***Exxon Valdez* Oil Spill Trustee Council**

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

Annual Project Reporting Form

Project Number: 24120114-M

Project Title: Prince William Sound Marine Bird Populations Trends and Associated Shelf Waters

Principal Investigator(s): Robert Kaler, U. S. Fish and Wildlife Service, Migratory Bird Management

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

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

Project Website: https://gulfwatchalaska.org/

Please check all the boxes that apply to the current reporting period.

☒ **Project progress is on schedule.**

☐ **Project progress is delayed**

☐ **Budget reallocation request.**

☐ **Personnel changes.**

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1. Summary of Work Performed:

This report summarizes marine bird survey work conducted in Prince William Sound (PWS) and on the Seward Line for the Gulf Watch Alaska Long-Term Research and Monitoring (GWA-LTRM) program and in the Northern Gulf of Alaska-Long Term Ecological Research (NGA-LTER) study area.

July Prince William Sound Marine Bird Survey:

Boat based marine bird surveys in PWS are conducted in alternating years (2023, 2025). No surveys were conducted in 2024. In 2023, we conducted boat-based surveys to monitor abundance and distribution of marine birds in PWS (Fig. 1) and completed the 17th year of summer surveys since the 1989 T/V *Exxon Valdez* oil spill. In July 2023, the randomly selected shoreline (n=212), coastal (n=91) and pelagic (n=50) 200-meter wide transects were completed

from three 25-foot (7.6 meter) length survey boats. Data collected during the 2023 surveys were analyzed in 2024.

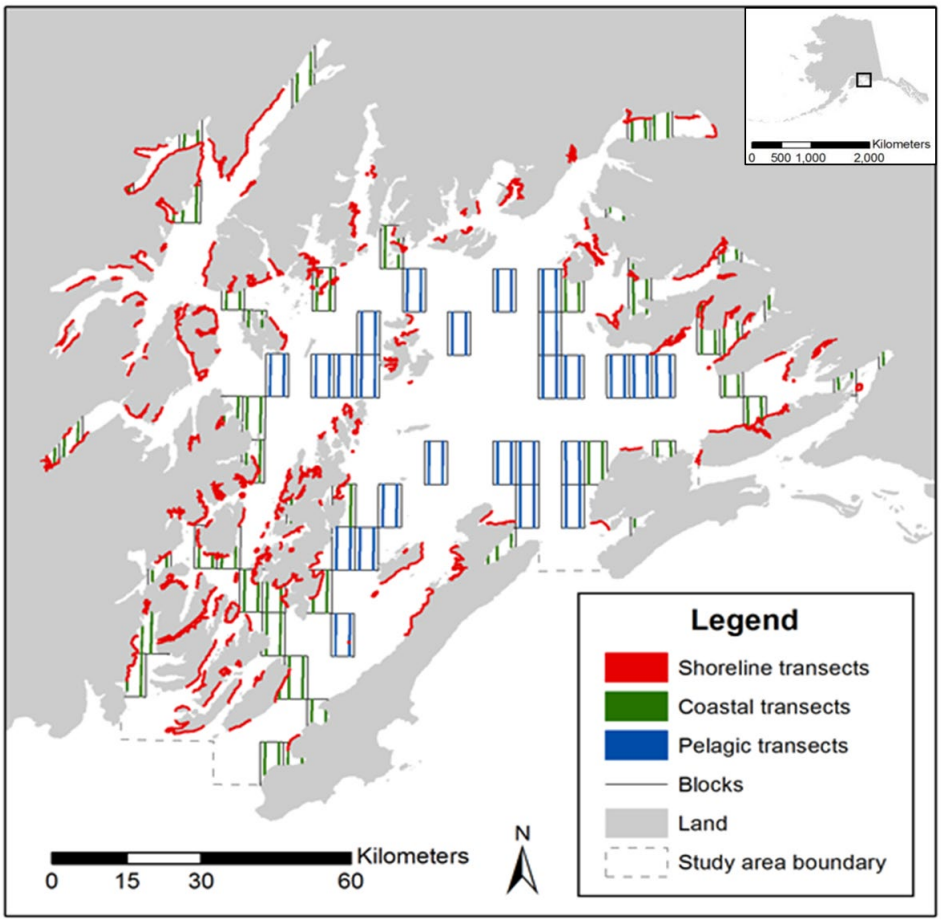


Figure 1. Map of the Prince William Sound, Alaska, July marine bird survey study area and transects indicating shoreline (red), coastal (green), and pelagic (blue) transects.

Analysis:

To detrend the time-series, we fit linear regressions to log-transformed abundances, using generalized least squares with variance-covariance matrices that incorporated continuous first-order autoregressive structure. The time series with significant trends (declines) were tufted puffins (*Fratercula cirrhata*) in PWS. There were no other significant trends. For the four tufted puffin time-series with declines, we used the residuals from the regression analyses instead of the

original data. This analysis used the non-linear mixed-effects modeling package (nlme) version 3.1-163, and R version 4.3.2.

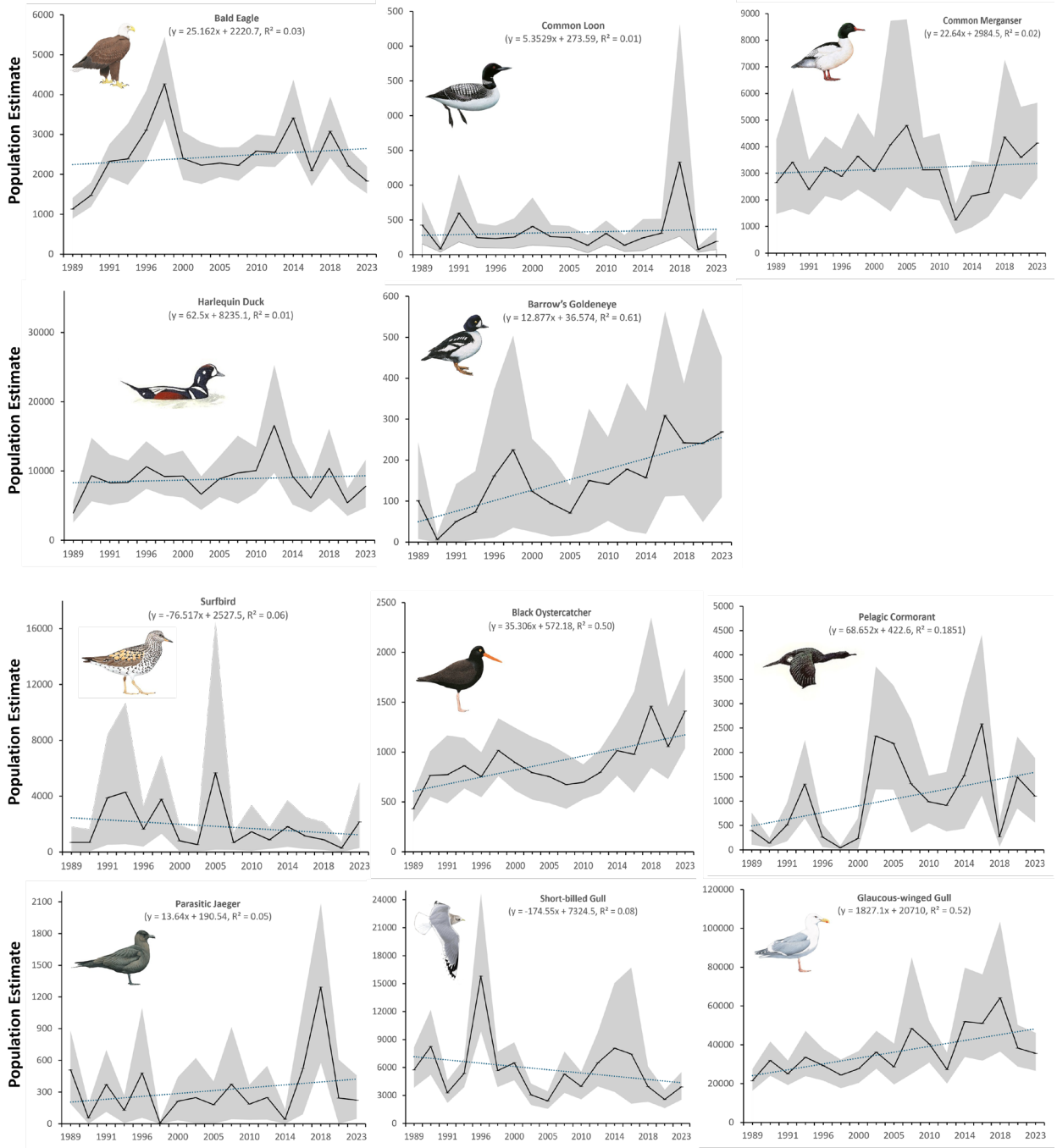
July 2023 Prince William Sound Marine Bird Survey:

- Harlequin duck (*Histrionicus histrionicus*) numbers Sound-wide are stable since 1989 ($y = 62.5x + 8235.1$, $R^2 = 0.0135$; Fig. 2).
- Pigeon guillemot (*Cepphus columba*) numbers have declined Sound-wide since 1989 ($y = -140.22x + 4151$, $R^2 = 0.3471$; Fig. 2) from a high of 6,665 in 1991 to a low of 1,184 in 2000. The population estimate of guillemots was 2,242 in 2023.
- Marbled murrelet (*Brachyramphus marmoratus*) numbers are stable Sound-wide since 1989 ($y = -0.9534x + 44545$, $R^2 = 0.00000001$; Fig. 2). Between 2012 and 2023, population estimates fluctuated between a high of 63,447 birds (2014) and a low of 1,849 (2022). In 2023, marbled murrelet numbers increased to 46,244 birds.
- Kittlitz's murrelet (*B. brevirostris*) numbers have declined since 1989 ($y = -183.69x + 3577.7$, $R^2 = 0.3306$; Fig. 2). Since 2012, murrelet population estimates have fluctuated between a high of 1997 birds in 2016 to a low of 194 birds in 2022.
- Arctic tern (*Sterna paradisaea*) numbers have declined in PWS since 1989 ($y = -422.95x + 7143$, $R^2 = 0.7128$; Fig. 2). Since 2012, however, tern population estimates have fluctuated from a low of 884 terns in 2014 to a high of 2,038 birds in 2023.
- Tufted puffin numbers declined Sound-wide since 1989. Since 2012, population estimates of puffins ranged from a high of 5,770 in 1996 to a low 551 in 2023 ($y = -286.91x + 5020.8$, $R^2 = 0.63$; Fig. 2). Following the 2014-2016 Gulf of Alaska marine heatwave, the tufted puffin population estimate declined to 984 birds in 2018 and then increased to 2,038 individuals in 2023.
- Common murre (*Uria aalge*) numbers have fluctuated Sound-wide since 1989 and population estimates have ranged from 270 in 1989 to 16,005 in 1993 ($y = -67.417x + 5425.2$, $R^2 = 0.0047$; Fig. 2). Mean population estimates have decreased from a high of 339 (2012) to a low of 27 (2018). In 2023, the number of murres counted was the same as the number counted in 2016 (39) during the Gulf of Alaska marine heatwave (2015-2016) (Fig. 5). Following the 2014-2016 Gulf of Alaska marine heatwave, the common murre population estimate declined to 492 birds in 2018 and then increased to 3,265 individuals in 2023.

Exxon Valdez Oil Spill Trustee Council

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

Annual Project Reporting Form



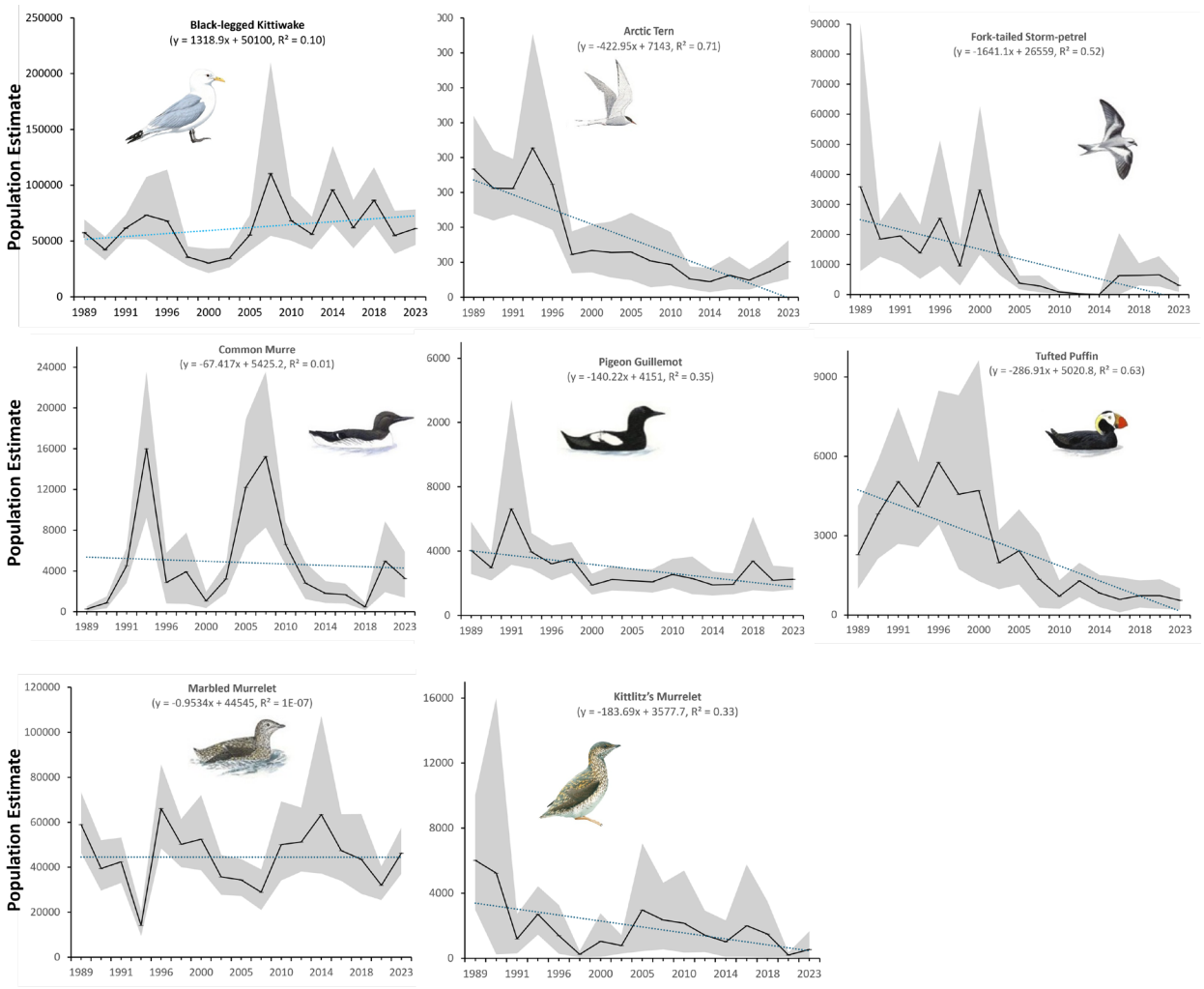


Figure 2. July population estimates and linear regression analysis of selected marine birds in Prince William Sound, Alaska, 1989-2023.

Overall, based population estimates based on boat-based surveys from1989 to 2023:

- Increase - Bald eagles (*Haliaeetus leucocephalus*), Barrow's goldeneye (*Bucephala islandica*), black oystercatcher (*Haematopus bachmani*), pelagic cormorant (*Phalacrocorax pelagicus*), and glaucous-winged gull (*Larus glaucescens*)
- Stable - Common loon (*Gavia immer*), common merganser (*Mergus merganser*), common murre, black-legged kittiwake (*Rissa tridactyla*), harlequin duck, short-billed

gull (*L. brachyrhynchus*), parasitic jaeger (*Stercorarius parasiticus*), and surfbird (*Aphriza virgata*)

- Decrease - tufted puffin, fork-tailed storm-petrel (*Oceanodroma furcata*), pigeon guillemot, Arctic tern, and Kittlitz's murrelet

Given that *Exxon Valdez* oil is considered sequestered and not currently bioavailable to wildlife in PWS (National Oceanic and Atmospheric Administration 2018), these data suggest broad-scale declines in prey availability. The 2014-2016 marine heatwave may have influenced population trends, as demonstrated by Renner et al. 2024 for common murres throughout their Alaska range.

Northern Gulf of Alaska-Long Term Ecological Research:

During 2024, we conducted a total of 2,280 linear km of marine bird surveys during two Seward Line and NGA-LTER cruises: April 24 – May 10 (Fig. 3), and September 10 – 20 (Fig. 4). During spring, the mean density of marine birds was 8.7 birds/km^2, while the mean density during fall was 6.4 birds/km^2.

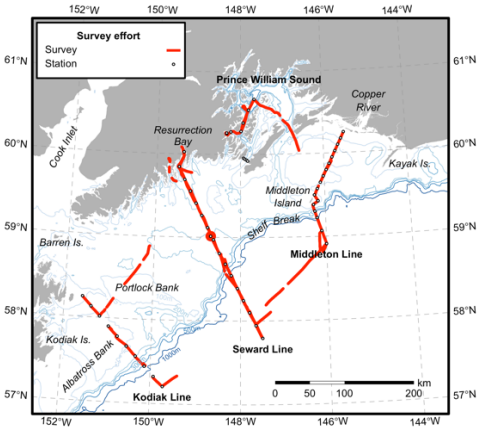


Figure 3. Seabird surveys during April-May 2024 Northern Gulf of Alaska-Long Term Ecological Research cruise (R/V Sikuliaq).

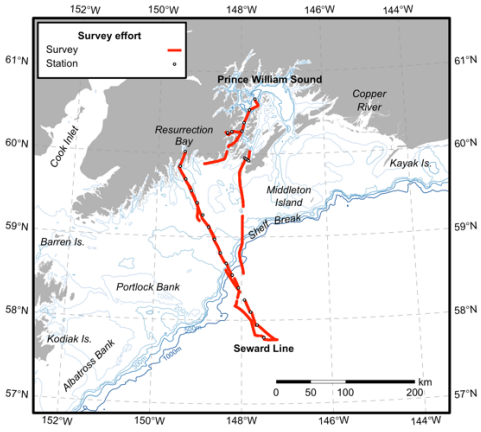


Figure 4. Seabird surveys during September 2024 Northern Gulf of Alaska-Long Term Ecological Research cruise (R/V Tiglax).

Analysis:

We conducted new analyses integrating seabird surveys conducted during oceanographic cruises along the Seward Line with small-boat surveys in PWS, focusing on the 27-year time span (1998 – 2024) covered by both datasets. Our research questions were: 1) Were seabird at-sea abundance time-series characterized by common trends? 2) Were relationships of common trends with ocean temperatures consistent with direct or indirect forcing? 3) Did common trends reflect ecosystem changes?

We examined common trends in seabird at-sea abundance time-series using Dynamic Factor Analysis, which is a class of multivariate state-space model that explains temporal variability in a set of observed time-series with linear combinations of latent random walks. We aggregated surveys along the Seward Line during into four domains, the Inner Shelf, Middle Shelf, Outer Shelf, and Continental Slope, with PWS as a fifth domain. We included abundance time-series (abundance of a species in a domain) in our Dynamic Factor Analysis.

To evaluate whether common trends were more consistent with direct forcing by ocean temperature or with indirect forcing with ocean temperature acting through food-web processes, we made two comparisons. First, we calculated the correlation between common trends and temperature anomalies at GAK1. Second, we calculated the correlation between common trends and temperature anomalies after transformation via a damped autoregressive function (Di Lorenzo and Ohman 2013). We used a damping time scale of two years, representing the response of prey species with multi-year life spans to thermal conditions.

To determine whether common trends reflected ecosystem changes, we compared our results to those of Suryan et al. (2021), who performed a Dynamic Factor Analysis of 187 biological time-series from the Gulf of Alaska during 2010 – 2018, ranging from plankton to fisheries harvests.

The best model had a single common trend (Fig. 5A). Across all domains, 41% of time-series were associated with the common trend. The strongest effects occurred in PWS and the Middle Shelf, where most time-series were either positively or negatively associated with the common trend (Fig. 5B-F). The correlation between the common trend and temperature anomalies that were transformed using a damped autoregressive function (r = -0.74; Fig 6) was stronger than the direct correlation with temperature anomalies (r = -0.49). This is consistent with a response to thermal conditions that is mediated through the food web.

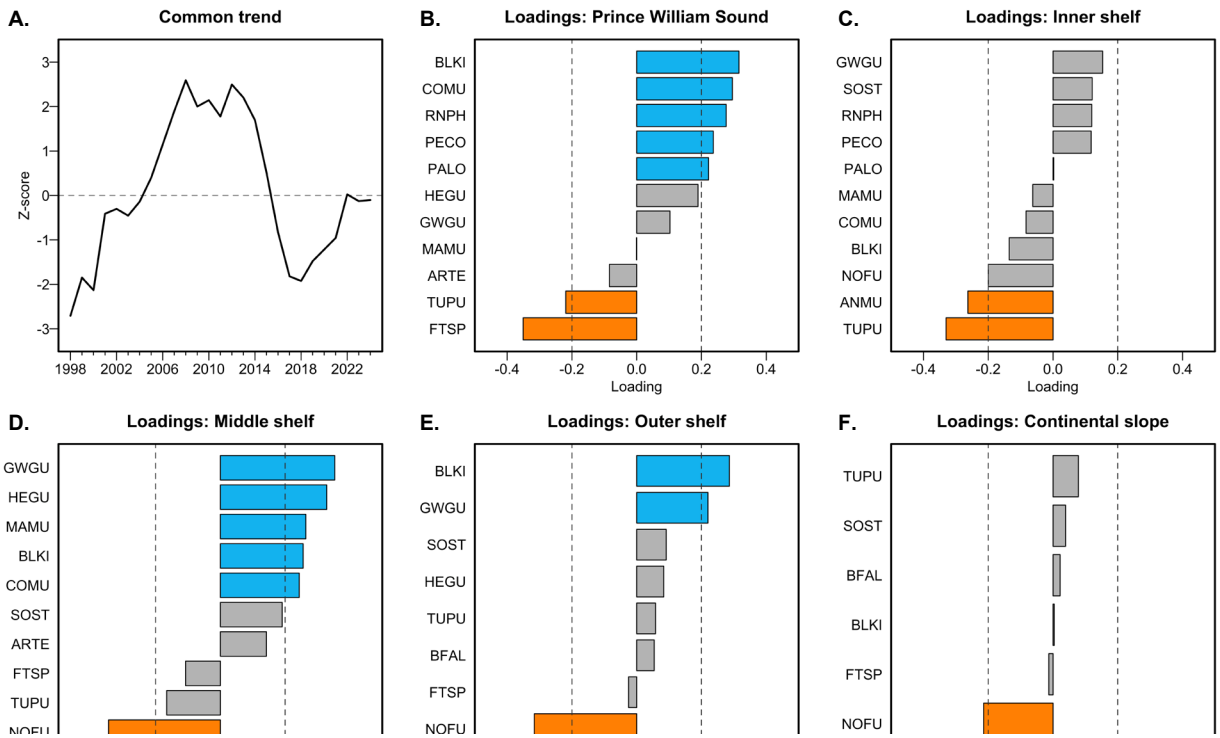


Figure 5. Panel A: Common trend from 46 seabird at-sea abundance time-series, 1998 – 2024. Panels B-F: Loadings describing the strength of the association of each time-series with the common trend by domain. Loadings with absolute values > 0.2 are considered associated with the common trend. Seabird species abbreviations are ANMU: ancient murrelet, ARTE: arctic tern, BFAL: black-footed albatross, BLKI: black-legged kittiwake, COMU: common murre, GWGU: glaucous-winged gull, MAMU: marbled murrelet, FTSP: fork-tailed storm-petrel, HEGU: herring gull, NOFU: northern fulmar, PALO: Pacific loon, PECO: pelagic cormorant, RNPH: red-necked phalarope, SOST: sooty and short-tailed shearwaters, TUPU: tufted puffin.

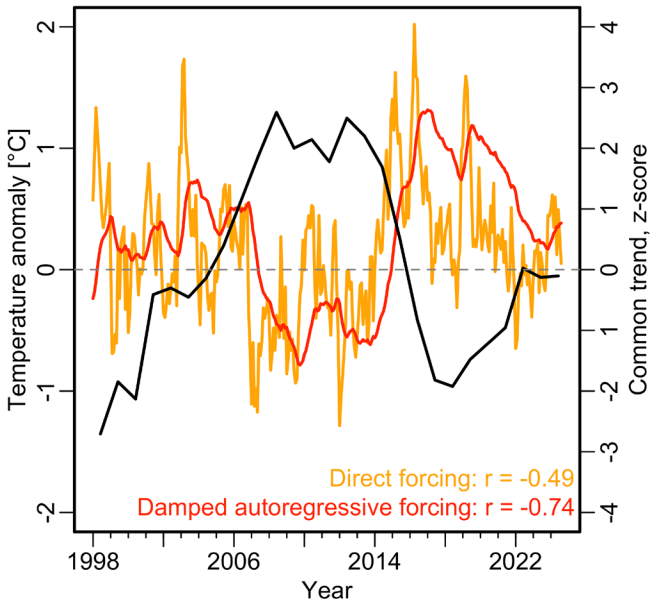


Figure 6. Comparison of common trend (black), GAK1 monthly temperature anomalies (orange) and temperature anomalies transformed via damped autoregressive function (red).

The common trend in seabird at-sea abundance time-series was highly correlated (r = 0.99) with the common trend identified by Suryan et al. (2021). However, 34 of the 187 time-series included in the Suryan et al. (2021) analysis were at-sea seabird abundance time-series, including some from the Seward Line. We therefore collaborated with R. Suryan to repeat this analysis with and without any of the at-sea abundance time series included. The estimated common trend was nearly identical (r = 0.99) in both cases, indicating that the seabird at-sea abundance time-series did not drive the overall results. The close correspondence between the common trend estimated using only seabird at-sea abundance (this study) with the common trend estimated by Suryan et al. (2021) indicates that fluctuations in seabird at-sea abundance reflected broad changes in the ecosystem before, during, and after the heatwave.

Literature cited:

Di Lorenzo, E., and M. D. Ohman. 2013. A double-integration hypothesis to explain ocean ecosystem response to climate forcing. Proceedings of the National Academy of Sciences of the USA 110:2496-2499.

National Oceanic and Atmospheric Administration. 2018. Lingering oil from Exxon Valdez spill. Feature story, NOAA Fisheries.

Renner, H. M., J. F. Piatt, M. Renner, B. A. Drummond, J. S. Laufenberg, and J. K. Parrish. 2024. Catastrophic and persistent loss of common murres after a marine heatwave. Science 386:1272-1276. DOI: 10.1126/science.adq4330.

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. 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. Irons, 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. 2021. Ecosystem response persists after a prolonged marine heatwave. *Scientific Reports* 11:6235. https://doi.org/10.1038/s41598-021-83818-5.

2. Products:

Peer-reviewed publications:

No new contributions for this reporting period.

Reports:

Arimitsu, M., D. Cushing, B. Drummond, S. Hatch, T. Jones, R. Kaler, E. Labunski, J. Lindsey, J. F. Piatt, H. Renner, and S. Whelan. 2024. Seabird Synthesis. Pages 152-163 *in* B. B. Ferris, editor. Ecosystem Status Report 2024: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West

Third, Suite 400, Anchorage, Alaska, 99501. https://apex.psmfc.org/akfin/r/akfin/151/files/static/v148/2024/GOA_ESR_2024.pdf.

Popular articles:

No new contributions for this reporting period.

Conferences and workshops:

Cushing D., E. Labunksi, R. Kaler, and R. Suryan. 2025. Seabird community responses to changes in ocean temperatures in the northern Gulf of Alaska. Oral presentation, Joint meeting of the Pacific Seabird Group and The Waterbird Society, San Jose, Costa Rica, January.

Cushing, D., R. Kaler, E. Labunski, and R. Suryan. 2025. Common trends in seabird abundance time-series on the northern Gulf of Alaska shelf. Poster presentation, Alaska Marine Science Symposium, Anchorage, Alaska, January.

Kaler, R. 2024. Prince William Sound marine bird population trends, 1989-2022. Poster presentation, 51st Annual Pacific Seabird Group meeting, Seattle, Washington, February.

Public presentations:

Kaler, R. 2024. Alaska's Ocean Sentinels: Seabirds as Ecosystem Indicators. Chugach School District's Science Week, Whittier, Alaska. Opening lecture with interactive stations on marine bird research. Two sessions with over 30 high school students and five high school teachers from across southcentral Alaska.

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

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

Kaler, R. and D. Cushing. 2024. Population trends of marine birds in Prince William Sound, Alaska, 1989-2022. Poster and handouts.

Data sets and associated metadata:

Cushing, D., E. Labunski, R. Kaler. 2024. Marine bird observation and density data from Northern Gulf of Alaska LTER cruises, 2023-2024. Pending publication, Research Workspace.

Kaler, R. 2025. Prince William Sound marine bird observations and populations trends, 2022-2024. Pending publication, Research Workspace.

Kuletz, K., D. Cushing, and E. Labunski. 2023. Marine bird survey observation and density data from Northern Gulf of Alaska LTER cruises, 2018–2022. Research Workspace. Dataset. doi:10.24431/rw1k45w

Additional Products not listed above:

3. Coordination and Collaboration:

The Alaska SeaLife Center or Prince William Sound Science Center

As part of the GWA-LTRM program, the PWS marine bird survey project coordinates with the Prince William Sound Science Center during quarterly meetings and for annual reporting. Currently, there are no collaborations with the Alaska SeaLife Center.

EVOSTC Long-Term Research and Monitoring Projects

This project is part of the Pelagic component of the GWA-LTRM program and coordinates with other GWA-LTRM projects in the following ways:

- We are involved in an on-going discussion to explore opportunities to integrate the July PWS marine bird data with the other projects, including those within the GWA-LTRM Pelagic component and GWA Environmental Drivers component. Additionally, the principal investigator (PI) has been coordinating with the GWA-LTRM Nearshore component (Heather Coletti) and Science Lead (Rob Suryan) to merge marine bird data sets into a broader geographic analysis of population trends. Additional discussions include comparing boat-based PWS marine bird survey data, which include sea otters with fixed-wing aircraft surveys conducted by sister agencies, with marine bird and mammal data collected during Nearshore project work.

- Collaboration within the GWA-LTRM Pelagic component (forage fish [24120114-C], humpback whale [24120114-O], killer whale [24120114-M], and marine bird [this project]), and between the Pelagic and Herring Research and Monitoring components, will continue to focus on physical and biological features of locations where whales and seabirds have been found to overlap in time and space.
- Marine bird surveys during Seward Line and NGA-LTER cruises are operationally and scientifically integrated with project 24120114-L, Seward Line monitoring. Ongoing data analysis also incorporates temperature anomaly time-series from the GAK1 project (24120114-I).

EVOSTC Mariculture Projects

Data on marine bird distribution are available for use in mariculture project planning in PWS.

EVOSTC Education and Outreach Projects

Robb Kaler participated in a Chugach School District Science Week education program in Whittier, Alaska, that included over 30 high school students and five high school teachers from across southcentral Alaska. The program included an opening lecture and interactive stations on marine bird research about seabirds as ecosystem indicators.

Individual EVOSTC Projects

The July PWS marine bird survey data are being used in a manuscript for the mink removal and pigeon guillemot restoration at the Naked Island Group (2014-2018; 2019-2023; projects 11100853-Am.8.29.13 and 15100853 - 23110853).

Trustee or Management Agencies

Since 2021, we have contributed an annually updated time-series of spring cross-shelf distribution of seabirds along the Seward Line to the Seabird Synthesis within the Gulf of Alaska Ecosystem Status Report (North Pacific Fishery Management Council). We also present this information at the annual Spring Preview of Ecological and Economic Conditions meeting hosted by the Alaska Fisheries Science Center.

Native and Local Communities

The Chugach School District Science Week education program involved Native and local communities.

4. Response to EVOSTC Review, Recommendations and Comments:

September 2024 EVOSTC Science Panel Comment:

The PIs continue to carry out the yearly NGA surveys by leveraging the Seward Line / LTER sampling trips, as well as the every-other year PWS surveys that form the bulk of the budget for this proposal. We appreciated the PI response that NGA bird surveys will have highest value in conjunction with LTER / Seward Line Data, but had concerns that the promised analyses of mechanistic drivers of patterns in the PWS data did not seem to be progressing and may be in jeopardy with the retirement of PI Kuletz.

PI Response:

Thank you for the comment regarding first-author publications. Upon completion of the 2017-2025 PWS marine bird report to the EVOSTC, we intend to prepare a first-authored manuscript summarizing population estimates, trends, and associated factors influencing patterns, 1989-2025.

D. Cushing (University of Alaska Fairbanks) and R. Suryan (National Oceanic and Atmospheric Administration) included PWS and Seward Line marine bird survey data in a dynamic factor analysis that will be incorporated into the upcoming science synthesis report. The analysis addresses whether the changes in marine bird abundance on the shelf during have persisted, reverted to pre-heatwave, or changed to something different.

S. Start (U. S. Geological Survey) and E. Osnas (U. S. Fish and Wildlife Service) are using the pigeon guillemot trends as a PWS-wide variable to compare Naked Island Group guillemot recovery following culling of mink at historical colony locations. The effort includes D. Irons (U. S. Fish and Wildlife Service, ret.) and D. Roby (Oregon State University/ U. S. Geological Survey, ret.).

September 2024 EVOSTC Science Panel Comment:

This project has run spatially comprehensive shoreline, coastal, and pelagic boat-based transects in PWS in July in most years since 1989 to document the abundance and distribution of marine birds. This important time series is among the longest to record changes in seabird populations in PWS since the oil spill. More recently (2018-on), the project has run cross-shelf and along-shelf transects to monitor seabird distribution and abundance in the northern GOA, Resurrection Bay,

and PWS in association with the NGA-LTER project (NSF). These transects include the Seward Line that has been run routinely since 1998. The information they are gathering is of high value to assessing patterns of long-term variability in seabird abundances in PWS, the status of injured species, and the role of environmental change in the ecology of PWS and the northern GOA.

PI Response:

Thank you for the comment acknowledging the value of the data and the collaboration with the National Science Foundation's support of the NGA-LTER, which also includes support from the North Pacific Research Board. Long-term data collected on marine bird distribution and abundance are critical to assessing recovery of injured species and informing fisheries management in PWS and the Northern Gulf of Alaska.

September 2024 EVOSTC Science Panel Comment:

The Science Panel has concerns about the slow dissemination of results in refereed scientific literature, particularly of the PWS surveys. We encourage the PIs to take seriously the importance of leadership in this respect: contributing data to others is worthy, but not sufficient.

PI Response:

Thank you for the comment emphasizing the importance of publishing these data, particularly the PWS marine bird data, in a peer-reviewed journal. The PI understands that while these data are available and being used by collaborators, it is critical to lead a senior authored manuscript describing population trends and distributions of marine birds in PWS associated with mechanistic drivers of patterns using PWS data.

September 2024 EVOSTC Executive Director Comments

I concur with the Science Panel. The PI has been slow to respond to staff communications. Funding for this project is managed by NOAA. The expenses on the annual reports are well documented and easy to track. The Fiscal Manager is responsive to budget questions. We would like to see an improvement in PI communications in the future.

September 2024 EVOSTC PAC Comments

Whissel asked about published papers and project staffing. Kaler stated Cushing's master's was developed on the dataset, and he is now working on a PhD. With project staff retired, Kaler intends to work harder to get project data published and coordinate more with other Gulf Watch

Alaska components. It was difficult with vacated staff, and not all those responsibilities have been assumed by other PIs.

Stekoll asked about the decline in species in PWS, control sites, and separating causation between EVOS and climate change. Kaler stated the original study design in 1984/1985 included the entire coastline, and they continued collecting data after EVOS occurred. At this point, they no longer feel the oil is the major cause of species decline, and populations were probably declining already.

Whissel introduced a motion to proceed with minor concerns based on the Science Panel's comments. Stephens seconded. Whissel noted the project was one of few with a decent baseline dataset, and they appeared to be on their way to mitigating issues. There was no opposition to the motion, and it passed unanimously.

5. Budget:

PWS marine bird surveys are conducted every other year and the next survey will be in July 2025. Seward Line and NGA-LTRM were conducted in 2024, with funding support from EVOSTC and the North Pacific Research Board. Spending for this project is on track.

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

Budget Category:	Proposed FY 22	Proposed FY 23	Proposed FY 24	Proposed FY 25	Proposed FY 26	5- YR TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$28,907	$122,278	$31,869	$136,816	$37,377	$357,247	$183,054
Travel	$2,168	$20,913	$2,193	$21,384	$2,219	$48,877	$25,274
Contractual	$43,500	$110,058	$45,702	$113,952	$48,016	$361,228	$199,260
Commodities	$0	$21,020	$6,000	$27,613	$6,000	$60,633	$27,020
Equipment	$13,500	$102,250	$0	$4,400	$0	$120,150	$115,750
Indirect Costs Rate = 0%	$0	$0	$0	$0	$0	$0	$0
SUBTOTAL	$88,075	$376,519	$85,764	$304,165	$93,612	$948,135	$550,358
General Administration (9% of subtotal)	$7,927	$33,887	$7,719	$27,375	$8,425	$85,332	N/A
PROJECT TOTAL	$96,001	$410,406	$93,483	$331,540	$102,037	$1,033,467	
Other Resources (In-Kind Funds)	$29,053	$30,429	$32,841	$33,841	$35,879	$162,043	

COMMENTS:
No PWS marine bird surveys were conducted in July 2024. Seward Line and NGA-LTRM were conducted with funding support from the North Pacific Research Board. Dr. Erik Osnas (USFWS-Migratory Bird Management, Supervisory Biometrician) has provided in-kind matching contributions. Contractual costs in 2024 were $60k versus $74k; however, the Seward Line survey contract was lower than budgeted as agency staff were used (salary, travel). Cost share includes: USFWS Biometrician (GS-13, 2 months/year = $20K); GIS Biologist (GS-11, 1 months/year = $7K). The total in-kind contribution from USFWS is listed in the Other Resources row.

FY22-26	Project Number: 24120114-M Project Title: PWS/LTER Marine Bird Surveys Primary Investigator: Kaler (USFWS)	TRUSTEE AGENCY SUMMARY PAGE