ATTACHMENT C *EVOSTC Annual Project Report Form*

Form Rev. 10.3.14

1. Program Number: *See,* Reporting Policy at III (C) (1).

15120114-C

2. Project Title: *See,* Reporting Policy at III (C) (2).

Long-term monitoring of seabird abundance and habitat associations during late fall and winter in Prince William Sound

3. Principal Investigator(s) Names: *See,* Reporting Policy at III (C) (3).

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

Report prepared by: Anne Schaefer

4. Time Period Covered by the Report: *See,* Reporting Policy at III (C) (4).

February 1, 2015 – January 31, 2016

5. Date of Report: *See,* Reporting Policy at III (C) (5).

February 12, 2016

6. Project Website (if applicable): *See,* Reporting Policy at III (C) (6).

http://www.gulfwatchalaska.org/

http://pwssc.org/research/birds-2/seabirds/

7. Summary of Work Performed: *See,* Reporting Policy at III (C) (7).

The objectives of this project are to:

1) Characterize the spatial and temporal distribution of seabirds in Prince William Sound (PWS) during late fall and winter.
2) Relate seabird presence to prey fields identified during hydroacoustic surveys.
3) Identify critical biological and physical habitat characteristics for seabirds across PWS within and between winters.
4) Use increased temporal sampling resolution to improve our estimates of herring consumption by seabirds during the winter.

For this FY15 report we provide preliminary results that address objectives 1, 3 and 4. Objective 2 will be addressed as hydroacoustic survey data become available from the juvenile herring surveys.

2015 Field Work and Preliminary Analyses

During FY2015 (1 February 2015 – 31 January 2016), one observer (Anne Schaefer) with the Prince William Sound Science Center (PWSSC) performed 4 marine bird surveys in Prince William Sound (PWS), covering a total of 1016 km (Table 1; Figure 1). The ships of opportunity used for the 2015 surveys included vessels surveying Pacific herring (Exxon Valdez Oil Spill [EVOS] Herring Research and Monitoring, PWSSC) and spot shrimp (Alaska Department of Fish and Game [ADF&G]). We also surveyed marine birds concurrently with the annual maintenance of the Ocean Tracking Network (OTN) acoustic arrays that are stationed across the major entrances and southwest passages of PWS and serviced by the PWSSC. Previous years included surveys conducted concurrently with the Gulf Watch Alaska (GWA) Humpback whale project; however, neither fall nor winter whale surveys were conducted during this period.

All surveys followed established U.S. Fish and Wildlife Service (USFWS) protocols (USFWS 2007). Briefly, the observer recorded the number and behavior of all marine birds and mammals within a 300 m fixed-width strip (150 m on either side of the vessel) into a GPS-integrated data entry program (dLOG). The observer identified species to the lowest taxonomic unit possible. For each three km segment of the surveyed trackline, we calculated bird density (birds/km^2) for 11 species or species groups (Table 2).

Table 1. Cruises completed during FY2015. No milestones were scheduled to be completed for FY2015.

Month/Collaborator		Km surveyed	Observer	Status
February (A)	PWSSC	205	A. Schaefer	Completed, February 12–17, 2015
February (B)	PWSSC	108	A. Schaefer	Completed, February 23–24, 2015
October	ADF&G	371	A. Schaefer	Completed, October 12–23, 2015
November	PWSSC	332	A. Schaefer	Completed, November 6–15, 2015
January	PWSSC	400	A. Schaefer	Completed, January 6–8, 2016

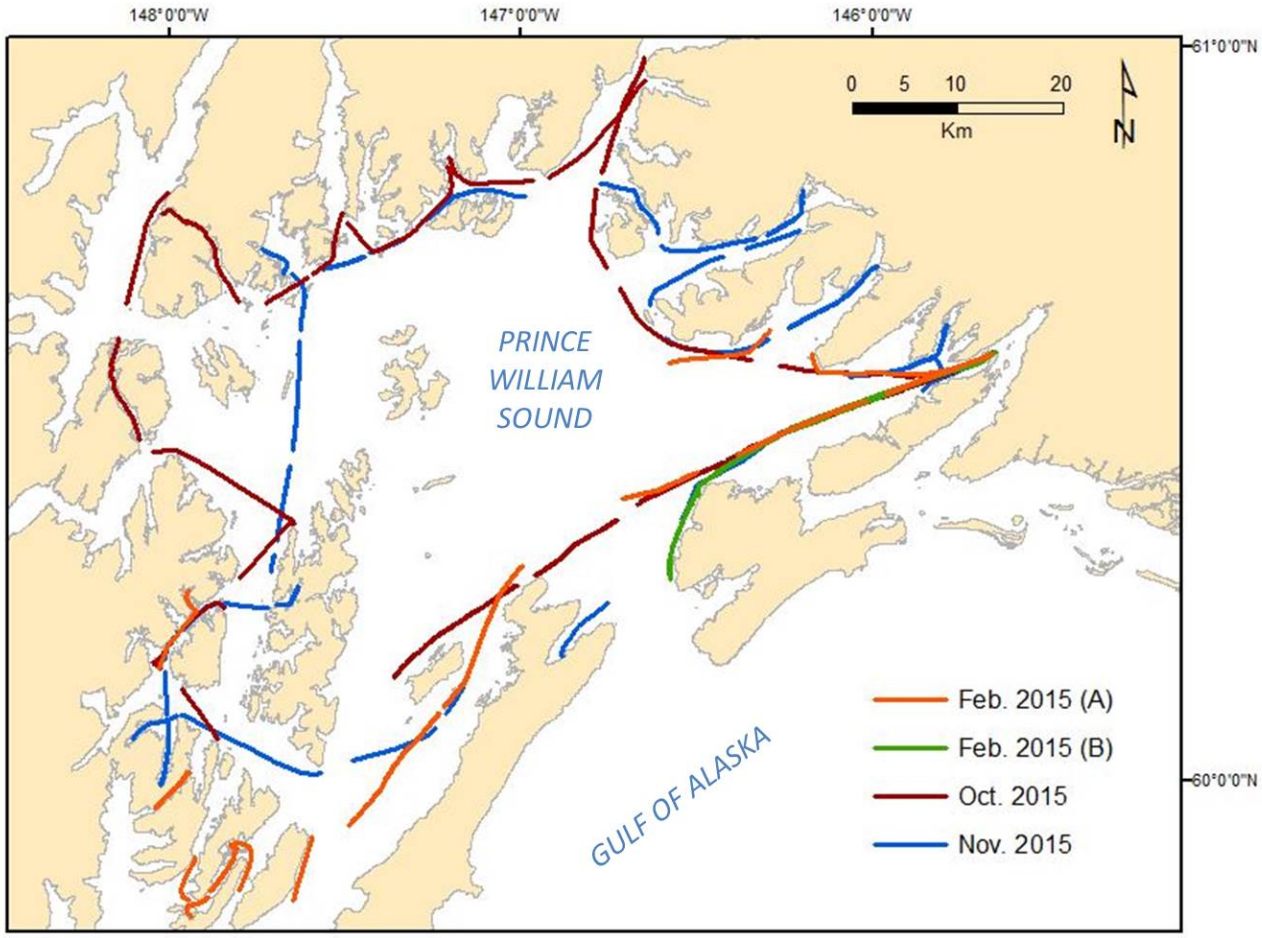

Figure 1. Spatial coverage of the four cruises completed in Prince William Sound, AK during FY2015.

Common Murre Die-off

Beginning in March 2015, observations of dead murres floating in the water or washed up on beaches began to be reported to wildlife officials along the Gulf of Alaska. The die-off continued through the summer and then spiked in December 2015 and early January 2016, after a period of severe storms and high winds. Examination of carcasses sent to the U.S. Geological Survey (USGS) National Wildlife Health Center determined starvation to be the cause of death.

Immediately preceding the die-off event, we recorded a dramatic increase in the number of common murres using the southwest passages of PWS (February 2015 surveys; Figures 2 & 3, Table 2). Common murres are typically the most abundant marine birds in PWS by late winter (March; Dawson et al. 2015, Bishop and Kuletz 2013). The early movement of murres into PWS may have signaled a change in food availability in the Gulf of Alaska due to unusually warm water temperatures. Sea temperatures in the Gulf of Alaska have increased 0.5-1.5 degrees Celsius since 2013, with temperature anomalies in PWS 2-4 degrees Celsius warmer than average (Campbell 2016). Murre densities in PWS were also higher this past October and November (2015; Figure 3, Table 2), right before the spike in reported mortalities, as compared to previous surveys during this time period.

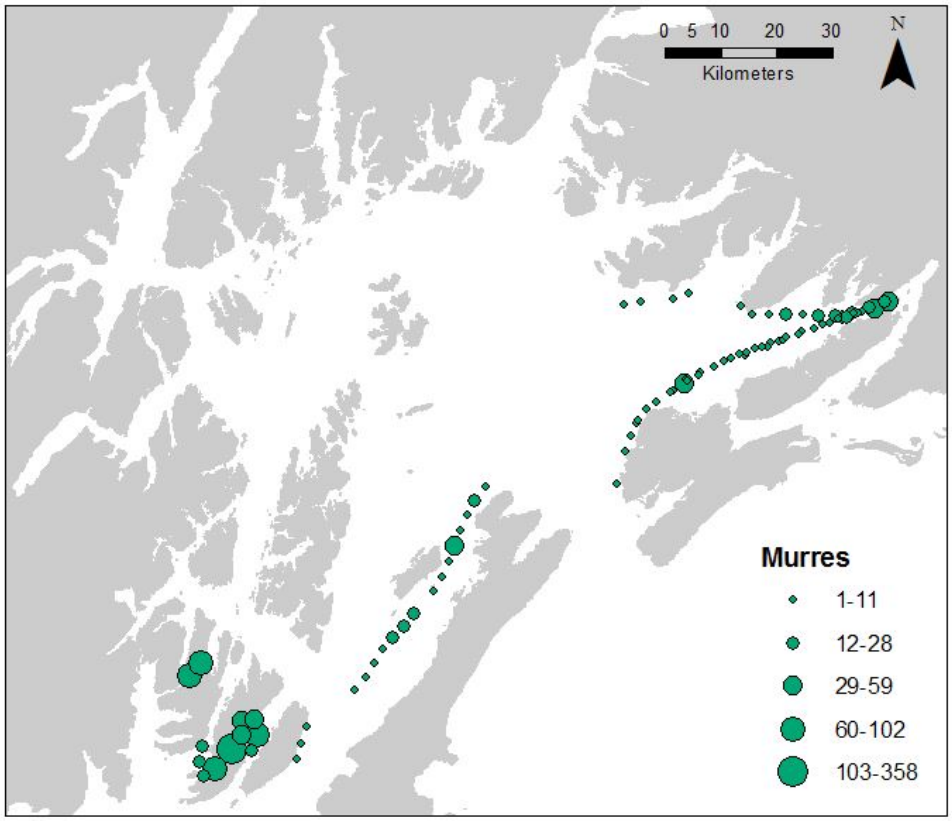

Figure 2: The highest densities of common murres to date were observed in the southwest passages of Prince William Sound during February 2015, immediately prior to the die-off beginning in March 2015.

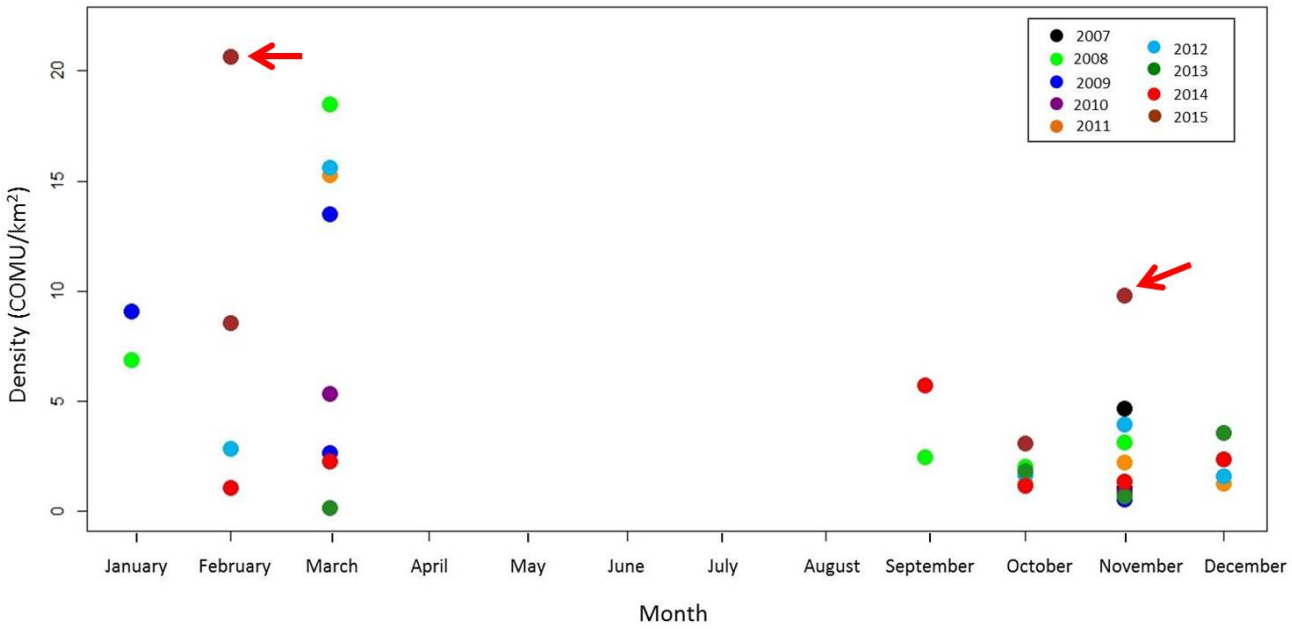

Figure 3: Common murre (COMU) densities by month and year in Prince William Sound, 2007-2015. Dramatic increases in the number of common murre observed during 2015 within Prince William Sound immediately preceded the beginning (March 2015) and the peak (December 2015 and January 2016) of the murre die-off occurring along the Gulf of Alaska (red arrows).

In response to reports of hundreds and thousands of dead common murre carcasses washing up along beaches in the western part of PWS, in January 2016 we conducted an additional survey focused on documenting common murre mortalities as part of a larger collaborative effort involving USFWS, USGS, and GWA scientists. Our survey occurred over a three-day period (January 6-8, 2016) from the R/V New Wave in conjunction with the GWA Long Term Monitoring Oceanographic Conditions in Prince William Sound project (R. Campbell, PWSSC). We counted floating common murre carcasses while traveling between ocean sampling locations (pelagic transects) and carcasses washed up along the shoreline (beach transects). The total sampling effort was approximately 400 km: 378 km pelagic transects, and 22 km of boat-based beach surveys (Figure 4).

Overall, we counted 392 dead murres: 316 on beaches and 76 while traveling (Figure 4). We also collected 6 carcasses for submission to the USGS National Wildlife Health Center in Madison, Wisconsin. While we did not observe high densities of dead murres compared to other reports, our results indicate that the spatial extent of the die-off in PWS was quite large. We observed dead murres on 21% of the 122, 3-km segments of surveyed pelagic transects (Figure 4). These transects covered a wide range of habitat types, including open water, narrow passages, and bays. Further, dead murres were recorded on 7 of the 16 boat-based beach scans.

The larger collaborative response effort by USGS, USFWS, PWSSC, and GWA scientists resulted in 184 km of beach surveys and 451 km of ocean surveyed for dead birds (these numbers include the survey effort by PWSSC described above) from January 1-10, 2016. Approximately 10 km of beaches were walked, with the rest surveyed from boats. On

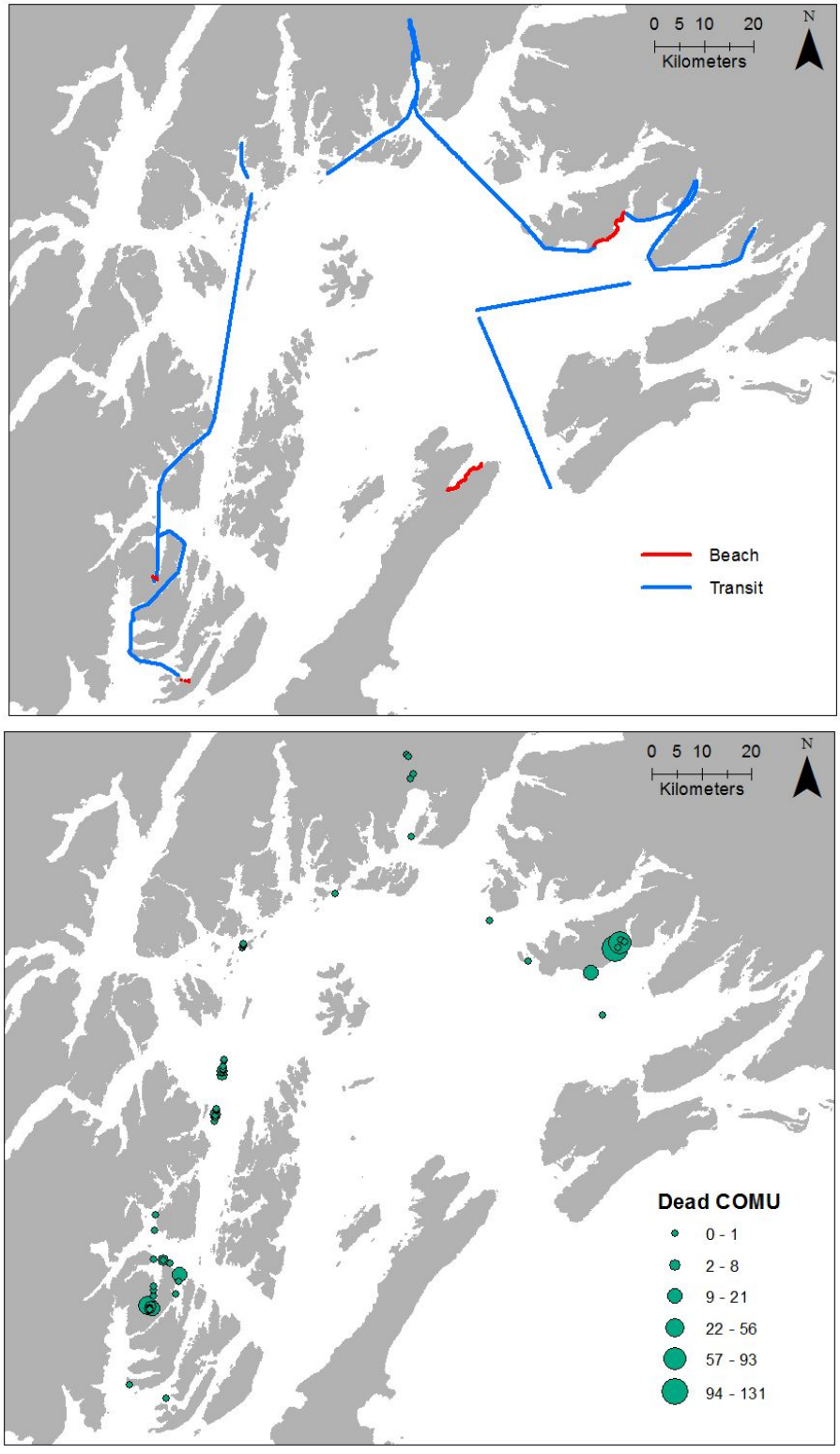

Figure 4: On effort beach (red) and transit (blue) transects (top panel) surveyed for common murre (COMU) carcasses (bottom panel) conducted by Prince William Sound Science Center, January 6-8, 2016.

the beaches 17,293 dead murres were counted (estimated as 21,759 with detectability correction), with the highest densities of carcasses recorded in the northwest region of PWS. At sea, 854 dead murres were counted, resulting in an average density of 3.7 dead birds/km^2, or 33,500 total dead murres when extrapolated to the rest of PWS. However, sampling was not random or systematic, so this extrapolated estimate is biased. Field necropsies of 60 carcasses recovered from PWS revealed that birds were severely underweight compared to average breeding murres in the Gulf of Alaska (n = 219 birds, May-August, 1988-2000). Further, the majority of carcasses displayed strongly emaciated pectoral muscles, zero subcutaneous fat, and stomachs were completely empty. Based on the collaborative surveys, the estimated total murre mortality to date has likely been in the hundreds of thousands (J. Piatt, USGS, pers. comm.).

Comparison of 2014/2015 and 2015/2016 winters. Although this reporting period only covers surveys completed in FY2015, we present data summaries for the 2014/15 winter (n = 6) and the 2015/16 winter (up to November 2015, n = 2), with emphasis placed on the FY2015 surveys (n=4).

During the FY2015 surveys we observed 29 avian species over 1,016 km of survey effort, with an average density of 17.14 ± 31.84 (SD) birds/km^2. When analyzed by winter, during the 2014/15 winter, 33 species were observed over 1,678 km of surveyed tracklines, with an average density of 13.93 ± 39.40 (SD) marine birds/ km^2. Birds were observed in the greatest densities during the first, 12-17 February 2015 survey. To date for the 2015/16 winter, we have observed 25 species in 703 km of survey effort. Average density for the two cruises (October and November) was 13.87 ± 20.55 (SD) marine birds/ km^2 with the highest density recorded during November. These densities are higher than those observed during the same time period during the previous winter (October and November 2014; Table 2).

We observed distinct temporal patterns in species occurrence over both winters, emphasizing the importance of not characterizing the nonbreeding season as a single time period when describing marine bird communities (Figure 5, Table 2). As in previous years, common murre was the most numerous species observed during the winter marine bird surveys, with density peaking in February 2015 during the first OTN maintenance survey. Across both winters, murres were distributed throughout PWS with the largest congregations occurring in the southwestern and northeastern portions of the Sound (Figures 2, 6, & 7).

The highest densities of *Brachyramphus* murrelets were observed in February (first OTN survey, 2014/15 winter) and November (2015/16 winter). The lowest densities of *Brachyramphus* murrelets were recorded in September (2014) and October (2015) when murrelets emigrate from PWS to complete their pre-basic molt. Similar to murres, murrelets were clustered primarily in the northeastern and southwestern regions of PWS (Figures 6 & 7). Black-legged kittiwakes were broadly distributed throughout PWS in both winters (Figures 6 & 7) with densities peaking in September during winter 2014/15. Interestingly, in 2015 there were still high densities of kittiwakes observed in PWS into mid-November. Typically, kittiwakes disperse to over-

wintering areas outside of PWS immediately after the breeding season (McKnight et al. 2011). During winter 2014/15, loons were recorded primarily in the northeastern and southwestern parts of PWS (Figures 6 & 7), with densities peaking in November 2014. So far for winter 2015/16, loons were sparsely distributed throughout the Sound, with the highest density observed in November.

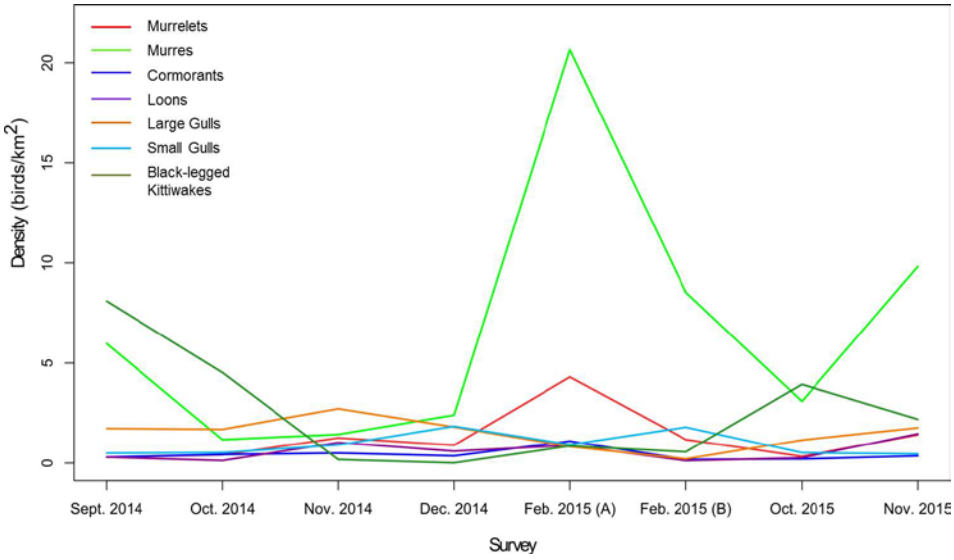

Figure 5. Observed densities of the most abundant species groups during winters 2014/15 and 2015/16 in Prince William Sound. The four surveys during 2015 were completed during this reporting period. Note the large spike of common murres in February 2015, coinciding with the die-off that began in the Gulf of Alaska during March 2015.

Table 2. Density (birds/km^2 $\pm$ SE) of main species groups observed within the 300 m transect strip during winters 2014/15 (top) and 2015/16 (bottom). Highest density values for each species group by winter are indicated in bold.

Species or Species Group	2014				2015	
	September	**October**	**November**	**December**	**February (A)**	**February (B)**
Murrelets	0.29 (0.10)	0.41 (0.11)	1.26 (0.34)	0.90 (0.18)	**4.30 (0.97)**	1.17 (0.34)
Murres	5.97 (1.96)	1.17 (0.48)	1.43 (0.36)	2.40 (0.66)	**20.65 (6.25)**	8.53 (2.17)
Cormorants	0.29 (0.08)	0.43 (0.25)	0.50 (0.18)	0.36 (0.09)	**1.10 (0.42)**	0.18 (0.09)
Loons	0.29 (0.11)	0.12 (0.04)	**1.03 (0.37)**	0.59 (0.22)	0.89 (0.42)	0.12 (0.07)
Mergansers	0 (0)	0.10 (0.05)	0.05 (0.03)	**0.11 (0.10)**	0 (0)	0 (0)
Large Gulls	1.73 (0.53)	1.69 (0.34)	**2.72 (0.53)**	1.80 (0.35)	0.83 (0.23)	0.21 (0.10)
Small Gulls	0.50 (0.42)	0.52 (0.17)	0.91 (0.30)	**1.84 (0.59)**	0.92 (0.34)	1.79 (1.41)
Black-legged Kittiwakes	**8.09 (4.71)**	4.52 (1.81)	0.18 (0.09)	0.01 (0.01)	0.86 (0.38)	0.56 (0.14)
Scoters	0.08 (0.07)	0.12 (0.06)	0.16 (0.09)	0.08 (0.04)	**0.51 (0.46)**	0.06 (0.06)
Grebes	0.08 (0.06)	0.09 (0.05)	**0.11 (0.06)**	0.06 (0.04)	0 (0)	0 (0)
Long-tailed Ducks	0 (0)	0 (0)	0 (0)	0.05 (0.03)	**0.62 (0.48)**	0 (0)
Harlequin Ducks	0.02 (0.02)	0.07 (0.03)	0.03 (0.03)	0.01 (0.01)	**0.25 (0.21)**	0 (0)
Inshore Ducks	0 (0)	**0.49 (0.39)**	0.20 (0.16)	0.02 (0.02)	0 (0)	0 (0)
Total	17.35 (5.71)	9.75 (2.14)	8.58 (1.39)	8.25 (1.29)	30.94 (7.24)	12.62 (2.56)

Species or Species Group	2015	
	October	**November**
Murrelets	0.33 (0.14)	**1.42 (0.34)**
Murres	3.08 (0.45)	**9.82 (1.51)**
Cormorants	0.20 (0.06)	**0.36 (0.08)**
Loons	0.26 (0.13)	**1.47 (0.88)**
Mergansers	**0.11 (0.08)**	0.07 (0.07)
Large Gulls	1.15 (0.24)	**1.76 (0.44)**
Small Gulls	**0.52 (0.20)**	0.46 (0.09)
Black-legged Kittiwakes	**3.93 (0.64)**	2.19 (0.77)
Scoters	**0.10 (0.07)**	0.04 (0.03)
Grebes	0.03 (0.02)	**0.04 (0.03)**
Long-tailed Ducks	0 (0)	**0.03 (0.03)**
Harlequin Ducks	**0.07 (0.05)**	0.04 (0.02)
Inshore Ducks	**0.63 (0.34)**	0.15 (0.09)
Total	10.44 (1.23)	17.87 (2.60)

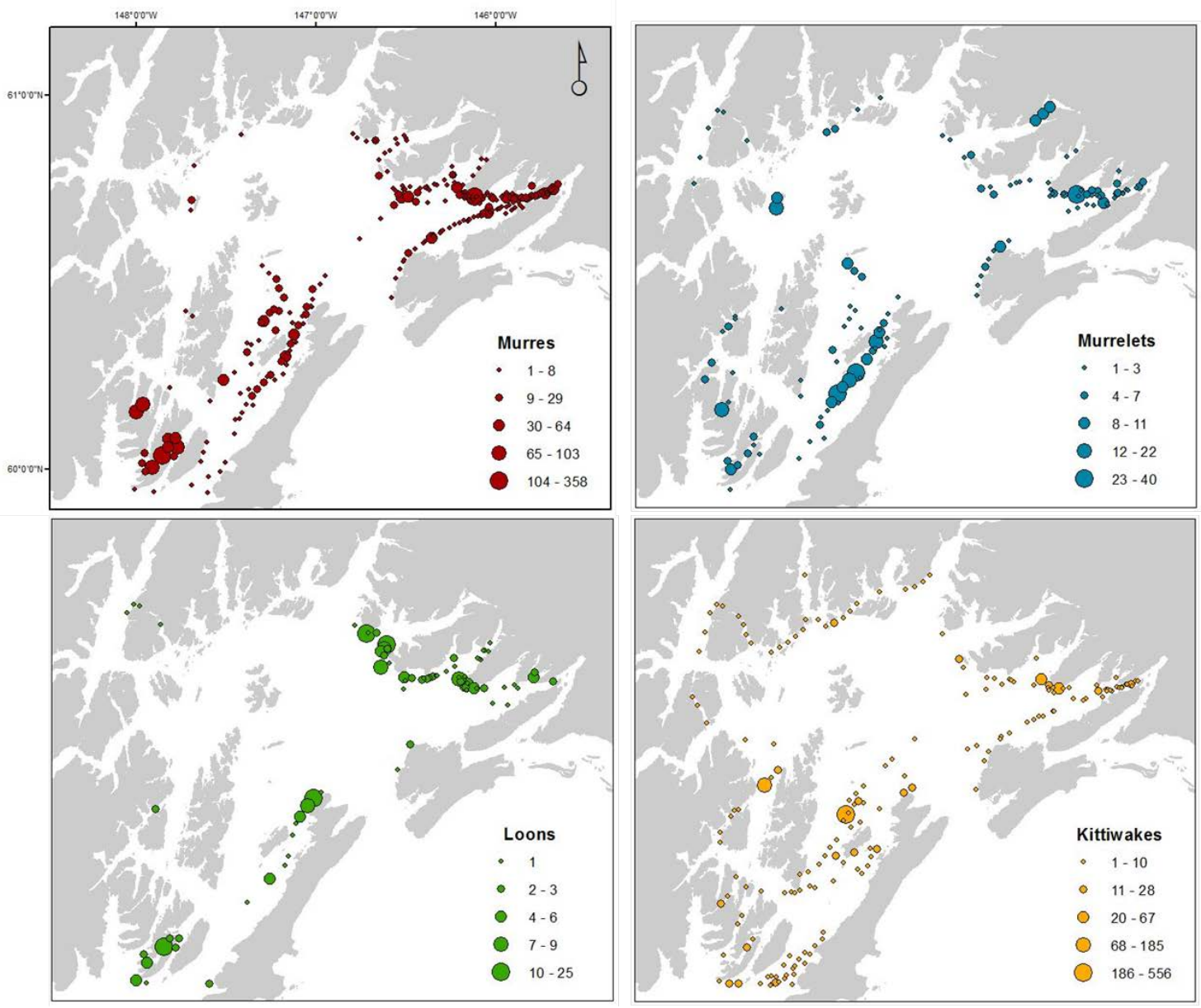

Figure 6. Distribution of common murre, *Brachyramphus* murrelets (Kittlitz's and marbled murrelets), loons (common loon, Pacific loon, red-necked loon, and yellow-billed loon) and black-legged kittiwakes recorded during winter 2014/15 surveys (n = 6) in Prince William Sound. Note that scales for each figure legend vary by species.

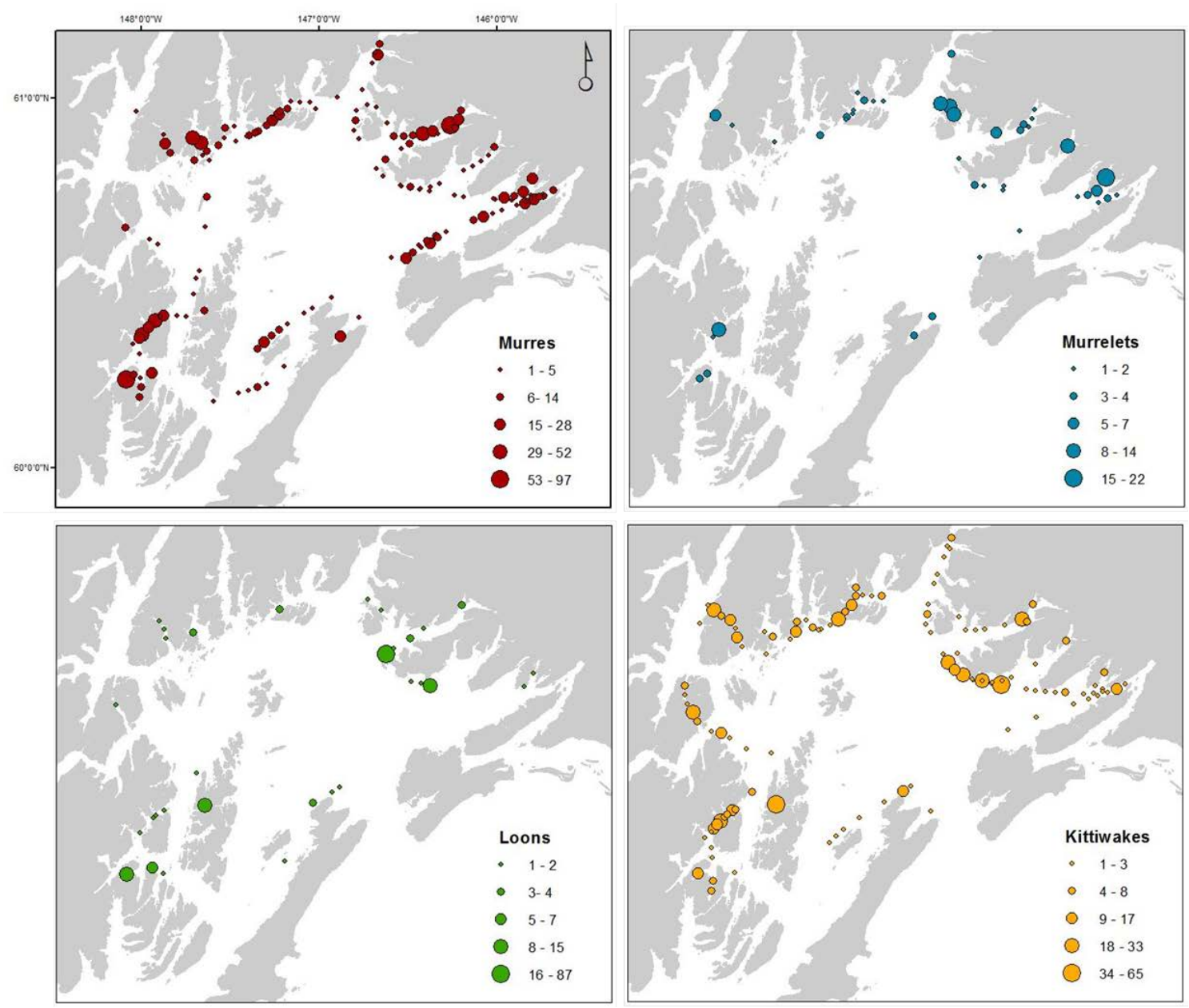

Figure 7. Distribution of common murre, *Brachyramphus* murrelets (Kittlitz's and marbled murrelets), loons (common loon, Pacific loon, red-necked loon, and yellow-billed loon) and black-legged kittiwakes recorded during October & November 2015 surveys (n = 2) in Prince William Sound. Note that scales for each figure legend vary by species.

Modeling by Quanticipate Consulting

We continue to work with Dr. Ali Arab of Quanticipate Consulting modeling habitat associations using zero-inflated Poisson (ZIP) models. These types of models incorporate zeros that we suspect are due to lack of detection of birds that were present. Exploratory data analyses have been completed, and we are now extending the current analyses to spatial and spatio-temporal analyses. Using the first seven winters of data, we developed a spatial Poisson hurdle model to explore geographic variation in marbled murrelets while accounting for zero inflation.

For future analyses, we will expand our data set to cover nine winters (2007/2008 – 2015/2016 winters). Our plan is to submit a manuscript detailing our findings for submission as part of the joint long-term programs' special issue of Deep Sea Research II.

Future Work

In 2016 marine bird observations will be conducted in February (Ocean Tracking Network maintenance cruise), October (Alaska Department of Fish & Game spot shrimp cruise), and November (EVOS Herring Research & Monitoring). We are still awaiting confirmation on GWA whale cruises for FY2016.

In addition to our modeling efforts with Quanticipate Consulating, beginning in spring 2016 we will begin an analysis to evaluate associations between Pacific herring and marine birds during winter. Pacific Herring (*Clupea pallasii*) 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, a phenomena that may be related to reduced forage fish availability. Despite the dynamic association between marine birds and forage fish, few studies have addressed seabird-herring relationships during winter months and the potential for effects on population recovery.

For this study we will use seabird 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 and distribution of seabird predators in relation to prey abundance and distribution and habitat characteristics;
- Identify habitats and characteristics of seabird-associated and seabird-non-associated fish schools;
- For seabird-associated schools, characterize the key habitats and fish school features influencing the abundance of marine birds selecting the schools.

We will prepare a manuscript detailing our findings for submission as part of the special issue of Deep Sea Research II.

Milestones/Deliverables

No milestones were scheduled to be completed in FY2015. Below is an update on our progress.

Deliverable/Milestone	Status
Characterize the spatial and temporal abundance of seabirds in PWS during late fall and winter.	Conducted marine bird surveys from vessels of opportunity in February, October, and November for a 1016 km of survey effort. Patterns of distribution and abundance are summarized in this report.
Model species abundance and distribution within and across winters in relation to biological and physical environmental factors.	We continue to work with Dr. Ali Arab of Quanticipate Consulting to model these relationships. Using the first seven winters of data, we developed a model to explore geographic variation in marbled murrelets. We are now extending the analyses to include nine winters and other species groups.
Relate species composition and distribution to prey fields.	Hydroacoustic data are currently being processed and analyses will begin in spring 2016. We will prepare a manuscript detailing our findings for submission as part of the special issue of Deep Sea Research II.
Identify critical marine habitats used by seabirds during late fall and winter.	Analyses using nine winters of survey data from vessels of opportunity are on-going.
Submit year 5 work plan	Year 5 work plan was prepared and provided to Trustee Council staff. Plan was approved during the November 2015 EVOSTC meeting.
Submit annual project report	This document constitutes report submission.

References

Bishop, M.A. and K.J. Kuletz. 2013. Seasonal and Interannual Trends in Seabird Predation on Juvenile Herring. *Exxon Valdez* Oil Spill Restoration Project Final Report (Project 10100132-H), Prince William Sound Science Center, Cordova, Alaska.

Campbell, R. 2016. Surface layer and bloom dynamics observed with the Prince William Sound autonomous profiler. Presentation for 2016 Ocean Sciences Meeting, New Orleans, LA.

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.

McKnight, A., D. B. Irons, A. J. Allyn, K. M. Sullivan, R. M. Suryan. 2011. Winter dispersal and activity patterns of post-breeding black-legged kittiwakes *Rissa tridactyla* from Prince William Sound, Alaska. Marine Ecology Progress Series 442: 241–253.

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.

8. Coordination/Collaboration: *See,* Reporting Policy at III (C) (8).

Coordination and collaboration is critical to this project as all our surveys require placing an observer on vessel charters associated with other projects. During FY2015 we placed an observer on EVOS PWS Herring Research & Monitoring program (November), as well as the Alaska Department of Fish and Game spot shrimp survey (October) and Ocean Tracking Network

annual maintenance cruise (February) (Table 1). We also collaborated with the GulfWatch Alaska zooplankton survey for PWS in order to conduct the January 2016 murre survey.

When not conducting daytime marine bird surveys, the bird observer assists the other projects when possible. During the past year, assistance has included helping set and pick shrimp pots and process their contents, helping process the catches from plankton trawls, fish trawls, and gill nets, and collecting and processing stratified water samples.

9. Information and Data Transfer: *See,* Reporting Policy at III (C) (9).

Publications:

Bishop, M.A., J. Watson, K. Kuletz, and T. Morgan. 2015. Pacific herring consumption by marine birds during winter in Prince William Sound, Alaska. *Fisheries Oceanography* 24(1):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.

Popular Press:

Bishop, M.A. 2016. Seabird die-off in Prince William Sound. *The Cordova Times*, January 8, Page 1.

Schaefer, A. L. 2015. Fish, birds, whales- they're all connected! *Delta Sound Connections* (circulation ~15,000). This annual newspaper published about the natural history of PWS and the Copper River Delta is distributed each May to airports and tourist areas in southcentral Alaska.

Posters:

Bishop, M.A., K. Kuletz, J. Stocking, and A. Schaefer. 2016. Spatial and temporal patterns of winter marine bird distribution in Prince William Sound, Alaska. Alaska Marine Science Symposium, Anchorage, AK.

Lindeberg, M., M. Arimitsu, M.A. Bishop, D. Cushing, R. Kaler, K. Kuletz, et al. 2016. Population trends of Top Predators and Prey in PWS. Alaska Marine Science Symposium, Anchorage, AK.

Presentations:

Kuletz, K.J., H. Renner, R. Kaler, J. Parrish, B. Bodenstein, J. Piatt, and M.A. Bishop**.** 2016**.** Seabird Die-off events, 2014-2016. Workshop on Unusual Mortality Events. Alaska Marine Science Symposium, Anchorage, AK.

Meetings

Bishop participated in the Herring Research Monitoring/Gulf Watch Alaska synthesis meeting during February 2015 in Anchorage. Bishop also participated in the Gulf Watch Alaska meeting

for Principal Investigators in November 2015 in Anchorage and attended the Gulf Watch Alaska meeting during January 2016 at Alaska Marine Science Symposium via teleconference. Bishop also attended the quarterly teleconference meetings of Gulf Watch Alaska principal investigators.

Schaefer attended the Gulf Watch Alaska meeting and presented the poster "Spatial and temporal patterns of winter marine bird distribution in Prince William Sound, Alaska" in January 2016 at Alaska Marine Science Symposium.

Data:

Datasets and associated metadata through November 2015 have been uploaded to the Gulf Watch Alaska portal.

Data from the January 2016 murre survey were made available to collaborators at the USGS and USFWS.

In January 2016 we met with Stacey Buckelew of Axiom Consulting to discuss project metadata and address changes or additions that were needed.

10. Response to EVOSTC Review, Recommendations and Comments: *See,* Reporting Policy at III (C) (10).

No issues were raised by the most recent EVOSTC review.

11. Budget: *See,* Reporting Policy at III (C) (11).

Please see provided program work book.

The contract cost of Dr. Ali Arab of Quanticipate Consulting for conducting the habitat association analyses is coming out of money originally designated for personnel since it was not initially budgeted. Travel to the annual PI meeting in November 2015 for Bishop and to AMSS 2016 for Schaefer was charged to the project, although it was not initially budgeted.