

1. Program Number:

18120114-E

2. Project Title:

Long-term Monitoring of Marine Bird Abundance and Habitat Associations during Fall and Winter in Prince William Sound

3. Principal Investigator(s) Names:

Mary Anne Bishop, Ph.D., Prince William Sound Science Center

Report prepared by: Anne Schaefer, Prince William Sound Science Center

4. Time Period Covered by the Report:

February 1, 2018-January 31, 2019

5. Date of Report:

April 1, 2019

6. Project Website (if applicable):

www.gulfwatchalaska.org

<http://pwssc.org/seabirds>

<http://pwssc.org/monitoring-marine-birds/>

7. Summary of Work Performed:

This project uses vessels of opportunity to monitor marine birds in Prince William Sound (PWS), Alaska during fall and winter (September through March). These time periods are critical for survival as food tends to be relatively scarce or inaccessible, the climate more extreme, light levels and day length reduced, and water temperatures cooler. By monitoring marine birds during fall and winter, we will improve our predictive models of species abundance and distribution across PWS in relation to biological and physical environmental factors. Furthermore, continued monitoring will help determine marine bird vulnerability to environmental change and future perturbations, including oil spills.

The specific objectives of this study are to:

1. Characterize the spatial and temporal distribution of marine birds in PWS during fall and winter.
2. Estimate marine bird abundance and distribution in areas with known seasonally predictable aggregations of predators and prey.
 - a. relate marine bird presence to prey fields identified during concurrent hydroacoustic surveys.

- b. characterize marine bird-humpback whale foraging dynamics.
3. Model species abundance in relation to physical and biological variables across time and space.

In FY18, all cruises were completed as expected and there were no changes to the project. In this FY18 report, we summarize 2018 field work and provide preliminary results addressing objectives 1 and 2. Objective 3 will be addressed as more data become available.

2018 Field Work and Preliminary Analyses

During FY18 (1 February 2018 – 31 January 2019), one observer (Anne Schaefer) with the Prince William Sound Science Center (PWSSC) performed four marine bird surveys in PWS covering a total of 1,448 km (Fig. 1, Table 1). In September 2018, we conducted marine bird surveys as part of the Gulf Watch Alaska Integrated Predator-Prey (IPP) Survey (National Oceanic and Atmospheric Administration [NOAA]/U.S. Geological Survey [USGS]/PWSSC). The multi-project effort also surveyed humpback whales and forage fish (including euphausiids).

Ships of opportunity used for additional FY18 marine bird surveys included vessels surveying spot shrimp (Alaska Department of Fish and Game [ADF&G]) and juvenile walleye pollock (NOAA). We also surveyed marine birds concurrently with the annual maintenance cruise for the Ocean Tracking Network (OTN) acoustic arrays stationed across the major entrances and southwest passages of PWS and serviced by the PWSSC.

For each 3 km segment of surveyed trackline, we calculated bird density (birds/km²) across two habitat types (bays & passages and open waters) for all marine birds (Fig. 2) and for three target species (Fig. 3) and compared these densities with the long-term monthly average. Overall, marine bird densities for FY18 were below the long-term mean. Marine bird densities in open water remain relatively stable throughout the winter, while densities in bays and passages increase from fall to late-winter (Figs. 2 and 3).

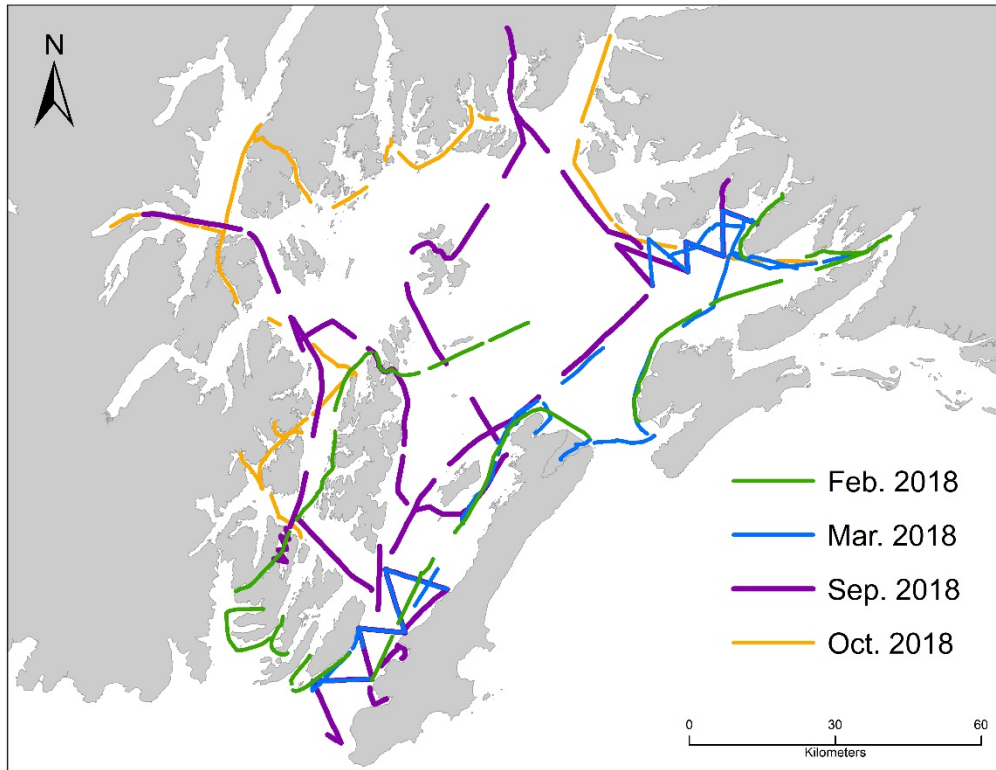


Figure 1. Spatial coverage of the four marine bird surveys completed in Prince William Sound, Alaska during FY18.

Table 1. Fall through winter marine bird surveys, FY18.

Cruise	Km surveyed	Observer	FY18 Cruise Dates
PWSSC OTN Maintenance	301	A. Schaefer	Feb 7-12, 2018
NOAA Pollock	320	A. Schaefer	Mar 10-15, 2018
NOAA, USGS, PWSSC Gulf Watch Alaska IPP	550	A. Schaefer	Sep 11-18, 2018
ADF&G Shrimp	277	A. Schaefer	Oct 13-24, 2018

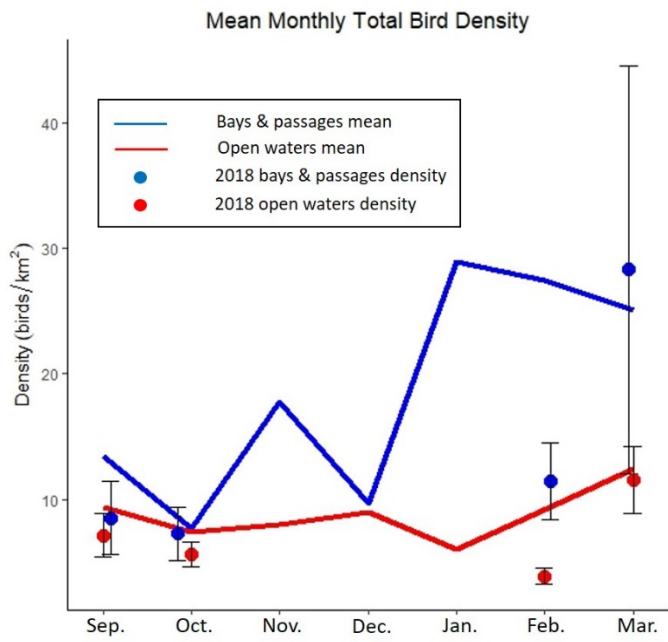


Figure 2. Long-term marine bird densities for each month by habitat type overlaid with the density estimates (and standard errors) from surveys completed in FY18.

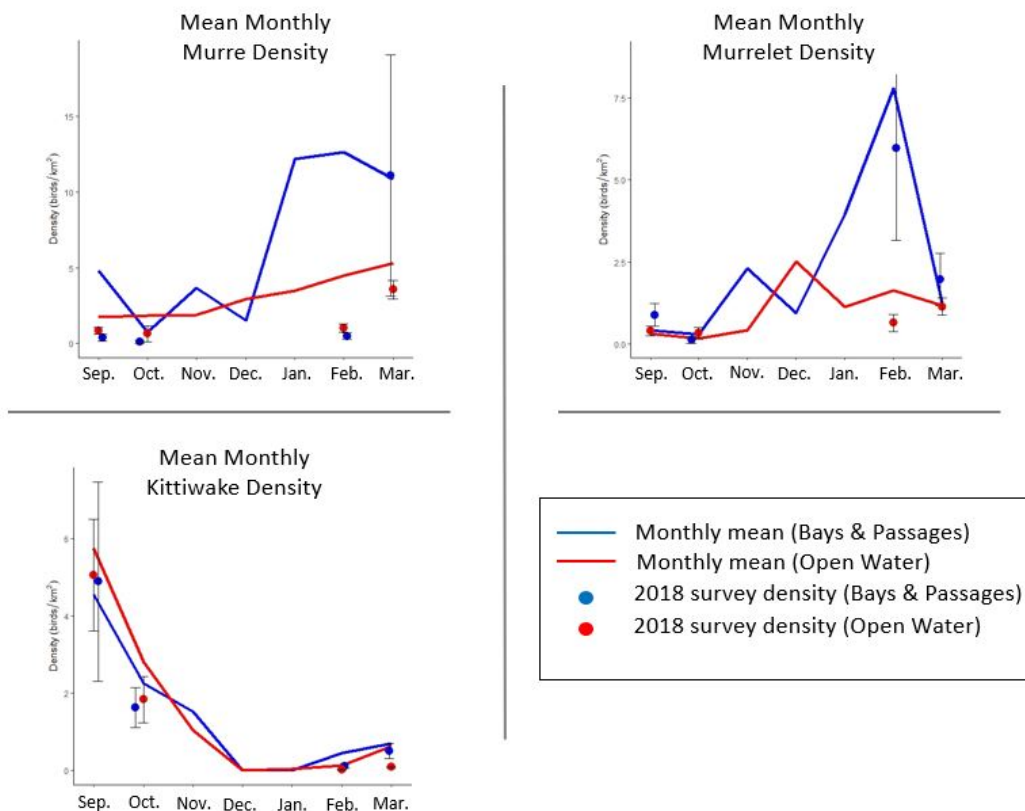


Figure 3. Long-term mean densities for murres, murrelets, and kittiwakes by habitat, overlaid with the density estimates (and standard errors) from surveys completed in FY18.

Patterns in marine bird density

We have recently examined the use of ecosystem indicators to understand the influence of environmental variability on marine bird populations in PWS. Our previous modeling efforts found that murres and murrelets demonstrate relatively consistent temporal patterns in PWS within winter; murres tend to be present in low densities during fall and high densities during spring, whereas murrelets tend to occur in low densities in early fall increasing to higher densities in late fall, and then occur in low densities during spring (Dawson et al. 2015, Stocking et al. 2018).

We examined anomalies in murre and murrelet densities over time as potential ecosystem indicators because, as piscivorous seabirds, murres and murrelets are particularly sensitive to changes in the marine ecosystem. Both murre and murrelet densities appear to be highly variable within months and across winters (Fig. 4). For murres, our surveys detected changes in densities and distribution in PWS during the months leading up to a prolonged die-off event that occurred along the Gulf of Alaska beginning during the winter of 2014-15 and ending in the spring of 2016. Our surveys recorded anomalously high densities in February 2015 (immediately preceding the onset of the die-off) and fall 2015 (immediately prior to the peak December 2015 die-off). This increased use of PWS by murres during the winter coincided with persistently high ocean temperatures in the Northeast Pacific Ocean beginning during the winter of 2013-14 and was strongest (with regional variability) through 2016 in

the northeast Pacific (Di Lorenzo and Mantua 2016), with positive temperature anomalies continuing through 2017 and 2018 in PWS (PI Campbell 18120114-G). Since the die-off, we have observed murre densities below the long-term monthly averages during fall 2016-2018 surveys and spring 2018 surveys (Fig. 4). Murrelet densities followed a similar pattern as murrees and were also below long-term monthly averages for fall 2016-2018 and spring 2018 (Fig. 4).

Gulf Watch Alaska Integrated Predator-Prey Survey

In September 2018, we conducted marine bird surveys as part of the Gulf Watch Alaska IPP Survey (NOAA/USGS/PWSSC). The multi-project effort also surveyed humpback whales and forage fish (including euphausiids). These integrated surveys allow us to estimate forage biomass at the same locations in which marine birds and humpback whales are feeding, thereby providing comparable information on both predator density and prey availability. Results from the FY18 survey are summarized below:

Hydroacoustic/Marine Bird Transects: During the IPP surveys, marine bird observations are recorded concurrent with hydroacoustic fish and krill surveys along fixed transect lines. These transects were designed to sample areas of historic humpback whale feeding locations in Montague Strait, Bainbridge Passage, and Port Gravina. In September, bird observations were conducted simultaneously with hydroacoustic surveys over 146.8 km of effort. Observations from these surveys (in addition to observations recorded while transiting between sampling locations) are included Figs. 2, 3, and 4.

In September 2018, marine bird densities on both the acoustic transects as well as the in-transit transects were lower than densities observed in our two previous predator-prey surveys (2014 and 2017; Fig. 5), mirroring patterns observed in macrozooplankton density indices (Fig. 6).

Forage Flock/Humpback Whale Foraging Dynamics: When a forage flock is encountered during surveys, the marine bird observer records if there are any marine mammals associated with the flock (within 150 m of flock), the time and position of the encounter, species composition, and number of individuals per species in the forage flock. During the September cruise, 11 foraging flocks were recorded, with 2 forage flock-whale interactions (Fig. 7). In both instances, the whale emerged through a forming forage flock, after which the flock quickly dispersed. One forage flock consisted of 30 gulls, 6 horned puffins, 2 bald eagles, and 1 double-crested cormorant, while the other consisted of 30 black-legged kittiwakes. In 2017, only 5 foraging flocks were recorded during surveys with one forage flock-whale interaction (Fig. 7). Again, the whale surfaced in the middle of a forming forage flock (42 black-legged kittiwakes and 4 marbled murrelets), after which the group of birds quickly dispersed. Interestingly, forage flocks were only recorded on the eastern side of Montague Strait and at the mouth of Port Gravina in both 2017 and 2018. The eastern side of Montague Strait was also the only area in Montague Strait where herring were observed in 2018 (Fig. 6). This suggests potential competitive interactions between humpback whales and foraging birds for the few herring schools available during the recent years of very low herring biomass in PWS.

Focal follows of individual whales are conducted opportunistically, during which hydroacoustic surveys for fish and zooplankton occur simultaneously. During focal follows, the marine bird observer goes off formal survey effort and only records encounters between the focal whales and marine bird aggregations. During the September 2018 survey, we conducted seven focal follows for ~9 hours. No forage flock-whale interactions were observed during focal follows.

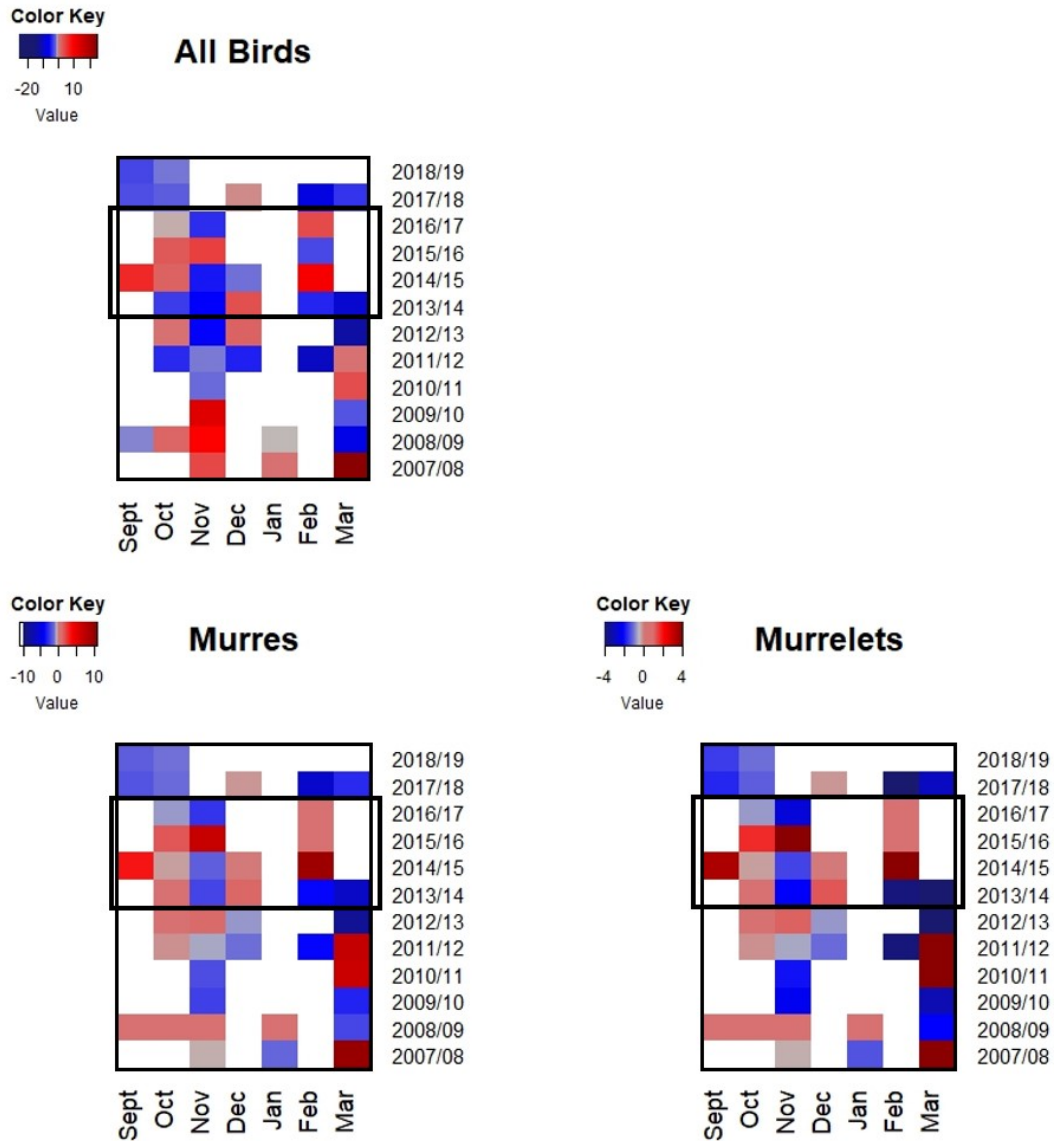


Figure 4. Monthly density anomalies for all marine birds, murres, and murrelets observed during fall and winter bird surveys in PWS, 2007-2018. A marine heatwave event occurred throughout the Northeast Pacific Ocean beginning in the winter of 2013/14 and was strongest (with regional variability) through 2017 (indicated by black box). However, positive temperature anomalies still persisted through 2018 in the Gulf of Alaska, including coastal regions (PI Danielson, project 18120114-I) and PWS (PI Campbell, project 18120114-G)

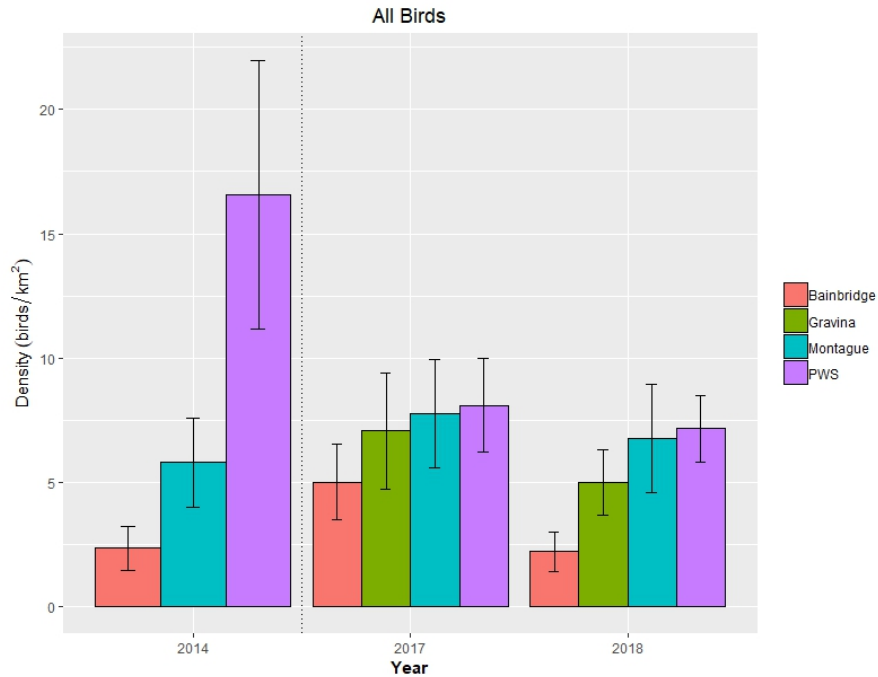


Figure 5. September marine bird densities in 2018 on acoustic transects and overall in PWS were lower than densities observed in 2017 and 2014. The 2014 survey was a pilot and coverage in Montague Strait was less than subsequent surveys.

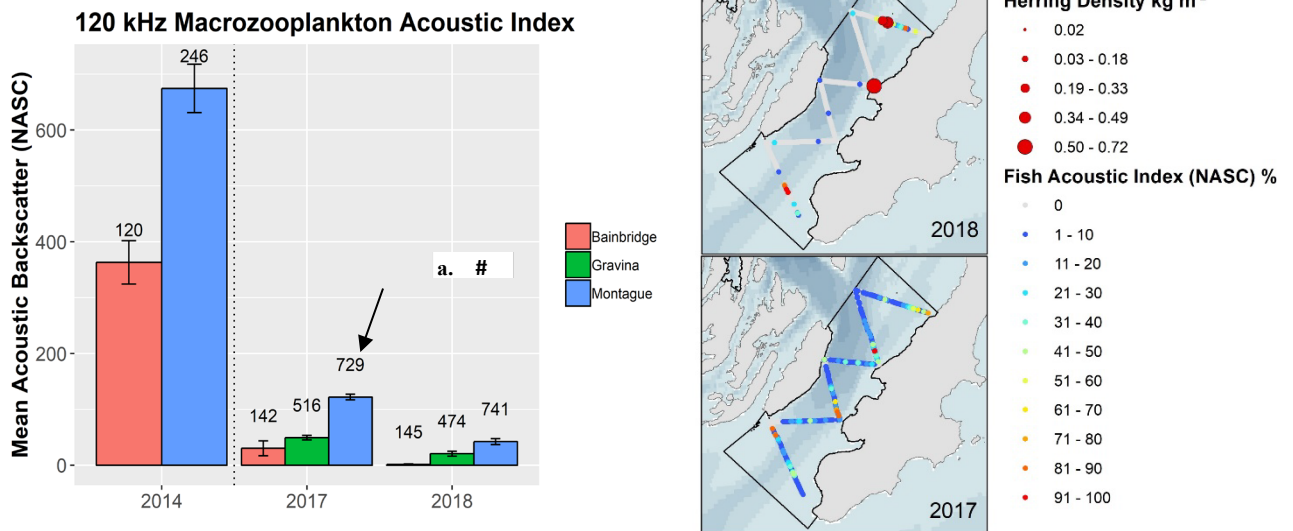


Figure 6. Macrozooplankton (e.g., krill, amphipod, mysiid) density indices and forage fish densities recorded during September IPP surveys, PWS. The 2014 survey was a pilot year and coverage in Montague Strait was less than subsequent surveys. Figures provided by M. Arimitsu (project 18120114-C).

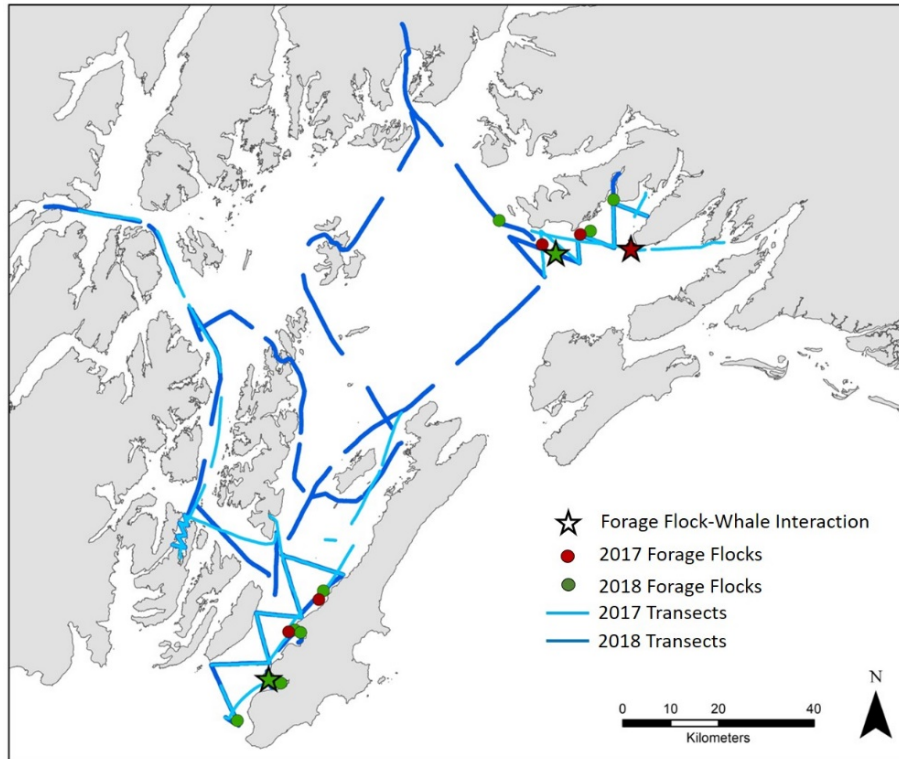


Figure 7. Forage flocks (circles) and forage flock-whale interactions (stars) recorded during the September 2017 (red) and 2018 (green) Integrated Predator-Prey Surveys, PWS.

Future work

In 2019, marine bird surveys will be conducted in March (marine bird survey, PWSSC), September (Gulf Watch Alaska IPP Survey, NOAA/USGS/PWSSC), and November (marine bird survey, PWSSC). From 2007-2016 our surveys included sampling in a series of PWS bays in March and November in collaboration with the Herring Research and Monitoring Juvenile Herring Nursery Bay Project (18120111-F). Since the termination of this project, most marine bird survey efforts have occurred in open water and passages of PWS. However, our research has shown that compared to open waters, marine birds are more likely to be present and in larger aggregations in the protected bays of PWS during winter (Figs. 2 and 3). In FY19, thanks to additional funding, dedicated marine bird surveys in these months will allow us to extend our long-term, consistent dataset within bays of PWS and continue identifying shifts in the winter marine bird community of PWS, as well as their potential impact on juvenile herring. Our plan is to conduct our surveys using the PWSSC's vessel, the RV New Wave, in conjunction with Dr. Rob Campbell's Monitoring of Oceanographic Conditions in Prince William Sound (project 18120114-G).

We are continuing our work to evaluate associations between Pacific herring (*Clupea pallasii*) and marine birds during winter. Pacific herring was identified as a resource injured by the 1989 *Exxon Valdez* oil spill. Concurrent with the decline in Pacific herring abundance, several marine birds wintering in PWS have demonstrated a reduced capacity to recover post-oil spill, which could be related to reduced forage fish availability. Despite the dynamic association between marine birds and

forage fish, few studies have addressed marine bird-herring relationships during winter months and the potential for effects on population recovery. For this study we are using marine bird observation data collected concurrently with hydroacoustic herring surveys in PWS during November and March cruises (2008-2012). Analysis of these data will allow us to characterize the abundance of marine bird predators in relation to prey abundance and distribution and to understand habitat and fish school characteristics that influence marine presence and abundance in PWS. Our findings will be submitted to a peer-reviewed journal in FY19.

8. Coordination/Collaboration:

A. Projects Within a Trustee Council-funded program

1. Within the Program

This project is a component of the integrated Gulf Watch Alaska-Long-term Monitoring of Marine Conditions and Injured Resources and Services. This long-term monitoring program is composed of three ecosystem components (Environmental Drivers, Pelagic, and Nearshore) with a series of projects in each component led by principal investigators from several institutions.

The fall and winter marine bird project is headed by Dr. Mary Anne Bishop, and is part of the Pelagic monitoring component. This project shares research vessels associated with the IPP surveys in September. Marine bird observations from this project are integrated into the humpback whale surveys (PIs Moran/Straley, project 18120114-O) and forage fish surveys (PI Arimitsu, project 18120114-C). This collaboration affords efficiencies in field work, as well as facilitates greater understanding of predator-prey interactions in the Sound. Beginning in March 2019, we will also share a vessel with the PWS oceanographic monitoring project (PI Campbell, 18120114-G) for our November and March marine bird surveys.

Our program also complements the pelagic component's PWS Marine Bird Summer surveys conducted every two years by the U.S. Fish and Wildlife Service (USFWS) (PI Kaler, project 18120114-M) and allows for regional comparisons of marine bird densities and environmental drivers with Seward Line/Gulf of Alaska (PI Kuletz, project 18120114-L) and Kachemak Bay/Lower Cook Inlet (PI Holderied, project 18120114-J), and nearshore surveys in PWS, Kenai Fjords, Kachemak Bay, and Katmai (PI Coletti, project 18120114-H).

2. Across Programs

a. Herring Research and Monitoring

As currently designed for FY17-21, the fall/winter marine bird project will not be conducting marine bird surveys onboard any PWS Herring Research and Monitoring Program cruises because none are scheduled during the fall and winter months. However, our data will complement the suite of data collected by this program, including insertion of key predator data into the population modeling of herring. As part of the integrated predator-prey surveys we will collect forage fish for PI Kristin Gorman's Herring Age at Maturity project (project 18170111-D).

b. Data Management

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the timeframes required.

c. Lingering Oil

N/A

B. Projects not Within a Trustee Council-funded program

This project will coordinate with other *Exxon Valdez* Oil Spill Trustee Council-funded projects as appropriate by providing data, discussing the relevance and interpretation of data, and collaborating on reports and publications. Of particular note, this project may share data and relevant information with the Pigeon Guillemot restoration project on the Naked Island Complex (PIs Kuletz, Irons, Kaler, project 1910853).

C. With Trustee or Management Agencies

This long-term marine bird monitoring project uses as observing platforms vessels associated with other agencies. We have arrangements with the following agencies and organizations to place a marine bird observer onboard during these regularly scheduled annual surveys:

Alaska Department of Fish and Game: Jan Rumble. ADF&G provides a berth for a marine bird observer during the October spot shrimp surveys. Beginning in 2019, we will not place an observer onboard as we will be instituting our annual, dedicated November marine bird cruise supported by newly awarded FY19-21 EVOSTC funds.

Alaska Ocean Observing System/Prince William Sound Science Center: Mary Anne Bishop. PWSSC provides a berth for a marine bird observer during the February cruise to upload data from and conduct maintenance on the Ocean Tracking Network arrays. Funding for this annual cruise is provided by the Alaska Ocean Observing System. Beginning in 2019, we will not place an observer onboard as we will be instituting our annual, dedicated March marine bird cruise.

National Oceanic and Atmospheric Administration: PI Ron Heintz. NOAA provided a berth for a marine bird observer during the March 2018 juvenile pollock survey. There are no longer funds for this survey. Beginning March 2019, we will have a dedicated vessel supported by newly awarded FY19-21 EVOSTC funds for our March marine bird surveys.

Finally, information from this project will feed into the *North Pacific Pelagic Seabird Database*, a database that is maintained by USFWS and USGS.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

Bishop, M. A. 2018. Long-term monitoring of seabird abundance and habitat associations during late fall and winter in Prince William Sound. *Exxon Valdez* Oil Spill Long-Term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 16120114-C), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Bishop, M. A., and A. Schaefer. 2018. Long term monitoring of marine bird abundance and habitat associations during fall and winter in Prince William Sound. FY17 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 17120114-M.

Schaefer, A., M.A. Bishop, and R. Thorne. *In prep.* Piscivorous seabird response to forage fish biomass in Prince William Sound, Alaska.

Stocking, J. S., M. A. Bishop, and A. Arab. 2018. Spatio-temporal distributions of piscivorous birds in a subarctic sound during the nonbreeding season. *Deep-Sea Research II* 147:138–147. doi: 10.1016/j.dsr2.2017.07.017.

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

Conference Presentations

Cancelled due to government shutdown: Arimitsu, M., M. A. Bishop, D. Cushing, S. Hatch, B. Heflin, R. Kaler, K. Kuletz, C. Matkin, J. Moran, D. Olsen, J. Piatt, A. Schaefer, and J. Straley. 2019. Still awaiting ecosystem recovery following the North Pacific Heat Wave: Gulf Watch Alaska Pelagic Monitoring Update 2018. Poster presented at Alaska Marine Science Symposium, January 2019, Anchorage, AK.

Outreach

Schaefer, A. 2018. A winter refuge for seabirds. *Delta Sound Connections* 2018-2019. Prince William Sound Science Center.

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

NA

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

“PWS Fall and Winter 2017-2018 seabird observations.csv”: uploaded and published to data portal

“PWS Fall and Winter 2018-2019 seabird observations.csv”: uploaded to data portal and updated after each cruise; will be published summer 2019.

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (EVOSTC FY18 Work Plan): This proposal was very well presented and seems very reasonable. The Panel was pleased to see that the PI incorporated previous suggestions into the proposal. The Panel commends the PI’s effort to integrate seabirds and mammals in her work on herring.

Regarding a statement on pg. 66 of this proposal: “As currently designed for FY17-21, the fall/winter marine bird project will not be working directly with the PWS Herring Research and Monitoring Program.” The Panel would like clarification on what is meant here. The Panel recommends coordinating and collaborating to the extent reasonable.

PI Response, FY18 Workplan: Thank you for the opportunity to clarify our coordination and collaboration with the HRM program. In past years, we have placed a marine bird observer onboard

HRM project cruises. The HRM program has no scheduled cruises between September 2018 and March 2019. Thus, we are not able to collaborate directly with HRM during FY18. However, this project will share data with the HRM program, and we will explore possibilities for joint publications.

11. Budget:

Please see provided program workbook.

Personnel for this project was underspent in FY18 as the avian research assistant took a 2-month leave of absence.

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	\$80.8	\$83.2	\$86.0	\$88.7	\$91.5	\$430.1	\$138.9
Travel	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$1.4
Contractual	\$1.7	\$1.7	\$25.7	\$25.7	\$25.7	\$80.5	\$4.7
Commodities	\$0.2	\$0.2	\$0.1	\$0.1	\$0.1	\$0.7	\$0.6
Equipment	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
Indirect Costs (<i>waived</i>)							
SUBTOTAL	\$82.7	\$85.1	\$111.8	\$114.5	\$117.3	\$511.3	\$145.6
General Administration (9% of	\$7.4	\$7.7	\$10.1	\$10.3	\$10.6	\$46.0	N/A
PROJECT TOTAL	\$90.1	\$92.7	\$121.9	\$124.8	\$127.9	\$557.3	
Other Resources (Cost Share Funds)	\$53.0	\$53.0	\$53.0	\$53.0	\$53.0	\$265.0	

Literature Cited

Dawson, N., M.A. Bishop, K. Kuletz and A. Zuur. 2015. Using ships of opportunity to assess winter habitat associations of seabirds in subarctic coastal Alaska. *Northwest Science* 89:111–128.

Di Lorenzo, E. and N. Mantua. 2016. Multi-year persistence of the 2014/15 North Pacific marine heatwave. *Nature Climate Change* 6:1042–1047.

Stocking, J., M. A. Bishop, and A. Arab. 2018. Spatio-temporal distributions of piscivorous birds in a subarctic sound during the non-breeding season. *Deep-Sea Research Part II* 147:138–147.

USFWS. 2007. North Pacific pelagic seabird observer program observer’s manual, inshore/small vessel version, November 2007. U.S. Fish and Wildlife Service, Migratory Bird Management Nongame Program, Anchorage, Alaska. Unpublished protocol manual, 25 pp.