

**EVOSTC FY17-FY21 INVITATION FOR PROPOSALS  
FY20 (YEAR 9) CONTINUING PROJECT PROPOSAL SUMMARY PAGE**

**Project Number and Title**

Gulf Watch Alaska: Pelagic Component Project

**20120114-E**—Long-term Monitoring of Marine Bird Abundance and Habitat Associations during Fall and Winter in Prince William Sound

**Primary Investigator(s) and Affiliation(s)**

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

**Date Proposal Submitted**

August 16, 2019

**Project Abstract**

The fall-winter marine bird surveys in Prince William Sound (PWS) will continue to build upon a 12-year time series (2007-2019) of marine bird abundance and habitat associations. Surveys occur onboard research vessels conducting oceanographic, fisheries, or marine mammal surveys, thereby increasing opportunities for cross-project collaboration and reducing project costs. Our September surveys are integrated with Gulf Watch Alaska (GWA) pelagic component's forage fish assessments of prey availability (20120114-C) and humpback whale monitoring (2020114-O) with all three projects sharing logistics, timing, and location of sampling. 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. Our November and March surveys are in conjunction with the GWA project monitoring of oceanographic conditions in PWS (2020114-G) and enable us to extend our long-term dataset of marine bird observations within juvenile herring bays of PWS that previously relied on fishery survey vessels that are no longer funded. For all surveys we use established protocols employed by all other GWA marine bird survey efforts (Kachemak Bay/Cook Inlet, Seward Line/Gulf of Alaska, PWS summer).

Of the marine birds that overwinter in PWS nine species were initially injured by the *Exxon Valdez* oil spill, including three species that have not yet recovered or have unknown recovery status. Fall and winter are critical periods for survival as food tends to be relatively scarce or inaccessible, day length reduced, and water temperatures colder. 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. Our long-term monitoring has shown that the nonbreeding season cannot be characterized as a single time period when describing marine bird distribution and suggests that multiple surveys are required to quantify wintering populations and understand changes in distribution. We are not proposing changes to this project.

**EVOSTC Funding Requested\* (must include 9% GA)**

FY17	FY18	FY19	FY20	FY21	TOTAL
\$90,100	\$92,700	\$121,900	\$124,800	\$127,900	\$557,300

**Non-EVOSTC Funds to be used, please include source and amount per source: (see Section 6C for details)**

FY17	FY18	FY19	FY20	FY21	TOTAL
\$53,000	\$53,000	\$0	\$0	\$0	\$106,000

## 1. PROJECT EXECUTIVE SUMMARY

### *Pelagic Component*

The pelagic component research team proposed for FY17-21 to continue monitoring key pelagic species groups in Prince William Sound (PWS) using the same five projects focused on killer whales (20120114-N), humpback whales (20120114-O), forage fish (19120114-C), and marine birds (20120114-E, 20120114-M). Thus, the two over-arching questions for the pelagic component to answer during this 5-year period are:

1. What are the population trends of key upper trophic level pelagic species groups in PWS – killer whales, humpback whales, marine birds, and forage fish?
2. How do predator-prey interactions, including interannual changes in prey availability, contribute to underlying changes in the populations of pelagic predators in PWS and Middleton Island?

### *Fall-Winter Marine Bird Monitoring*

During the current 5-year period (2017-2021), our project will: a) continue to conduct systematic surveys to document the fall-winter abundance and distribution of marine birds in PWS, with 3 surveys identified for FY20; and, b) investigate trophic linkages in areas with high marine bird concentrations by expanding and integrating our efforts with two other projects in the pelagic component - the forage fish and humpback whale projects. Predator-prey surveys that combine the marine bird, humpback whale, and forage fish (including euphausiids) projects will be conducted each fall (September). Using two vessel platforms (one for acoustic and forage fish trawls and marine bird surveys, and a second for humpback whale sampling), concurrent surveys will provide quantitative measures of the density and distribution of marine bird and humpback whale predators relative to forage fish availability and will facilitate an integrated analysis of how predator communities respond to changes in prey availability (quantity, distribution, and quality).

Furthermore, our marine bird study will gather data to improve our ability to monitor status and trends of marine bird populations during fall and winter. Additionally, this research will address the following hypotheses:

1. Marine bird distribution and abundance varies with physical and biological habitat characteristics within the fall/winter season.
2. Marine bird distribution and abundance varies with prey availability (quantity and/or quality).
  - a. Marine bird forage flocks signal the presence of prey aggregation to humpback whales.

To address the first hypothesis, our project is conducting marine bird surveys throughout PWS in September, November, and March. September surveys will be conducted during the Integrated Predator-Prey (IPP) survey. November and March surveys will be conducted using a dedicated charter vessel. The second hypothesis will be addressed during marine bird surveys conducted as part of the Pelagic Component's IPP Surveys. Marine bird observations will be recorded aboard the acoustic-trawl vessel and observations will include fish schools when bird and mammal predators are both present and absent. There are no major changes to sampling expected for this project in FY20.

### *Background*

Of the marine birds that overwinter in PWS, nine species were initially injured by the *Exxon Valdez* Oil Spill (EVOS). As of 2014, two species that overwinter in PWS have not yet recovered (marbled murrelet and pigeon guillemot) and a third species, Kittlitz's murrelet, has an unknown recovery status (EVOSTC 2014). Most of the marine bird monitoring in areas affected by EVOS has occurred around breeding colonies during the

reproductive season when food is generally at its most plentiful. Long-term monitoring of marine birds in PWS during fall and winter is needed to understand how post-spill ecosystem recovery and changing physical and biological factors are affecting marine bird abundance and species composition, as well as marine bird distribution and habitat use.

Systematic fall and winter marine bird surveys began in 2007 under the direction of co-principal investigators (PIs) Bishop and Kuletz. In 2012 this research project became part of the Gulf Watch Alaska (GWA) Pelagic Component under the direction of PI Bishop. Over the past 12 winters (2007/08 - 2018/19) a total of 47 marine bird surveys, typically 6-9 days in duration, have been conducted across PWS following established U.S. Fish and Wildlife Service (USFWS) survey protocols adapted for GPS-integrated data entry (USFWS 2007). Observers are typically placed on “ships of opportunity” that include research vessels already conducting oceanographic, fisheries, or marine mammal surveys, thereby enabling integration of data across projects. Collaborators have included the EVOS Trustee Council (EVOSTC) funded GWA Pelagic- Humpback Whale and Forage Fish projects (ongoing), GWA Oceanographic Conditions in PWS (since 2019), Herring and Research Monitoring (HRM) program juvenile herring hydroacoustic surveys (2007-2016), as well as Alaska Department of Fish and Game (ADF&G) spot shrimp surveys (2013-2018), PWS Science Center (PWSSC) Ocean Tracking Network (OTN) maintenance cruises (2014-2018), and National Oceanic and Atmospheric Administration (NOAA) pollock cruises (2017-2018).

From 2007-2016, our surveys included sampling in a series of bays in collaboration with the HRM program’s Juvenile Herring Nursery Bay Project (16120111-F). Since the termination of this project, most marine bird survey efforts have occurred in open water and within passages of PWS. However, our research has shown that compared to open waters, marine birds are more likely to be present and in greater abundance in protected bays during winter.

Thanks to additional EVOSTC funding, in FY19 we began conducting dedicated marine bird surveys in juvenile herring bays of PWS during March and November. These surveys are enabling us to extend our long-term, consistent dataset and continue identifying shifts in the winter marine bird community of PWS, as well as the potential impact on juvenile herring. These dedicated marine bird surveys are conducted using PWSSC’s vessel, the RV New Wave, in conjunction with the Monitoring of Oceanographic Conditions in PWS project (20120114-G).

#### *FY 2019 Update*

We have documented consistent temporal patterns in density and distribution from fall through winter for the most abundant marine bird species, including common murre, marbled murrelet, black-legged kittiwake, and large gulls (primarily glaucous-winged gull) (Zuur et al. 2012, Dawson et al. 2015, Stocking et al. 2018). Our surveys have also identified patterns in the spatial distribution of marine birds in the Sound. When we modeled the relationship between spatial covariates and bird distributions over nine seasons, seasonal differences were important for seven of nine species groups, illustrating movement patterns into and out of PWS (Stocking et al. 2018). We found that piscivorous birds have an overwhelming preference for shallower, warmer, and increasingly protected waters closer to shorelines. This supports the assertion that birds are seeking refuge during winter, which could render PWS superior winter habitat relative to the harsher Gulf of Alaska (GOA; Stocking et al. 2018).

Furthermore, we have identified areas of persistent, high marine bird concentrations, including northeast PWS, Montague Strait, and the southwest passages, which are also areas in which humpback whales concentrate. Similarly, Montague Strait is a known hotspot for killer whales, suggesting that environmental drivers in these

areas, such as currents and nutrients, are creating dependable, favorable foraging conditions for marine birds and marine mammals.

We also developed a bioenergetics model for marine birds in winter. Our model results highlight the importance of herring to marine birds in PWS during winter and suggest that predation by marine birds may have an important top-down effect on the PWS herring population. Our model shows that in winters with relatively high numbers of marine birds or with relatively low adult herring biomass, as much as 10% (1,864 t) of the adult biomass can be removed by avian predators (Bishop et al. 2015). This relationship is especially important considering the recent historically low estimates of the Pacific herring population in PWS (P. Rand, PWSSC, unpubl. data).

*FY18 and FY19 field work summary*

In FY18, we performed 4 surveys over a total of 1,448 km survey effort: the February 2018 OTN maintenance cruise (712 birds of 20 species), the March 2018 NOAA pollock cruise (1690 birds of 16 species), the September 2018 IPP survey (1561 birds of 22 species), and the October 2018 ADF&G Shrimp survey (756 birds of 22 species) (Table 1, Fig. 1).

Table 1. Fall and winter marine bird surveys in Prince William Sound, Alaska during FY18 & FY19.

<b>Fiscal Year</b>	<b>Cruise</b>	<b>Km surveyed</b>	<b>Observer</b>	<b>FY17 Cruise Dates</b>
FY18	PWSSC OTN Maintenance	301	A. Schaefer	Feb 7-12, 2018
FY18	NOAA Pollock	320	A. Schaefer	Mar 10-15, 2018
FY18	NOAA, USGS, PWSSC EVOS GWA IPP	550	A. Schaefer	Sep 11-19, 2018
FY18	ADF&G Shrimp	277	A. Schaefer	Oct 13-24, 2018
FY19	PWSSC Marine Bird	306	A. Schaefer	Mar 4-7, 2019
FY19	NOAA, USGS, PWSSC EVOS GWA IPP			To be completed Sep 2019
FY19	PWSSC Marine Bird			To be completed Nov 2019

For each 3-km segment of surveyed trackline, we calculated bird density (birds/km<sup>2</sup>) 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 surveys were below the long-term monthly mean. Interestingly, mean marine bird densities in open water remain relatively stable throughout the fall and winter, while mean densities in bays and passages increase from fall to late winter.

So far, in FY19, we have conducted one survey over a total of 306 km of survey effort (Table 1, Fig. 1). We completed the first dedicated PWSSC Marine Bird Survey in March 2019. During the cruise, we surveyed 6 juvenile herring bays (Simpson, Port Gravina, Eaglek, Lower Herring, Whale, Zaikof), in addition to surveying within the southwest passages of PWS and select USFWS nearshore transects. Overall, we counted 1293 birds representing 25 species while on effort. Approximately 26% of the total counts were surf scoter, 14% were Barrow’s goldeneye, and 10% were harlequin duck. Density analyses for this survey are forthcoming. Still to be completed in FY19 are the IPP survey in September 2019 and the PWSSC Marine Bird Survey in November 2019.

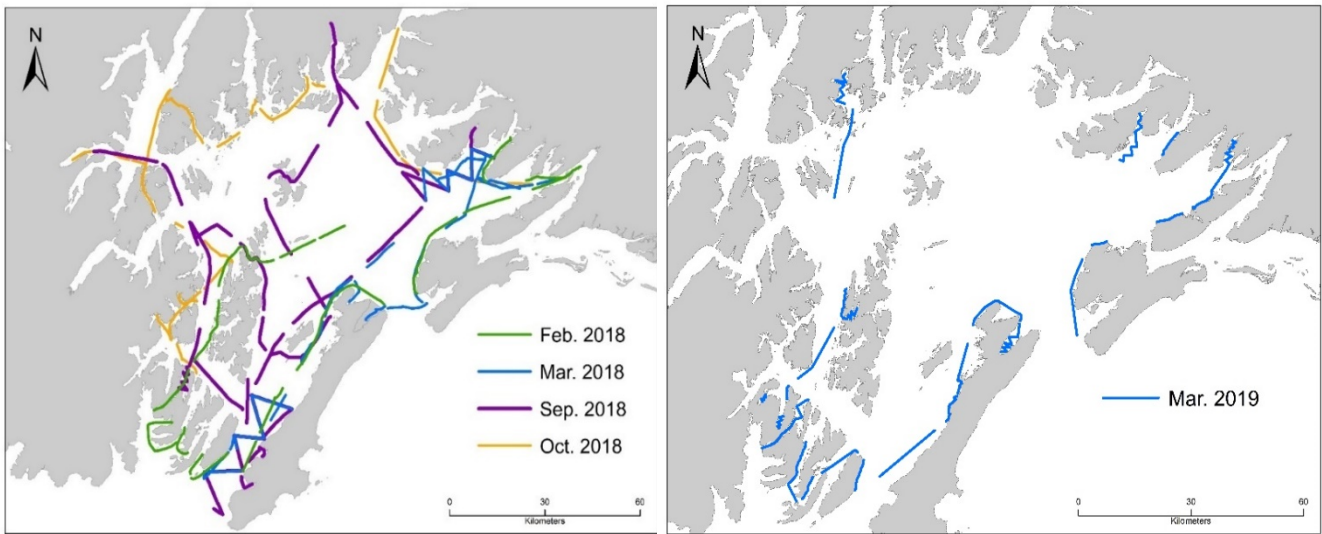


Figure 1. Spatial coverage of marine bird surveys in Prince William Sound. Left: Location of four marine bird surveys completed during FY18. Right: Location of March 2019 marine bird survey. Note that spatial coverage shown for March 2019 will be replicated hereafter for all November and March surveys to ensure coverage in juvenile herring nursery bays, and in selected U.S. Fish and Wildlife Service nearshore transects with historic data.

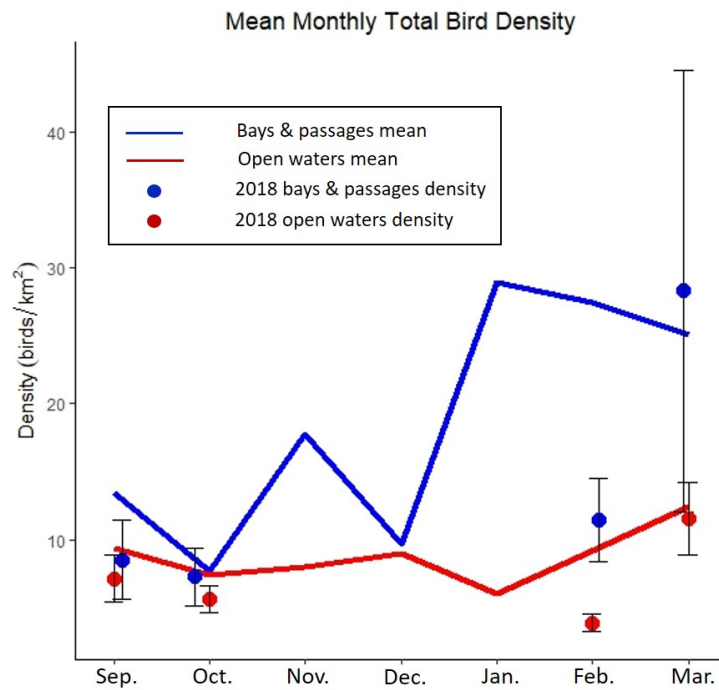


Figure 2. Long-term marine bird densities for each month by habitat type overlaid with the density estimates (and standard errors) from surveys completed in FY18.

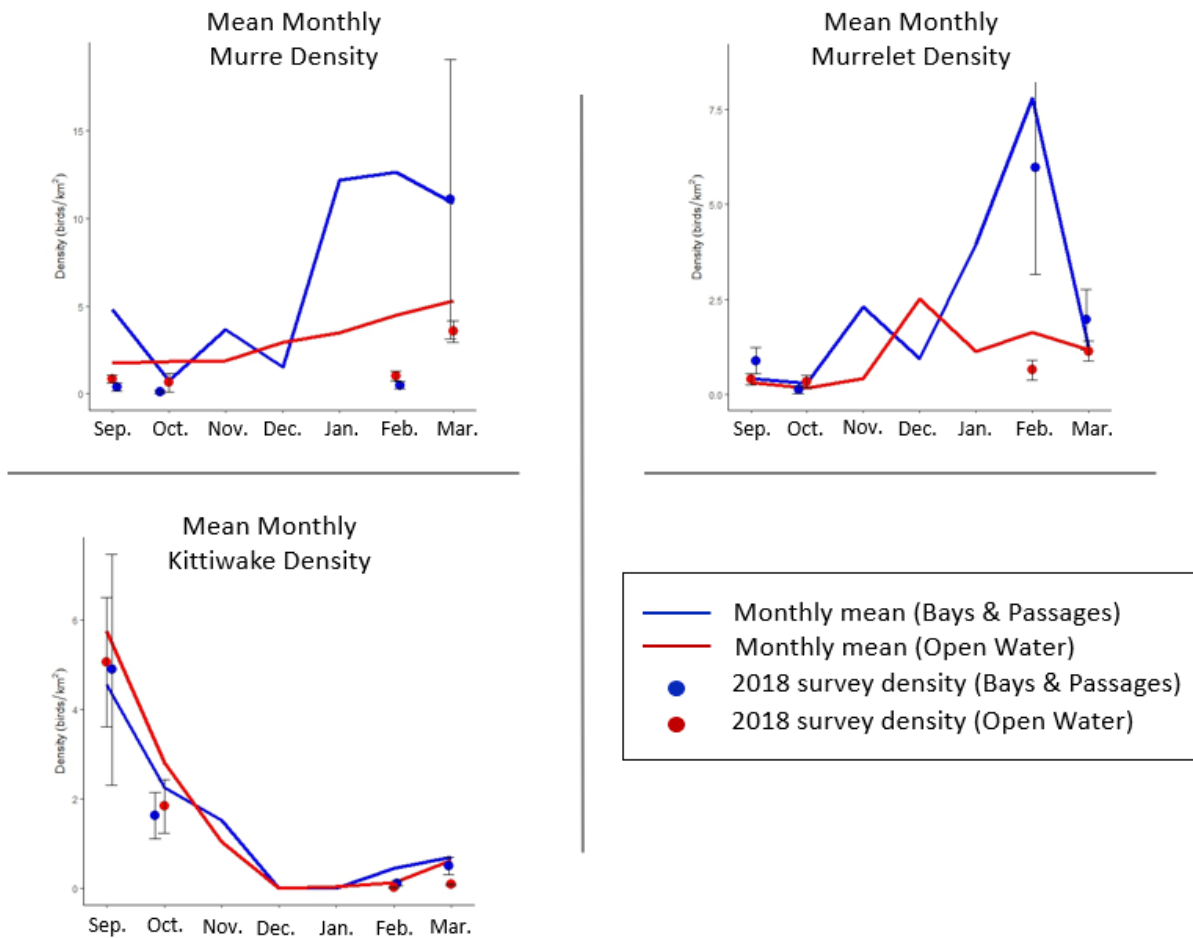


Figure 3. Long-term mean densities for murre, murrelets, and kittiwakes by habitat, overlaid with the density estimates (and standard errors) from surveys completed in FY18.

*Gulf Watch Alaska Integrated Predator-Prey Survey*

In September 2014, 2017, and 2018 we conducted marine bird surveys as part of the Gulf Watch Alaska IPP Survey (NOAA, U.S. Geological Survey [USGS], PWSSC), which also included surveys for humpback whales, forage fish, and 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. Marine bird densities recorded during the 2018 survey were lower than densities observed during the two previous predator-prey surveys (Fig. 4), mirroring patterns observed in the density indices for microzooplankton (Fig. 5).

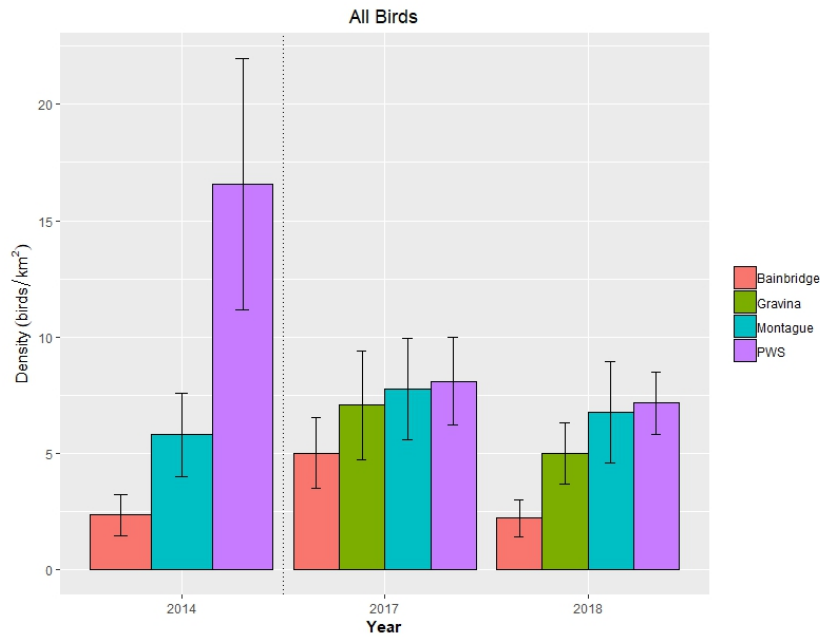


Figure 4. September marine bird densities in 2018 on acoustic transects and overall in Prince William Sound were lower than densities observed in 2017 and 2014. The 2014 survey was a pilot year and coverage in Montague Strait was less than subsequent surveys.

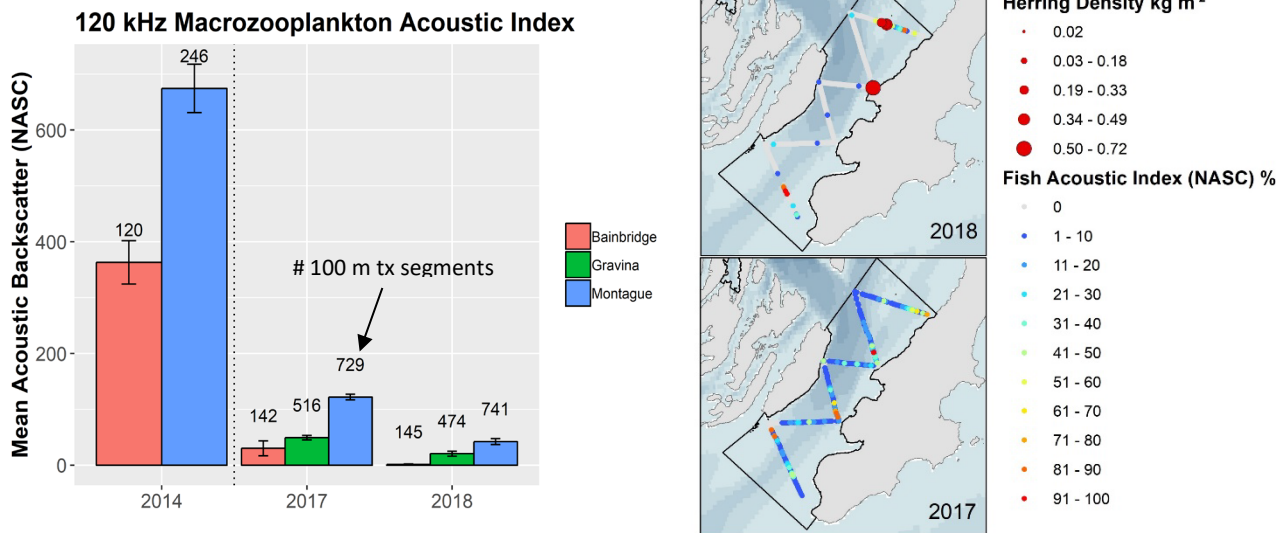


Figure 5. Macrozooplankton (e.g., krill, amphipod, mysiid) density indices and forage fish densities recorded during September integrated predator-prey surveys, Prince William Sound. The 2014 survey was a pilot year and coverage in Montague Strait was less than subsequent surveys. Figures provided by M. Arimitsu (project 20120114-C).

During the integrated September surveys, forage flocks and any marine mammals within 150m of a flock are recorded. In 2018, 11 forage flocks were recorded with 2 forage flock-whale interactions. In both 2017 and 2018, forage flocks were only observed along the eastern side of Montague Strait and at the mouth of Port Gravina. The eastern side of Montague Strait was also the only area in Montague Strait where herring were observed in 2018 (Fig. 5), suggesting 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.

#### *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 murre and murrelets demonstrate relatively consistent temporal patterns in PWS during winter; murre 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 identified anomalies in monthly densities of murre and murrelets as potential indicators because, as piscivorous seabirds, murre and murrelets are particularly sensitive to changes in the marine ecosystem. For murre, our surveys detected changes in densities and distribution in PWS during the months leading up to a prolonged die-off event occurring along the GOA beginning during the winter of 2014-2015 and ending in the spring of 2016. Our surveys recorded unusually high densities in February 2015 (immediately preceding the onset of the die-off in March 2015) and fall 2015 (immediately prior to the peak of the die-off in December 2015) (Fig. 6). The increased use of PWS by murre during winter coincided with persistently high ocean temperatures in the North Pacific Ocean beginning during the winter of 2013-14 and persisting through 2016 in the northeast Pacific (with regional variability) (Di Lorenzo and Mantua 2016), with positive temperature anomalies continuing through 2017 and 2018 in PWS (PI Campbell 20120114G). Since the die-off, we have observed murre densities below the long-term monthly averages during fall 2016-2018 surveys and spring 2018 surveys, but slightly above average densities during February 2016 & 2017 surveys (Fig. 6). Murrelet densities followed a similar pattern as murre and were also below long-term monthly averages for fall 2016-2018 and spring 2018 (Fig. 6). Continued sampling in FY20 will allow us to assess how recovery from or persistence of the recent marine heat wave (the Blob and El Niño) is affecting marine bird abundance, prey associations, and habitat use.



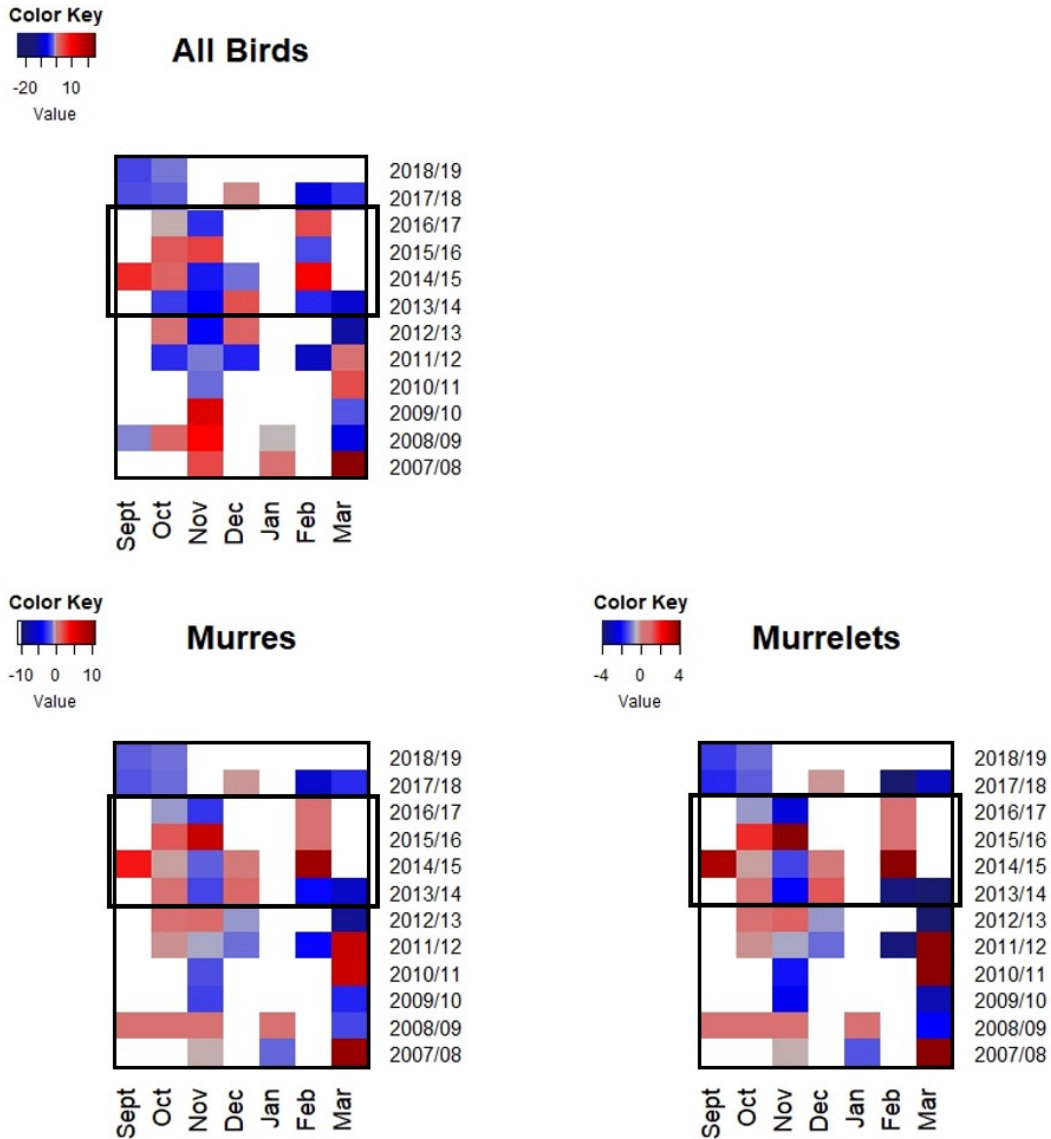


Figure 6. Monthly density anomalies for all marine birds, murres, and murrelets observed during fall and winter bird surveys in Prince William Sound, 2007-2018. A marine heatwave event occurred throughout the Northeast Pacific Ocean beginning in the winter of 2013/14 and was strongest (with regional 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 20120114-I) and Prince William Sound (PI Campbell, project 20120114-G).

## 2. PROJECT STATUS OF SCHEDULED ACCOMPLISHMENTS

### A. Project Milestones and Tasks

Table 2. This table breaks down project deliverables and their status into milestones and tasks by fiscal year and quarter, beginning February 1, 2017. Yellow highlight indicates proposed fiscal year workplan. C = completed, X = not completed or planned. Fiscal year quarters: 1 = Feb 1 – April 30; 2 = May 1 – July 31; 3 = Aug. 1 – Oct. 31; 4 = Nov. 1 – Jan. 31.

Milestone/Task	FY17				FY18				FY19				FY20				FY21				FY22
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
<b>Milestone 1: Data Collection</b>																					
Field cruises (Feb OTN, Sep IPP, Oct ADF&G)	C		C		C		C					X				X				X	
Dedicated surveys Mar & Nov (new EVOSTC funding, FY19 & onward)									C			X	X			X	X			X	X
Alternative Survey Schedule (NOAA funds lost after FY18)	C			C	C																
<b>Milestone 2: Data Processing/Mgmt</b>																					
Data summary/analysis	C	C		C	C	C		C	C			X	X			X	X			X	
Upload data workspace	C				C				C				X				X				X
Metadata/data published	C				C				C				X				X				X
<b>Milestone 3: Reporting</b>																					
Annual Reports	C				C				C				X				X				
Annual PI meeting				C				C			X					X				X	
FY Work Plan (DPD)			C				C				C					X					
5-Year Final Report																					X

In addition to the primary project deliverables in Table 2, during the past year we led or contributed to two presentations (a third was developed but not presented due to the federal government shutdown in January 2019) and contributed two outreach articles. We have one peer-reviewed paper in preparation (see Section 7). We anticipate completing FY19 and FY20 milestones and tasks as planned.

### B. Explanation for not completing any planned milestones and tasks

All sampling, milestones and tasks for 2018 and first two quarters of 2019 were completed in accordance with our proposal and with sampling protocols available on the GWA Research Workspace.

Due to the new funding of the dedicated marine bird surveys in March and November, we are no longer placing an observer onboard the February OTN maintenance cruise (FY19-21 quarter 1) or the October ADF&G spot shrimp survey (FY19-21 quarter 3). Therefore, the first quarter data collection task for February OTN field cruises listed in FY17 and FY18 in Table 1 has been shifted to the March dedicated survey.

### C. Justification for new milestones/tasks

No new milestones or tasks proposed.

### 3. PROJECT COORDINATION AND COLLABORATION

#### A. Within an EVOSTC-funded Program

##### Gulf Watch Alaska

This project is a component of the integrated GWA-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 PIs from a number of 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 and Straley, project 20120114-O) and forage fish surveys (PIs Piatt and Arimitsu, project 20120114-C). This collaboration affords efficiencies in field work, as well as facilitates greater understanding of predator-prey interactions in the Sound.

Our annual winter sampling program in PWS also complements the Pelagic Component's PWS Marine Bird Summer surveys conducted every two years by USFWS (PIs Kuletz & Kaler, project 20120114-M). Beginning in March 2019, portions of our March and November surveys will replicate select USFWS nearshore transects, allowing comparisons with historic data. Collectively, marine bird surveys cross all seasons and survey regions of GWA and allow for regional comparisons of marine bird densities and environmental drivers from PWS (PIs Bishop and Kaler) to Kachemak Bay/Lower Cook Inlet (PI Holderied, project 20120114-J), PWS, Kenai, and Katmai (PI Coletti, project 20120114-H), and Seward Line/GOA (PIs Hopcroft and Kuletz, project 20120114-L).

Beginning in FY19, the fall and winter marine bird project also shares a research vessel with the Monitoring of Oceanographic Conditions in PWS Project (PI Campbell, project 20120114-G). In addition to sharing a research platform, these surveys will enable us to evaluate patterns in marine bird abundance and distribution in juvenile herring bays relative to *in situ* measurements of sea surface temperature and zooplankton abundance.

##### Herring Research and Monitoring

In the past, we placed an observer onboard vessels associated with the PWS HRM program. As designed for FY17-21, the fall/winter marine bird project is not working directly with the HRM program, because no herring research cruises 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 IPP surveys we will collect forage fish for PI Kristen Gorman's Herring Age at Maturity project (project 20170111-D).

##### 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.

## **B. With Other EVOSTC-funded Projects**

This project will coordinate with other EVOSTC-funded projects as appropriate by providing data, discussing the relevance and interpretation of data, and collaborating on reports and publications. Of particular note, this project may share data and relevant information with the pigeon guillemot restoration project on the Naked Island complex.

## **C. With Trustee or Management Agencies**

This long-term marine bird monitoring project uses as observing platforms vessels associated with other agencies. From FY2008-2016 we had arrangements with the HRM program to have an onboard observer during surveys of juvenile herring nursery bays in November (2007-2016) and March (2008-2012). Funding for the nursery project has been discontinued. In the past we have also placed an observer onboard NOAA pollock cruises (2017-2018; funding since discontinued), and ADF&G October shrimp survey cruises (2013-2018).

Finally, information from this project will feed into the *North Pacific Pelagic Seabird Database* (NPPSD), a database that is maintained by USFWS and USGS. During spring 2019, we worked with Gary Drew (USGS) to prepare survey data from 2007-2016 for the NPPSD. Our data will be included in the updated version of the database (v 3.0), due to be released by the end of 2019.

# **4. PROJECT DESIGN**

## **A. Overall Project Objectives**

Our long-term monitoring has shown that the nonbreeding season cannot be characterized as a single time period when describing marine bird distribution and suggests that multiple surveys are required to quantify wintering populations and understand changes in marine bird distribution. For 2017-2021 this project will continue to conduct marine bird surveys in conjunction with marine research cruises, including the GWA IPP surveys (FY17-21; Table 3), ADF&G spot shrimp survey cruise and the PWSSC OTN maintenance cruise (both cruises FY17-18), and the PWSSC dedicated Marine Bird Survey (FY19 onward).

Objectives of this study are to:

1. Characterize the spatial and temporal distribution of marine birds in Prince William Sound 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.

Table 3. Integrated predator-prey collaborations by objective. Objectives related to this work plan are bolded.

<b>Objective</b>	<b>Index</b>	<b>Task</b>	<b>PI</b>
<b>a. Estimate humpback whale abundance, diet, and distribution</b>			
	Whale counts by sub-region	Integrated Surveys: whale counts, biopsies	Moran (NOAA)/ Straley (UAS)
	Whale Identification	Integrated Surveys: Photo ID	Moran (NOAA)/ Straley (UAS)
	Whale Diet	Integrated Surveys: scales, scat, biopsies, visual observations, hydroacoustics	Moran (NOAA)/ Straley (UAS)/ Arimitsu & Piatt (USGS)
<b>b. Estimate marine bird abundance and distribution in seasonally predictable predator aggregation areas</b>			
	<b>Georeferenced marine bird counts, group size, behavior by species</b>	<b>Integrated Surveys: marine bird transects</b>	<b>Bishop (PWSSC)</b>
<b>b.i. Relate marine bird and humpback whale presence to prey fields identified during hydroacoustic surveys.</b>			
	<b>Spatial coherence of bird and whale presence/ absence, acoustic estimates of forage fish and euphausiid biomass</b>	<b>Integrated Surveys: hydroacoustic and marine bird transects, whale focal follows</b>	Arimitsu & Piatt (USGS)/ <b>Bishop (PWSSC)</b> / Moran (NOAA)/ Straley (UAS)
<b>b.ii. Characterize marine bird-humpback whale foraging dynamics</b>			
	<b>Georeferenced marine bird and whale counts, group size, behavior by species</b>	<b>Integrated Surveys: marine bird transects; whale focal follows</b>	<b>Bishop (PWSSC)</b> / Moran (NOAA)/ Straley (UAS)/ Arimitsu & Piatt (USGS)
<b>c. Estimate index of forage fish availability in seasonally predictable predator foraging areas</b>			
	<b>Species composition and biomass within persistent predator foraging areas</b>	<b>Integrated Surveys: hydroacoustic-trawl data</b>	Arimitsu & Piatt (USGS)/Moran (NOAA) <b>Bishop (PWSSC)</b>
	<b>Density and depth distribution</b>	<b>Integrated Surveys: hydroacoustic-trawl data</b>	Arimitsu & Piatt (USGS)
	Diet, energy density	Sample Analysis: forage fish	Moran (NOAA)
<b>d. Estimate an index of euphausiid availability in seasonally predictable predator foraging areas</b>			
	Species composition and biomass within persistent predator foraging areas	Integrated Surveys: hydroacoustic-trawl data	Arimitsu & Piatt (USGS)
	Density and depth distribution	Integrated Surveys: hydroacoustic-trawl data	Arimitsu & Piatt (USGS)
<b>e. Relate whale, marine bird and forage fish indices to marine habitat</b>			
	<b>Oceanographic metrics and zooplankton biomass</b>	<b>Integrated Surveys: CTD and zooplankton samples</b>	Arimitsu & Piatt (USGS)/ Moran (NOAA)/ Straley (UAS)/ <b>Bishop (PWSSC)</b>

## **B. Changes to Project Design and Objectives**

In FY19 (and continuing through FY21) we added within bay surveys of PWS funded by EVOSTC. In addition to within-bay transects, we are also surveying within the southwest passages of PWS and surveying select nearshore transects coinciding with historic USFWS survey transects. These surveys will be replicated every November and March and will extend our long-term and most consistent (2007-2016) dataset of wintering marine bird abundance and distribution. With the addition of these dedicated, consistent surveys, we are no longer placing an observer onboard ships of opportunity in October (ADF&G Shrimp survey) and February (OTN Maintenance Cruise).

## **5. PROJECT PERSONNEL – CHANGES AND UPDATES**

There are no personnel changes or updates.

## **6. PROJECT BUDGET**

### **A. Budget Forms (See GWA FY20 Budget Workbook)**

Please see project budget forms compiled for the program.

### **B. Changes from Original Project Proposal**

Our FY19 workplan requested funding from EVOSTC to conduct dedicated November and March marine bird surveys within bays of PWS that were discontinued at the end of the first 5-year funding cycle. We thank EVOSTC for the additional funding (\$24K for FY19, 20, and 21 for a total of \$72K).

### **C. Sources of Additional Project Funding**

We were provided a berth during FY17 and FY18 onboard the ADF&G spot shrimp surveys and the OTN maintenance cruise (funded by a grant from the Alaska Ocean Observing System). These charters were valued at \$53.0 k. Beginning in FY19 EVOSTC provided funding for a dedicated marine bird surveys in March and November that eliminated the need to put an observer onboard the ADF&G and OTN cruises.

## **7. FY17-19 PROJECT PUBLICATIONS AND PRODUCTS**

### Publications

- 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.
- Bishop, M. A., and A. Schaefer. 2019. Long term monitoring of marine bird abundance and habitat associations during fall and winter in Prince William Sound. FY18 annual report to the *Exxon Valdez Oil Spill Trustee Council*, project 18120114-E.
- 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.

#### Published and updated datasets

##### **DataONE Published Datasets**

Bishop, M. A., A. Schaefer, K. Kuletz, M. McCammon, and K. Hoffman. 2017. Fall and Winter Seabird Abundance Data, Prince William Sound, 2007-2017, Gulf Watch Alaska Pelagic Component. Research Workspace. 10.24431/rw1k1w.

##### **Gulf of Alaska Data Portal Datasets**

Bishop, M. A., and A. Schaefer. 2018. Fall and Winter Seabird Abundance: PWS fall and winter 2017-2018 seabird observations. *Exxon Valdez Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Gulf of Alaska Data Portal.*

##### **Research Workspace**

Bishop, M. A., and A. Schaefer. 2019. Fall and Winter Seabird Abundance: PWS fall and winter 2018-2019 seabird observations. *Exxon Valdez Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace.*

##### **North Pacific Pelagic Seabird Database**

Drew, G. and J. Piatt. *In prep.* Fall and Winter Seabird Abundance: PWS fall and winter 2007-2016 seabird observations. Bishop, M. A. and A Schaefer contribution to North Pacific Pelagic Seabird Database 3.0 (NPPSD): U.S. Geological Survey data release.

#### 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 Presentation.** Alaska Marine Science Symposium, January 2019, Anchorage, AK.

Arimitsu, M., M. A. Bishop, S. Hatch, R. Kaler, K. Kuletz, C. Matkin, J. Moran, D. Olsen, J. Piatt, A. Schaefer, and J. Straley. 2018. Changes in marine predator and prey populations in the aftermath of the North Pacific Heat Wave: Gulf Watch Alaska Pelagic update 2017. **Poster Presentation.** Alaska Marine Science Symposium, January 2018, Anchorage, AK.

Schaefer, A. L., M. A. Bishop, and R. Thorne. 2018. Non-breeding marine bird response to forage fish schools in Prince William Sound, Alaska. **Poster Presentation.** Alaska Marine Science Symposium, January 2018, Anchorage, AK.

#### Outreach

Schaefer, A. 2018. A winter refuge for seabirds. *Delta Sound Connections.*

Schaefer, A. 2017. Avian invasion. *Delta Sound Connections*

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- Bishop, M.A., J.T. Watson, K. Kuletz, and T. Morgan. 2015. Pacific herring (*Clupea pallasii*) consumption by marine birds during winter in Prince William Sound, Alaska. *Fisheries Oceanography* 24:1–13.
- 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.
- Exxon Valdez Oil Spill Trustee Council. 2014. 2014 Update, Injured Resources and Services List. Anchorage, Alaska.
- 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.
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- Zuur, A.F., N. Dawson, M.A. Bishop, K. Kuletz, A.A. Saveliev, and E.N. Ieno. 2012. Two-stage GAMM applied on zero inflated Common Murre density data. Pages 155-188 in A.F. Zuur, A.F., A.A. Saveliev, and E.N. Ieno, editors. *Zero inflated models and generalized linear mixed models with R*. Highland Statistics Ltd., Newburgh, United Kingdom.