, S. Hatch, H. Renner, N. Rojek, S. Whelan. 2024. Seabird diets in the Gulf of Alaska 1978–2024. Pages 96-100 *in* Ferriss, B. E., editor. Ecosystem Status Report 2024: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Arimitsu, M., J. Piatt, S. Schoen, L. Turner, and C. Cunningham. 2025. Seabirds and Forage Fish in Alaska: Combining Data to Inform Spatiotemporal Models for Oil Spill Risk Analysis and Spatial Planning. Anchorage, Alaska: U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS study BOEM 2025-002.

Shotwell, K., and R. Dame. 2024. Ecosystem and Socioeconomic Profile of sablefish stocks in Alaska – Report Card. North Pacific Fishery Management Council, Anchorage, AK. Available from https://www.npfmc.org/library/safereports/; GWA data contribution: age-0 sablefish indices https://doi.org/10.5066/P94KVH9X.

Popular articles:

Arimitsu, M., S. Hatch, S. Whelan, C. Marsteller, and J. Piatt. 2024. Capelin on the rebound: Using seabird diets to track trends in forage fish populations. Delta Sound Connections 2024-2025. https://pwssc.org/wp-content/uploads/2024/05/DSC-2024_FINAL-WEB.pdf.

Bien, L., M. Arimitsu, J. Moran, and R. Suryan. 2024. Seabirds and humpback whales give early warning to marine heatwaves. Open Access Government April: 388:389. https://doi.org/10.56367/OAG-042-10703.

Cornwall, W. 2024. “Blob” heat wave killed millions of seabirds—and they haven’t bounced back: Historic 2016 event may have permanently altered norther Pacific ecosystem. Science doi: 10.1126/science.zc97ezo. (features interviews with Mayumi Arimitsu and

John Piatt). https://www.science.org/content/article/blob-heat-wave-killed-millions-seabirds-and-they-haven-t-bounced-back.

Conferences and workshops:

Arimitsu, M., H. Murphy, J. Piatt, V. von Biela, C. Marsteller, K. Ressel, J. Bell, T. Sutton. 2024. Capelin response to thermal habitat and large-scale ocean circulation in the North Atlantic and Pacific Oceans. Oral presentation, ESSAS meeting, St. John's, Newfoundland, Canada, June.

Arimitsu, M., C. Cunningham, B. Drummond, B. Ferriss, D. Goethal, S. Hatch, K. Oke, J. Piatt, H. Renner, N. Rojek, K. Shotwell, W. Strassburger, L. Turner, S. Whelan. 2024. Puffin diets provide annual forage fish indices to inform ecosystem-based fisheries management in Alaska. Oral presentation, PICES meeting, Honolulu, Hawaii, October.

Arimitsu, M., S. Schoen, C. Marsteller, D. Donnelly, S. Stark, N. Bargmann, J. Piatt. 2024. Impacts of marine heatwaves of seabirds and forage fish. Oral presentation, EcoLunch Seminar, Anchorage, Alaska. December.

Marsteller, C., M. Arimitsu, J. Piatt, V. von Biela, A. Stanek, C. Murdoch, E. Munk, and J. Tanguay. 2025. The little fish with big impacts: Signals of environmental change in spawning capelin throughout its Pacific range. Oral presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Moran, J., C. Gabriele, J. Nielson, L. Wild, H. Riley, B. Witteveen, M. Arimitsu, B. Drummond, S. Whelan, E. Ferguson, J. Straley. 2025. Humpback whale birth rates reflect a recovering food supply in the Gulf of Alaska. Oral presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Schoen, S. K., M. Arimitsu, N., Bargmann, C. Marsteller, M., Smith, J. Piatt, 2024. Assessment of paralytic shellfish toxin (saxitoxin) in seabird die-offs and marine food webs across Alaska. Oral presentation, Pacific Seabird Group Annual Meeting, Seattle, Washington, February.

Public presentations:

Arimitsu, M. 2025. USGS science on seabirds and forage fish response to marine heatwaves. Community Education Night for teachers, students, and community members, hosted by the Alaska Marine Science Symposium, Anchorage, Alaska. January.

Arimitsu, M., and R. Juzeler. 2024. High Sign of the Sea. Public lecture, Juneau STEAM Coalition's STEAM Café, Juneau, Alaska. March.

Liebich, K., and G. Eroh. 2024. Alaska's capelin/seabird story. U. S. Fish and Wildlife Service Fish of the Week podcast featuring expert interviews with Mayumi Arimitsu and Robb Kaler (U. S. Fish and Wildlife Service Migratory Bird Management), March 11. https://podcasts.apple.com/us/podcast/alaskas-capelin-seabird-story/id1546630514?i=1000648718220.

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

Arimitsu, M., and J. Piatt. 2024. Marine Heatwaves – The Effects of Climate Change on Seabirds and Marine Ecosystems. Science Spotlight blog post, July. Marine Heatwaves – The Effects of Climate Change on Seabirds and Marine Ecosystems | At the Core (usgs.gov).

Data sets and associated metadata:

Arimitsu, M. L., J. F. Piatt, B. M. Heflin, and C. E. Marsteller. 2017. Gulf Watch Alaska - Pelagic Ecosystems Forage Fish Component - data from Prince William Sound: distribution, abundance, and morphology of fish, zooplankton, and predators and oceanographic conditions (ver 4.0, September 2024): U.S. Geological Survey data release, https://doi.org/10.5066/F74J0C9Z.

Hatch, S., M. Arimitsu, J. Piatt, S. Whelan, and C. E. Marsteller. 2023, Seabird Diet Data Collected on Middleton Island, Gulf of Alaska (ver 2.0, October 2024): U.S. Geological Survey data release, https://doi.org/10.5066/P93I0P67.

Turner, L. C., M. L. Arimitsu, J. F. Piatt, G. L. Eckert, and C. J. Cunningham. 2024. Alaska Forage Fish Database (AFFD): U.S. Geological Survey data release, https://doi.org/10.5066/P9WZQJ8N.

Additional Products not listed above:

Mayumi Arimitsu and John Piatt worked on a website to highlight their work on a theme section in Marine Ecology Progress Series that included 13 contributed articles documenting mechanisms impacting seabirds around the world. Mechanisms by Which Heatwaves Impact Seabirds and Marine Ecosystems | U.S. Geological Survey (usgs.gov).

3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

We work closely with PWSSC scientists on several aspects of our work, e.g., with Scott Pegau (PWSSC) on validation of aerial surveys, Mary Anne Bishop (PWSSC) and Anne Schaefer (PWSSC) on marine bird surveys, and with Pete Rand (PWSSC), Kristen Gorman (University of Alaska Fairbanks), and Jenni Morella (Alaska Department of Fish and Game) regarding juvenile salmon samples, otolith protocols, and opportunities for sharing information and resources across projects. We shared juvenile salmon data (2010-2024), including length-weight, origin, and energy density, with Pete Rand and Kristen Gorman. We are currently discussing ways we may coordinate sample collection and future collaborations on the juvenile salmon project.

EVOSTC Long-Term Research and Monitoring Projects

Mayumi Arimitsu is on the GWA-LTRM science coordinating committee serving as lead for the GWA-LTRM pelagic component, which includes monitoring projects including marine birds, humpback whales, and forage fish. Her duties in this role have included leading science synthesis activities, coordinating pelagic program science products and information transfer, leading presentations at conferences and principal investigators meetings, and facilitating communications between the program management team and the pelagic component project leaders.

Under the pelagic component of the GWA-LTRM program, the forage fish project shares a research platform and common goals with the humpback whale project (24120114-O) also associated with the IPP surveys. Summer forage fish surveys and information regarding Middleton Island seabird diets also provide a means to understand trends in piscivorous marine birds (project 24120114-M).

EVOSTC Mariculture Projects

We engaged with *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) mariculture projects group at the GWA-LTRM principal investigator (PI) meetings and look forward to working with the mariculture team as our sampling goals and geographic regions are complementary.

EVOSTC Education and Outreach Projects

In FY24 we worked with the Community Organized Restoration and Learning (CORaL) Network to provide content for educational kiosks planned in spill-affected communities. In 2024 we worked closely with Lauren Bien (PWSSC), who led an article on seabirds and whales as in the journal Open Government Access, and provided an article for the Delta Sound

Connections magazine. We are currently developing outreach materials with education specialists at CORaL network, U. S. Fish and Wildlife Service Alaska Maritime National Wildlife Refuge, the Pratt Museum in Homer, and the Chugach Regional Resources Commission.

Individual EVOSTC Projects

The forage fish project works with the Data Management program to ensure data collected are properly reviewed, have current metadata, and are posted to the Gulf of Alaska data portal within required timeframes. To increase coordination and communication by PIs collecting marine bird survey data, Mayumi Arimitsu coordinated a Marine Bird Working Group meeting during the 2024 October PI meeting in Cordova. We also held an informal meeting to discuss synthesis activities and data management during the Alaska Marine Science Symposium in Anchorage, Jan 2024. Mayumi Arimitsu is on the PhD advisory committee of Dan Cushing, who is working on his dissertation entitled "Predator responses to variability in prey-field characteristics across contrasting oceanographic settings in the northern Gulf of Alaska".

Trustee or Management Agencies

Data and fish samples gathered as part of the GWA-LTRM forage fish study are used by NOAA National Marine Fisheries Science annual stock assessment process (e.g., Bridget Ferriss Gulf of Alaska Ecosystems Status Report and Kalei Shotwell et al. Sablefish Ecosystem and Socioeconomic Profile to the North Pacific Fisheries Management Council). The GWA-LTRM forage fish work is also complimentary to a related USGS outer Continental Shelf and Bureau of Ocean Energy Management funded study of forage fish and seabird trends in areas of oil and gas development in Cook Inlet. This continued coordination and collaboration with GWA-LTRM PIs and other researchers (Liz Labunski and Robb Kaler, U. S. Fish and Wildlife Service; Kris Holderied, NOAA) in Cook Inlet and Kachemak Bay increases the scope of ecosystem monitoring in the Northern Gulf of Alaska.

Native and Local Communities

We are working with John Johnson (Chugach Alaska Corporation) regarding information and sample collection and spawning capelin observations in Port Etches. We also continue to build relationships with members of the Chugach Regional Resources Commission, and we are seeking ways to share information in the future.

4. Response to EVOSTC Review, Recommendations and Comments:

September 2024 EVOSTC Science Panel Comment:

This project is on track and has been very successful in the dissemination of results, producing numerous high-profile papers in respected peer-reviewed scientific journals, reports, and conference and workshop presentations. The investigators have developed valuable collaborations with other EVOSTC projects, the NGA-LTER program, Chugach Alaska Corp., and others. It is on track in submitting data and metadata to the Data Management program. We have a few comments and questions.

PI Response:

We thank the reviewers for these positive comments on our work thus far and look forward to continuing this project.

September 2024 EVOSTC Science Panel Comment:

Page 3. The text states that "to the extent the birds foraged over the shelf in spring, age 1 and older herring were the main prey for Middleton seabirds in 2022". Does this statement mean that the age 1 herring were captured by seabirds as they foraged in the vicinity of Middleton Island or that the birds captured herring elsewhere (near shore) and flew with the prey to feed chicks on Middleton Island?

PI Response:

This is a great question, and one that is the focus of Katlyn Depot's masters thesis pairing kittiwake GPS tagging data that document foraging locations along with prey types brought back to the colony. Preliminary results from 2023 and 2024 indicate that tagged kittiwakes that brought age-1+ (as assessed by size) were foraging on the shelf between Middleton and PWS, including at Kayak Island, in bays in Hinchinbrook Entrance - Port Etches and Zaikof. The foraging area delineated in Fig. 1 within 100 km of Middleton is broadly representative of the habitat in which the age-1+ herring were sampled by kittiwakes. Katelyn is wrapping up her thesis in spring 2025 and has a manuscript in preparation that will detail these findings.

September 2024 EVOSTC Science Panel Comment:

The question about pink salmon as prey of seabirds is interesting and potentially important. The ADF&G herring assessments have generally been confined to waters inside PWS. This holds for spawn surveys (note spawning on Kayak Island in recent years), juvenile aerial surveys and past acoustic surveys. If juvenile pink salmon, or larval or juvenile herring, spent time (regularly or intermittently) outside PWS waters, then they might go undetected. This could have implications for stock assessments and other related work. The concern that some herring may routinely live outside PWS, after spawning inside PWS, might be addressed through analyses routinely conducted in the seabird surveys. For this reason, we applaud the collaborative communication and potential work analyses among the various projects.

Note that the FY23 annual report has two different Figure 8s. In the second Figure the frequencies of hatchery and wild pink salmon were low in some years. Could this reflect an artifact of sampling or a change in the habits of birds?

PI Response:

We thank the science panel for positive comments regarding the value of juvenile salmon samples in Middleton Island seabird diets. Seabird diet samples provide a wealth of samples that are otherwise difficult and costly to obtain. The FY23 report figure in question showed raw counts of samples that were determined to be hatchery origin (with thermal marks) or presumably wild (without thermal marks), however, we weren't able to read the otoliths of every salmon due to damaged samples (fish with damaged or missing heads) or unreadable otoliths (old frozen samples had unreadable or broken/brittle otoliths). So the data as shown were not reflective of the interannual variability of pink and chum indices in seabird diets. In hindsight, we agree this was a confusing way to graph the data. We clarified the text, and revised the figure to incorporate the pink and chum diet indices (proportion of biomass in rhinoceros auklet diets) by year, and applied hatchery vs. wild proportions estimated by their relative ratios in recovered otolith samples (see Fig. 9).

2024 EVOSTC Executive Director Comments:

I concur with the Science Panel. Funding for this project is managed by NOAA. The expenses on the annual reports are well documented and easy to track. The Fiscal Manager is responsive to budget questions. Staff do not have concerns at this time.

2024 EVOSTC PAC Comments

There were no questions or discussion, and Whissel introduced a motion to proceed with no concerns. Borer seconded, and there was no opposition. The motion passed unanimously.

5. Budget:

Differences between proposed and actual spending are due in part to the differences in fiscal year periods between EVOSTC and USGS, and because contracting for sample processing, instrument calibrations, federal hiring processes have gone more slowly than anticipated, and because airfare, hotel, and other travel costs have been more expensive than expected. We anticipate that spending categories will ultimately reflect our proposed amounts as the project progresses. USGS will continue to make a substantial in-kind contribution of salary for pelagic component lead and principal investigator, and field equipment required to conduct the work including hydroacoustic echosounders, oceanography sampling equipment, a trawl depth monitor system, small boats, a marine scale, and other sampling equipment. ISRC also continues to make substantial in-kind contributions for the use of facilities at Middleton Island.

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
PROJECT 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		$155,284	$96,905	$132,135	$137,923	$144,000	$666,247	$359,968
Travel		$14,492	$24,161	$15,226	$15,606	$15,996	$85,482	$58,597
Contractual		$106,800	$109,470	$112,207	$115,012	$117,887	$561,376	$313,908
Commodities		$32,000	$32,000	$32,000	$32,000	$32,000	$160,000	$96,241
Equipment		$10,650	$31,326	$11,189	$11,469	$11,756	$76,390	$56,571
Indirect Costs	Rate = 0%	$0	$0	$0	$0	$0	$0	
SUBTOTAL		$319,226	$293,863	$302,757	$312,010	$321,639	$1,549,494	$885,285
General Administration (9% of subtotal)		$28,730	$26,448	$27,248	$28,081	$28,947	$139,455	N/A
PROJECT TOTAL		$347,956	$320,311	$330,005	$340,091	$350,586	$1,688,949	
Other Resources (In-Kind Funds)		$482,500	$482,500	$482,500	$482,500	$482,500	$2,412,500	

COMMENTS:
Differences between proposed and actual spending are due in part to the differences in fiscal year periods between EVOSTC and USGS, and because contracting for sample processing, instrument calibrations, federal hiring processes have gone more slowly than anticipated, and because airfare, hotel, and other travel costs have been more expensive than expected. We anticipate that spending categories will ultimately reflect our proposed amounts as the project progresses. USGS will continue to make a substantial in-kind contributions of salary for pelagic component lead and PI, and field equipment required to conduct the work including hydroacoustic echosounders, oceanography sampling equipment, a trawl depth monitor system, small boats, a marine scale, and other sampling equipment. ISRC will also make substantial in-kind contributions for the use of facilities at Middleton Island.

FY22-26	Project Number: 24120114-C Project Title: Forage Fish Monitoring Primary Investigator: Arimitsu (USGS)	TRUSTEE AGENCY SUMMARY PAGE