1. Project Number:

20120114-C

2. Project Title:

Monitoring Long-term Changes in Forage Fish Distribution, Abundance and Body Condition in Prince William Sound

3. Principal Investigator(s) Names:

Mayumi Arimitsu and John Piatt, U.S. Geological Survey Alaska Science Center

Scott Hatch, Institute for Seabird Research and Conservation

4. Time Period Covered by the Report:

February 1, 2020-January 31, 2021

5. Date of Report:

March 2021

6. Project Website (if applicable):

www.gulfwatchalaska.org

7. Summary of Work Performed:

The Gulf Watch Alaska (GWA) 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, based on diets of adult and nestling seabirds at Middleton Island 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) in collaboration with the humpback whale (project 20120114-O, John Moran, National Oceanographic and Atmospheric Administration [NOAA], Jan Straley, University of Alaska Southeast [UAS]), and marine bird (project 20120114-E, Mary Anne Bishop, Prince William Sound Science Center [PWSSC]) projects, 3) summer aerial survey validation and acoustic-trawl surveys in PWS (Fig. 1). In this report we describe work conducted in 2020.

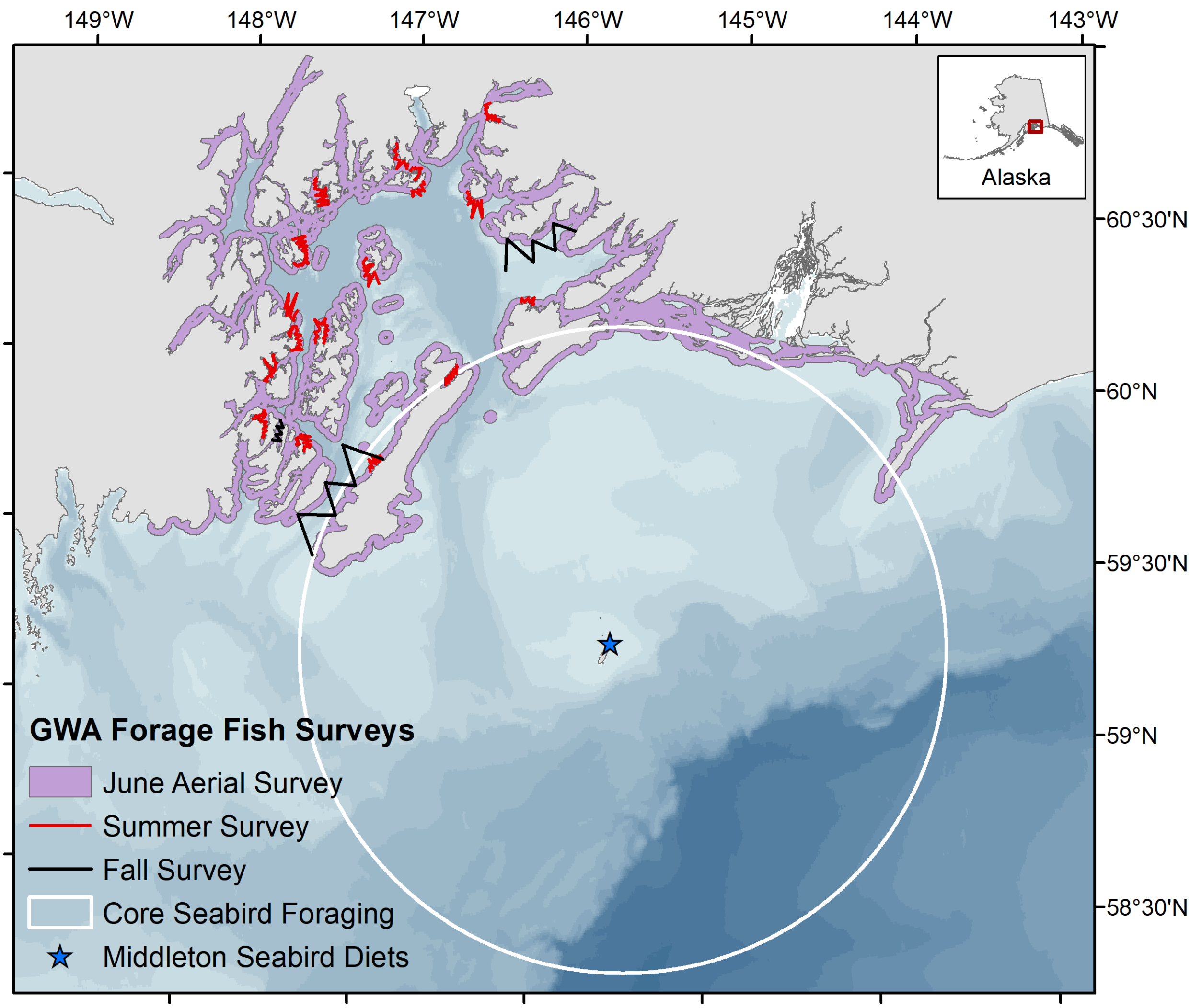

Figure 1. Distribution of Gulf Watch Alaska (GWA) seasonal forage fish survey effort in Prince William Sound and Middleton Island. Bathymetry is shown in blue with darker shades indicating deeper seafloor depth.

Due to the COVID-19 pandemic we were unable to conduct most of our planned sampling in 2020, including USGS-led efforts to validate June Herring Research and Monitoring (HRM) program aerial surveys, and the summer and fall acoustic – trawl surveys in PWS. Rob Campbell at the Prince William Sound Science Center (PWSSC) provided local support for forage fish sample collections, including spawning capelin from Port Etches in July. Those samples are currently being processed in the lab for measures of age-structure and energy content. We believe they will be useful in a planned analysis that compares responses of capelin following the two recent marine heatwaves in the region.

Middleton Island seabird diet sampling was conducted according to schedule, albeit with a smaller crew than normal due to the COVID-19 pandemic. Seabird diet samples at Middleton Island were collected from 20 Apr to 15 May, and from 10 Jun to 15 Aug 2020. This included 609 diet samples from black-legged kittiwakes and 322 diet samples from rhinoceros auklets. A detailed report on findings from Middleton Island is provided at the end of this report (Appendix, Hatch 2021).

Seabird diet information from Middleton Island integrates forage composition and availability over broad areas of the Northern Gulf of Alaska, across coastal, shelf, and slope regions (Hatch 2013, Arimitsu et al. 2021, Appendix). An in-depth analysis of auklet diets in relation to tagging data 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). The authors also highlighted the complexities of disentangling diet information in relation to individual specialization and prey switching. Predator diets at Middleton do appear to reflect large-scale synchrony among capelin abundance indices from NOAA trawl surveys that showed an abrupt decline between 2013 and 2015 (Arimitsu et al. 2021, McGowan et al. 2020).

In 2020, invertebrates (especially squid) and myctophids were important in the kittiwake diet during the pre-laying period (Apr-May), indicating extensive foraging off the continental shelf at that time. To the extent the birds foraged over the shelf in spring, age-1 and older herring were the main fish prey in 2020. Capelin were scarce throughout the season, absent in spring and present in only trace amounts during summer. Sand lance indices were moderate and relatively stable in kittiwake and auklet diets (Figs. 2 and 3). Cooling conditions in 2020 were associated with greater indices of hexagrammid species, especially age-0 greenlings, as an important part of kittiwake and auklet diets in 2020 (Figs. 2 and 3).

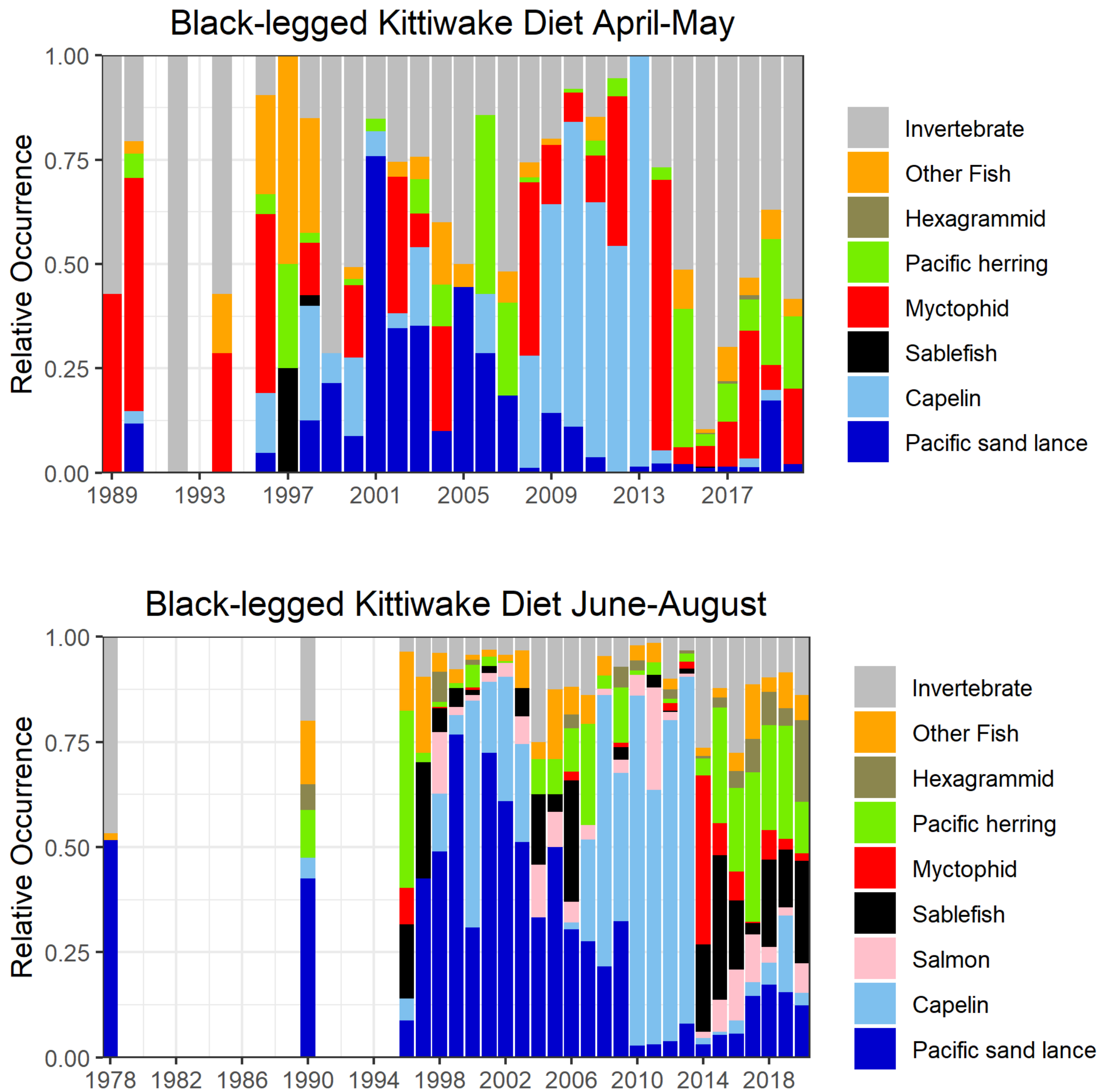

Figure 2. Interannual variation in diet composition of black-legged kittiwakes during spring (top) and summer(bottom) on Middleton Island.

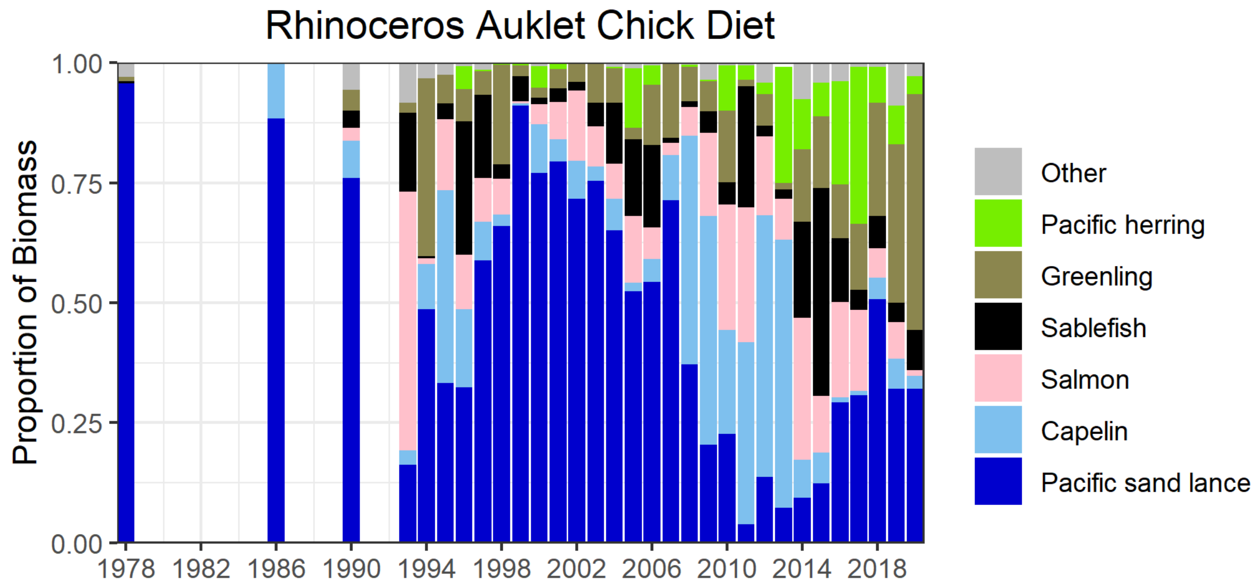

Figure 3. Interannual variation in rhinoceros auklet chick diets at Middleton Island.

Sand lance length frequency data in auklet diets indicate a mixture of age-0 and older age classes in 2020 (Fig. 4). Unlike 2016, when there was evidence of size truncation in the sand lance population (Arimitsu et al. 2021), larger more energetically rich sand lance have been more available to predators in recent years.

Herring were sparse in auklet diets in 2020 (Figs. 3 and 5). Length frequency data from 2010 to 2020 provide information on herring when auklets forage inshore (Fig. 5). For example, 2017 herring were dominated by the 2016 year class. The 2019 herring samples were also dominated by age-0 herring; however, that year class did not show up in seabird diets in 2020 (Fig. 5).

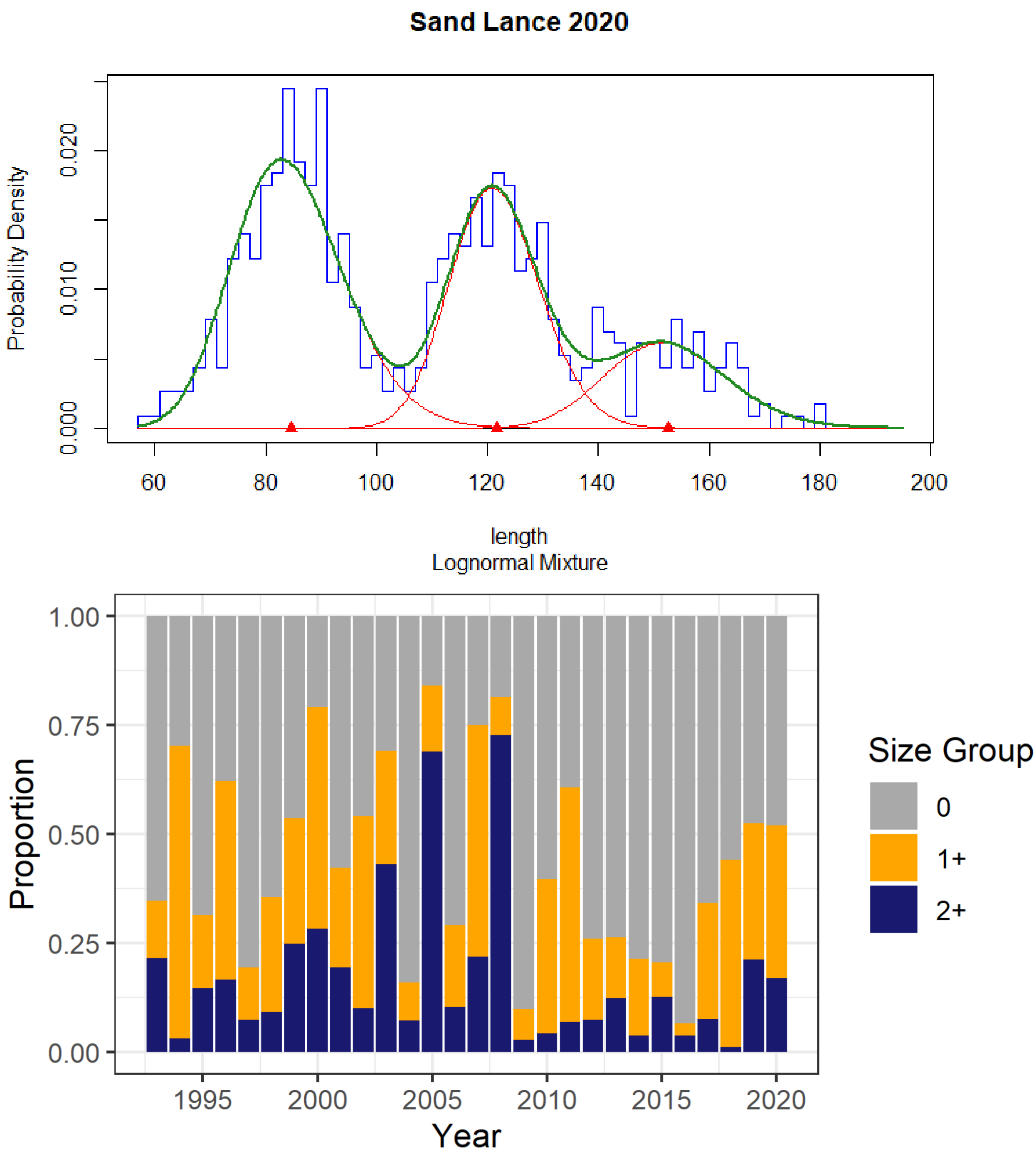

Figure 4. Size proportions of sand lance in rhinoceros auklet diets at Middleton Island. (top) Log-normal mixture models (lines, red triangles are estimated means for each size group) fit to length frequency data (blue histograms). (Bottom) time series of estimates of size proportions based on log-normal mixture models. Otolith data suggest that age-1 and older fish are not reliably estimated from lengths, but age-0 sand lance are typically represented in the first size group (labeled 0, < 100 mm) in summer.

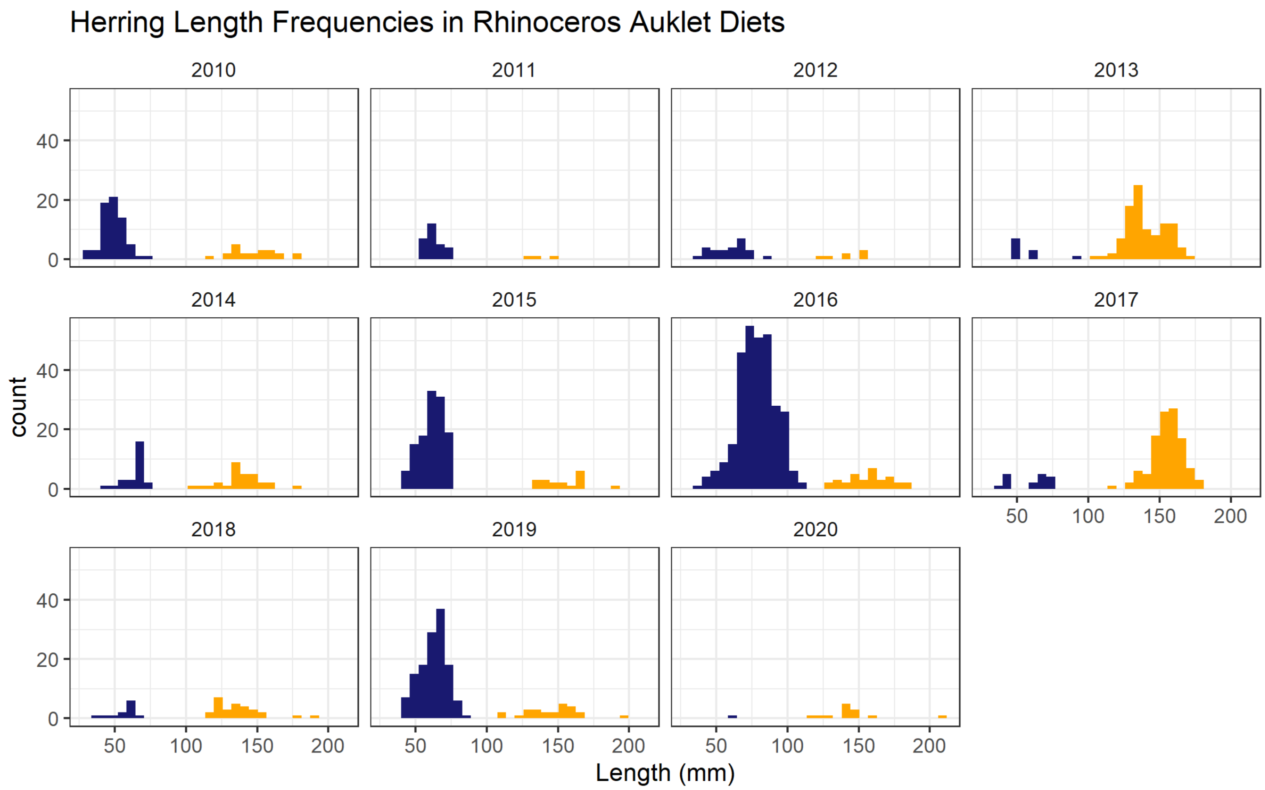

Figure 5. Herring length frequencies in seabird diets at Middleton Island 2010-2020.

Along with small pelagic forage fishes, juvenile stages of commercially important fish such as sablefish and salmon (Figs. 6 and 7) are frequently sampled by seabirds at Middleton Island. Seabirds have proven to be especially reliable samplers of juvenile sablefish over time. These data provide key information on young of the year growth as well as whole fresh fish samples for other kinds of analyses for this otherwise data-poor life stage. Sablefish spawn far offshore in late-winter, and foraging seabirds intercept juvenile sablefish, which occur in the surface waters within the core seabird feeding areas around Middleton Island during summer (Sigler et al. 2001; Fig 1.).

In October 2020 we contributed a young of the year sablefish growth index to NOAA for the sablefish ecological and socioeconomic profile in the annual stock assessment. The growth index in each year was calculated as the slope of the relationship between length and Julian day (Fig. 6). Using ordinary least squares regression (OLS), the interaction between Julian day and year explains 71% of the variability in length of juvenile sablefish over time ($OLS_{[F = 60.52,\ df = 57,\ 1332]}$ $R^2 = 0.71$, $p < 0.001$).

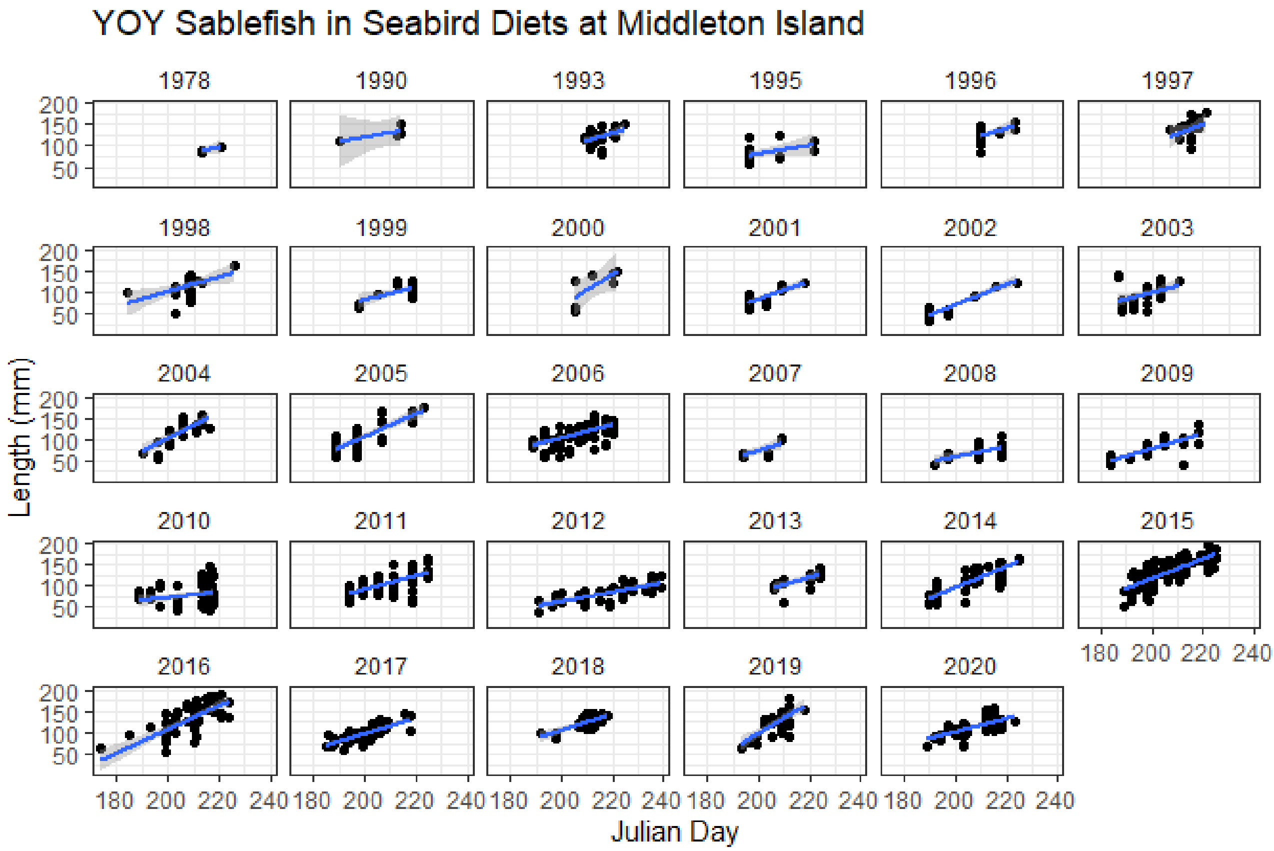

Figure 6. Young of the year (YOY) sablefish growth index (slope of the blue lines, mean±1SD: 1.9±0.7 mm/day) using seabirds as samplers to inform fisheries management.

Juvenile pink and chum salmon are also frequently sampled by seabirds at Middleton (Fig. 7). These fish are likely from a mix of hatchery and wild origin out migrating from streams in the region. All of the rhinoceros auklet diet samples are frozen in the field and samples are archived for many purposes. For example, sablefish and other forage species are being analyzed for isotopes, diet, age, energy density, and growth. Archived juvenile salmon samples going back to at least 2010 could also be processed for hatchery marks in the future.

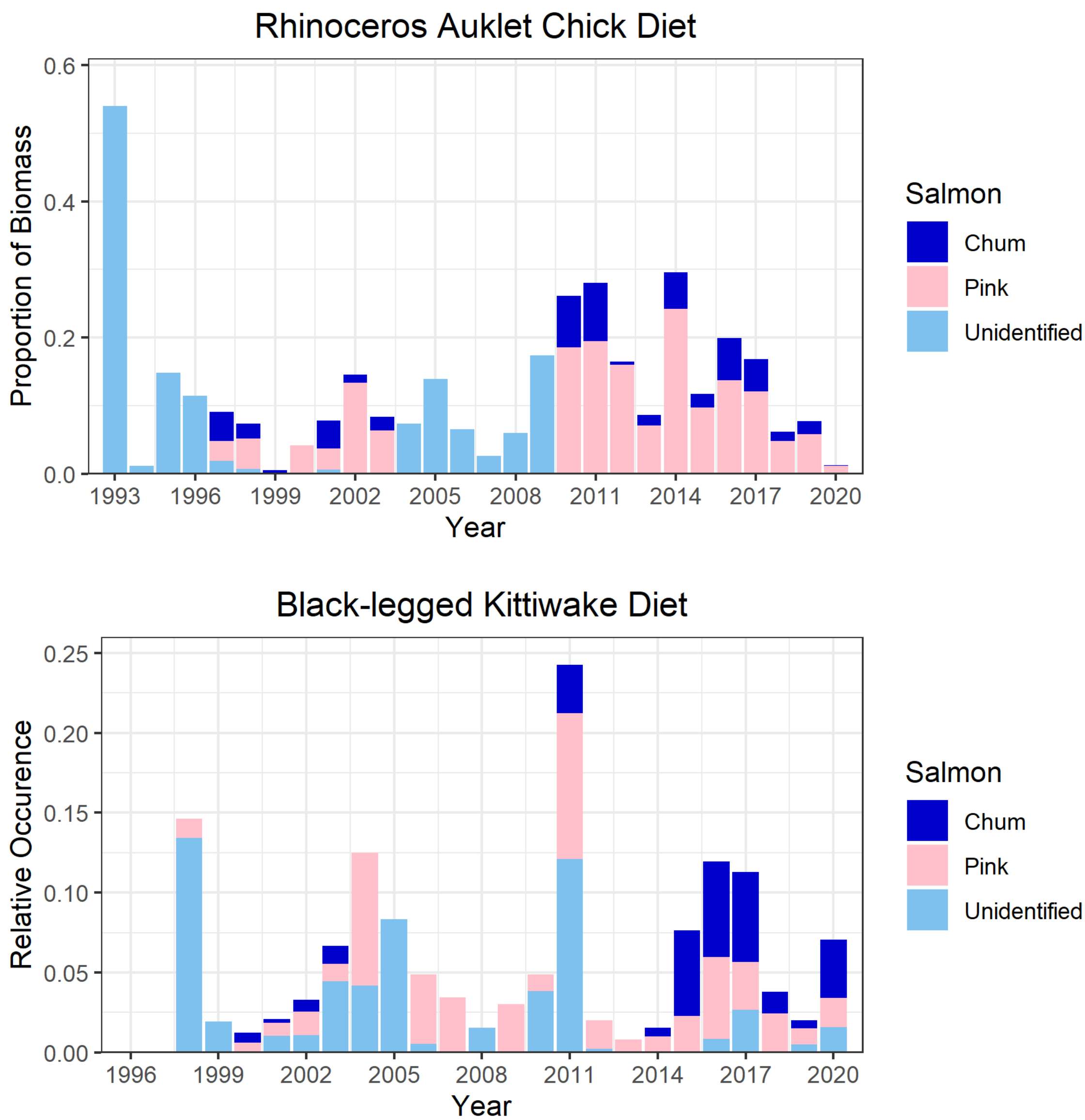

Figure 7. Juvenile salmon sampled by seabirds at Middleton Island.

8. Coordination/Collaboration:

A. Long-term Monitoring and Research Program Projects

1. Within the Program

Mayumi Arimitsu is on the GWA science coordinating committee serving as lead for the GWA pelagic component, which includes five monitoring projects including marine bird, humpback whale, killer whale, 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 acting as an intermediary in communications between the program management team and the pelagic component project leaders.

Under the pelagic component of the GWA program, the forage fish project shares a research platform and common goals of the humpback whale (project 20120114-O) and fall/winter marine bird (project 20120114-E) projects also associated with the Integrated Predator-Prey Surveys. Summer forage fish surveys and information regarding Middleton Island seabird diets also provide a means to understand trends in piscivorous marine birds (project 20120114-M).

In FY20 forage fish project principal investigators (PIs) led a science synthesis report chapter and manuscript published in Global Change Biology. Forage fish PIs also coauthored the Suryan et al. synthesis chapter and manuscript published in Nature Scientific Reports. These publications provide comprehensive analyses of the ecosystem response to the 2014-2016 Pacific marine heatwave, and they highlight the breadth of information.

2. Across Programs

a. Herring Research and Monitoring

We will continue collaborative work with Scott Pegau and the HRM program's aerial surveys for juvenile herring and other forage fish.

b. Data Management

In November 2020 we published an update to the USGS GWA forage fish data release to accompany our forage fish synthesis publication (Arimitsu et al. in press). We also coordinate with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the timeframes required.

B. Individual Projects

We are working with the Northern Gulf of Alaska Long Term Ecological Research (LTER) team (Russ Hopcroft, Kathy Kuletz) to assess connectivity between our collective ecosystem monitoring efforts. For example, in FY20 we developed a Bureau of Ocean Energy Management (BOEM)-GWA proposal to support student involvement in processing archived forage fish samples from LTER cruises. This work will facilitate a better understanding of the relationship between seabird diets at Middleton and the distribution for forage fish in trawls.

C. With Trustee or Management Agencies

Data and fish samples gathered as part of the GWA forage fish study will be used by NOAA National Marine Fisheries Science in annual stock assessments (Bridget Ferriss and Stephani Zador Ecosystems Considerations Chapter to the Northwest Pacific Fisheries Management Council). We are also collaborating with Gulf of Alaska Integrated Ecosystem program PIs and are nearing completion of a synthesis of capelin in the Gulf of Alaska. We also provided forage fish and macrozooplankton samples for studies on harmful algal blooms (North Pacific Research Board study PIs: Xiuning Du, Oregon State University, and Rob Campbell, PWSSC; US Geological Survey (USGS) study PIs: Sarah Schoen, Matt Smith, and Caroline van Hemert). The GWA forage fish work is also complimentary to a related USGS-BOEM study of forage fish and seabird trends in areas of oil and gas development in Cook Inlet (Arimitsu and Piatt, USGS). This continued coordination and collaboration with GWA PIs (Kris Holderied, NOAA; Kathy Kuletz, US Fish and Wildlife Service) in Cook Inlet and Kachemak Bay increases the scope of ecosystem monitoring in the Northern Gulf of Alaska.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

1. Peer-reviewed 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, W.S. Pegau, A. Schaeffer, S. Schoen, J. Straley, and V. von Biela. 2021. Heatwave-induced collapse of forage fish species disrupts energy flow to top pelagic predators. Global Change Biology. https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.15556

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.E. 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. Iron, A.B. 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.A. 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. In press. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports.

2. Reports

Arimitsu, M. and S. Hatch. 2020. Age-0 sablefish growth index time series from seabird diets. *In*: K. Shotwell, B. Fissel, and D. Hanselman. 2020. Appendix 3C Ecosystem and socioeconomic profile of the sablefish stock in Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501. https://apps-afsc.fisheries.noaa.gov/refm/docs/2020/sablefish.pdf

Arimitsu, M., J.F. Piatt, and S. Hatch. 2020. Monitoring long-term changes in forage fish distribution, abundance, and body conditions in PWS. FY19 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 19120114-C.

Arimitsu, M., J. Piatt, R. Suryan, S. Batten, M.A. Bishop, R. Campbell, H. Coletti, D. Cushing, K. Gorman, S. Hatch, S. Haught, R. Hopcroft, K. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, W.S. Pegau, A. Schaeffer, S. Schoen, J. Straley, and V. von Biela. 2020. Synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave. In: The Pacific marine heatwave: Monitoring during a major perturbation in the Gulf of Alaska. Long-Term Monitoring Program (Gulf Watch Alaska) Synthesis Report *Exxon Valdez* Oil Spill Trustee Council Program 19120114 (Eds: Suryan, R.M., M.R. Lindeberg, and D.R. Aderhold). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Hatch, S.A., M. Arimitsu, J.F. Piatt. 2020. Seabird-derived forage fish indicators from Middleton Island. *In:* B. Ferriss and S. Zador. 2020. Ecosystem Status Report 2020: Gulf of Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501. https://www.fisheries.noaa.gov/alaska/ecosystems/ecosystem-status-reports-gulf-alaska-bering-sea-and-aleutian-islands

Suryan, R., M. Arimitsu, H. Coletti, R. Hopcroft, M. Lindeberg, S. Batten, M.A. Bishop, R. Brenner, R. Campbell, D. Cushing, S. Danielson, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, B. Laurel, J. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaeffer, S. Straley, K. Sweeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. 2020. Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. In: The Pacific marine heatwave: Monitoring during a major perturbation in the Gulf of Alaska. Long-Term Monitoring Program (Gulf Watch Alaska) Synthesis Report *Exxon Valdez* Oil Spill Trustee Council Program 19120114 (Eds: Suryan, R.M., M.R. Lindeberg, and D.R. Aderhold). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

3. Popular articles

Arimitsu, M., J. Piatt, and S. Hatch. 2020. Forage fish in the Northern Gulf of Alaska: on the road to recovery at last? Delta Sounds Connections 2020-2021. https://pwssc.org/wp-content/uploads/2020/07/DSC-2020-web.pdf

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

1. Conferences and Workshops

Arimitsu, M. 2020. Tools for data collection, processing, and synthesis of at-sea marine bird survey data. Gulf Watch Alaska Marine Bird Working Group meeting. 9 November.

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, W.S. Pegau, A. Schaeffer, S. Schoen, J. Straley, and V. von Biela. 2021. Heatwave-induced collapse of forage fish species disrupts energy flow to top pelagic predators. Poster presentation. Alaska Marine Science Symposium. Anchorage, AK. 26-28 January.

Lindeberg, M., R. Suryan, D. Aderhold, K. Hoffman, R. Hopcroft, H. Coletti, M. Arimitsu. 2021. Gulf Watch Alaska: building partnerships to understand ecosystem change. Poster presentation. Alaska Marine Science Symposium. Anchorage, AK. 26-28 January.

Van Hemert, C., M. Smith, S. Schoen, M. Arimitsu, J. Piatt, D. Gerik, C. Marsteller, J. Pearce. 2021. Harmful algal blooms and Alaska seabirds: a multifaceted approach to a complex issue. Poster presentation. Alaska Marine Science Symposium. Anchorage, AK. 26-28 January.

2. Public presentations

No new contributions for this reporting period.

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

Arimitsu, M.L., J.F. Piatt, B.M. Heflin, and C.E. Marsteller. 2017. Pelagic Ecosystems Forage Fish Component - data from Prince William Sound: distribution, abundance, and morphology of fish, zooplankton, and predators and oceanographic conditions (ver 2.0, November 2020): U.S. Geological Survey data release https://doi.org/10.5066/F74J0C9Z.

Heflin, B.H., M.L. Arimitsu, and J.F. Piatt. 2020. Inshore catch data for capelin (*Mallotus villosus*) in the Gulf of Alaska 1996-2017: U.S. Geological Survey data release https://doi.org/10.5066/P96XJDK3

Van Hemert, C., S.K. Schoen, R.W. Litaker, M.M. Smith, W.C. Holland, M.L. Arimitsu, J.F. Piatt, D.R. Hardison, and J.M. Pearce.2020. Algal toxins in seabirds, forage fish, and marine invertebrates, Gulf of Alaska, 2015-2017. U.S. Geological Survey data release https://doi.org/10.5066/P9UNY0FR

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

Final datasets and metadata for GWA 2019 were uploaded to the data portal by November 2020 (https://portal.aoos.org/gulf-of-alaska#metadata/3ca497e2-3421-4fa4-a550-f4d397a73c07/project/folder_metadata/2638365). These include:

- Echointegration data from acoustic transects. Acoustic data were obtained from a split beam dual frequency hydroacoustic system (Simrad® EK60) operating at 38 (12° beam width) and 120 (7° beam width) kHz frequencies. Tranducers were calibrated at the start of each survey.
- Fish catch and morphological data from various net sampling methods including aluette trawl, cast net, dip net, jig, and gill net.
- Zooplankton biomass. Samples were collected with a 150 micron mesh 0.25 m diameter paired ring net on a 50 m. vertical haul during daylight hours.
- CTD profiles. Oceanographic conditions were sampled with a Seabird Electronics SBE19Plus v2 CTD equipped with various sensors (e.g., oxygen, pH, fluorescence, turbidity, beam transmission and photosynthetically active irradiance).
- Inorganic nutrient concentration, including phosphate, nitrate, nitrite and silicic acid.
- Middleton Island seabird diets, including sample information (date, seabird species, sample mass, prey species) and prey item measurements.

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (FY21): In general, the Science Panel supports the request to repurpose unspent FY20 funds for a graduate student or postdoc and equipment replacement. The SP appreciates the PI's detailed response to the Science Director's questions. What is the contingency plan for any FY21 unspent funds due to pandemic related restrictions?

GWA PI Response (FY21): As in 2020, we will make efforts to conduct as much of the work as possible. This may include contracting Cordova locals whenever possible to help with fish sample collections and aerial survey validation and implementing the large-vessel COVID-19 safety plan to conduct vessel-based surveys. The specific measures we take will depend on state and federal guidance at the time. If we are unable to conduct field work we anticipate using FY21 funds that would have paid for fieldwork on continued analysis and write-up of the data in hand. If necessary, we will request to roll over unspent FY21 funds into FY22 to complete these activities (pending approval).

Science Panel Comment (FY21): I support the redirection of unspent funds in FY20 to FY21 but would like to see a detailed description of the responsibilities of the graduate student or postdoc and what remaining synthesis activities need to be accomplished for FY21. Also, is maintenance and update of trawl gear regularly scheduled and normally funded by USGS?

GWA PI Response (FY21): We propose to redirect FY20 spending that would have occurred for field work to 1) maintenance and update of trawl gear for 13.5K, and 2) funding to support a student or post-doc with training in acoustic data analysis to help accomplish GWA forage fish project goals and synthesis for 54.5K. If approved, these expenditures in FY20 would balance out such that there are no changes to our originally proposed project total budget.

The trawl gear is central to the forage fish project as trawl sampling is required to ground-truth species composition and fish size for scaling the acoustic data to biomass. The modified herring trawl net and hardware we use for this application were purchased with funds from EVOSTC in 1995 during the APEX project. This gear needs to be replaced because it's worn and rusty from years of use, and some parts of the net, hardware, and gear that we use to move and install the trawl are failing. There are no USGS maintenance or base funds to support this kind of gear replacement, and equipment replacements such as this are usually purchased with project-specific funds.

Funding to support a student or post-doc in FY21 will be used to help process and analyze acoustic data that will help us meet our project objectives. These specific objectives include the following:

1. Estimate an index of forage fish availability in seasonally predictable predator foraging areas, including species composition and biomass within persistent predator foraging areas and density and depth distribution using acoustic-trawl data collected during the Integrated Predator Prey surveys.
2. Estimate an index of euphausiid availability in seasonally predictable predator foraging areas, including species composition and biomass within persistent predator foraging areas and density and depth distribution using acoustic – trawl data collected during the Integrated Predator Prey surveys.
3. Assess changes in forage fish abundance indices on acoustic-trawl surveys during summer.
4. Relate whale, marine bird, and forage fish indices to marine habitat, including oceanographic metrics and zooplankton biomass.
5. Relate marine bird and humpback whale presence to prey fields identified during acoustic surveys, including spatial coherence of bird and whale presence/absence, acoustic estimates of forage fish and euphausiid biomass.

We anticipate this student will focus on analyses of the acoustic data, particularly with respect to schools metrics and apportionment of acoustic backscatter indices to species and size frequencies. These analyses will directly address objectives 1-3 and contribute to analyses for objectives 4-5.

Science Panel Comment (FY20): The Science Panel appreciates the PIs response to last year's comments. The panel noted that seabird diets show an increase in the relative abundance of herring in seabird diets, whereas HRM projects are not seeing an increase in herring. This is something that is worth investigating together with the HRM projects. Please include this comparison and potential interpretations of its causes in your FY19 annual report. This sort of comparison should also be included in the science synthesis paper. There are many possible explanations, but they point to the likelihood that bird diets may not provide useful proxies for fish abundance.

GWA PI Response (FY20): We appreciate this suggestion from the science panel and we plan to address the issue in greater detail in our FY19 annual report. There are several reasons the Middleton seabird diets do not reflect the findings of the Herring Research and Monitoring program spring spawning stock biomass trends for Prince William Sound, including the following: 1) herring are not a primary prey species as they contribute a relatively small proportion (< 3% of prey biomass across years) of seabird diets sampled at Middleton; 2) more than 75% of the herring in rhinoceros auklet chick diets between 1993-2018 were juvenile herring (i.e., a mix of age-0 and age-1, < 10 cm in length), in recent years (especially 2013 and 2017) larger size classes of herring were represented in Middleton seabird diets; and 3) tagging studies indicate that shorter foraging trips are less costly, however, when preferred species are less available offshore Middleton Island seabirds can increase foraging range to include coastal mainland areas where juvenile herring occur.

Science Panel Comment (FY20): Minor question: regarding Figure 1 (page 3), on the top panel, what species do the clear bars at the top represent? This is missing from the figure legend.

GWA PI Response (FY20): The clear bars represent "other". Thank you for pointing this out, we will correct the legend in future use of this figure.

11. Budget:

Please see provided program workbook. Current expenditures of some line items exceed ± 10% deviation from the originally proposed amount in cases where 2020 field work had to be canceled due to COVID-19, where reporting accounts lagged behind actual expenses, inconsistencies between federal and *Exxon Valdez* Oil Spill Trustee Council fiscal year start dates, and because USGS budget system categories differ from those shown on the *Exxon Valdez* Oil Spill Trustee Council proposal. All expenditures are within keeping to our planned budget. These costs will even out over time, and we expect to spend the total proposed budget amount by the end of the project.

Due to the COVID-19 pandemic we were unable to conduct much of our planned sampling in 2020, including USGS-led efforts to validate June HRM aerial surveys, and the summer and fall acoustic – trawl surveys in PWS. In lieu of contracts to process zooplankton and nutrients samples we proposed to collect in 2020, we contracted Rob Campbell at the PWSSC to provide local support for aerial survey validation efforts and for forage fish sample collections.

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

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$122.0	$127.7	$159.5	$185.3	$170.6	$765.1	$511.4
Travel	$8.6	$7.3	$11.6	$7.3	$10.3	$45.0	$35.0
Contractual	$47.5	$47.5	$53.5	$53.5	$53.5	$255.5	$296.1
Commodities	$0.0	$0.0	$32.0	$0.0	$32.0	$64.0	$27.0
Equipment	$4.3	$28.4	$11.4	$24.9	$11.4	$80.4	$60.5
SUBTOTAL	$182.4	$210.8	$268.0	$271.0	$277.8	$1,210.0	$930.0
General Administration (9% of subtotal)	$16.4	$19.0	$24.1	$24.4	$25.0	$108.9	N/A
PROJECT TOTAL	$198.8	$229.8	$292.1	$295.4	$302.8	$1,318.9	
Other Resources (Cost Share Funds)	$256.0	$256.0	$256.0	$517.2	$517.2	$1,802.4	

LITERATURE CITED

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. https://doi.org/10.1111/gcb.15556

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.

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. W., E. D. Goldstein, M. L. Arimitsu, A. L. Deary, O. Ormseth, A. De Robertis, J. K. Horne, L. A. Rogers, T. Matthew, K. O. Coyle, K. Holderied, J. F. Piatt, W. T. Stockhausen, and S. G. Zador. 2020. Spatial and temporal dynamics of Pacific capelin Mallotus catervarius in the Gulf of Alaska: implications for ecosystem-based fisheries management. Marine Ecology Progress Series 637:117–140.

Sigler, M. F., T. L. Rutecki, D. L. Courtney, J. F. Karinen, and M.-S. Yang. 2001. Young of the year sablefish abundance, growth, and diet in the Gulf of Alaska. Alaska Fishery Research Bulletin 8:57–70.