ATTACHMENT C ***EVOSTC Annual Project Report Form***

Form Rev. 9.14.17

1. Project Number:

17120114-L

2. Project Title:

The Seward Line – Marine Ecosystem monitoring in the Northern Gulf of Alaska

3. Principal Investigator(s) Names:

Russell R Hopcroft, Principal Investigator, University of Alaska Fairbanks
Seth L Danielson, University of Alaska Fairbanks
Kenneth O. Coyle, University of Alaska Fairbanks

4. Time Period Covered by the Report:

February 1, 2017-January 31, 2018 (Year 6)

5. Date of Report:

March 2018

6. Project Website (if applicable):

www.gulfwatchalaska.org

7. Summary of Work Performed:

The scientific purpose of this project is to develop an understanding of the response of the northern Gulf of Alaska marine ecosystem to climate variability and provide baselines against which to access any anthropogenic influences. Toward this end, the Seward Line cruises on the Gulf of Alaska shelf determine the physical-chemical structure, primary production and the distribution and abundance of zooplankton, along with their seasonal and inter-annual variations. Some of the data are compared with historical data sets whereas other data sets are a product of this continuing systematic sampling effort on this shelf.

Specifically, cruises:

1. Determine thermohaline, velocity, and nutrient structure of the Gulf of Alaska shelf, emphasizing the Seward Line, and Prince William Sound (PWS) stations.
2. Determine the state of carbonate chemistry (i.e., Ocean acidification – Alaska Ocean Observing System funded)
3. Determine the patterns of macronutrient availability across the sampling domain
4. Determine phytoplankton biomass distribution (as chlorophyll)
5. Determine composition and biomass of phytoplankton and microzooplankton (North Pacific Research Board [NPRB] funded)
6. Determine the distribution, abundance and taxonomic composition of zooplankton.

7. Determine the distribution and abundance of seabirds and marine mammals (NPRB funded)

During 2017, monthly sampling of physics, chemistry and biology began at sampling stations GAK1 and Res2.5 in March and continued until November.

During the May cruise, failure of the hydrographic wire termination resulted in the loss of our Multinet the first night of sampling. Fortunately, a second system had been purchased during 2016, but the necessary return to port for the net and re-termination of the cable resulted in the loss of nearly a day of ship time. Despite this, continued issues with slippage of the termination, and poor weather, most of the planned activities were completed, with the line extended out to GAK14. High winds in eastern PWS prevented completion of conductivity, temperature, and depth casts (CTDs) and vertical egg tows (Calvets) at PWSD-F, as well as Multinet collections at PWSB-F. Deepwater zooplankton tows could not be made due to time constraints.

The September cruise was relatively uneventful. All routine stations were completed except for PWS-F and multinets at Montague Strait (MS2). Sampling was extended out to GAK15. Deepwater zooplankton sampling was completed at GAK15 and PWS2.

Oceanographic Sampling

Although spring temperatures in the upper 100m had returned to their long-term mean, remnants of warm water from "The Blob"/El Nino remained at depth (Fig. 1). Chlorophyll remained low throughout the cruise, although satellite images suggested the bloom had just occurred in prior weeks.

After a series of warm years, September temperatures in the upper 100m averaged across the line were at the long-term climatological mean, although a warm spot existed mid-shelf and cool waters occurred below the thermocline offshore (Fig. 2). In situ chlorophyll concentrations were typical of September albeit somewhat elevated on the mid and outer shelf. Between 2014 and 2017 anomalous warming at the surface and to depth were clearly documented on the Seward line in May and September (Fig. 3).

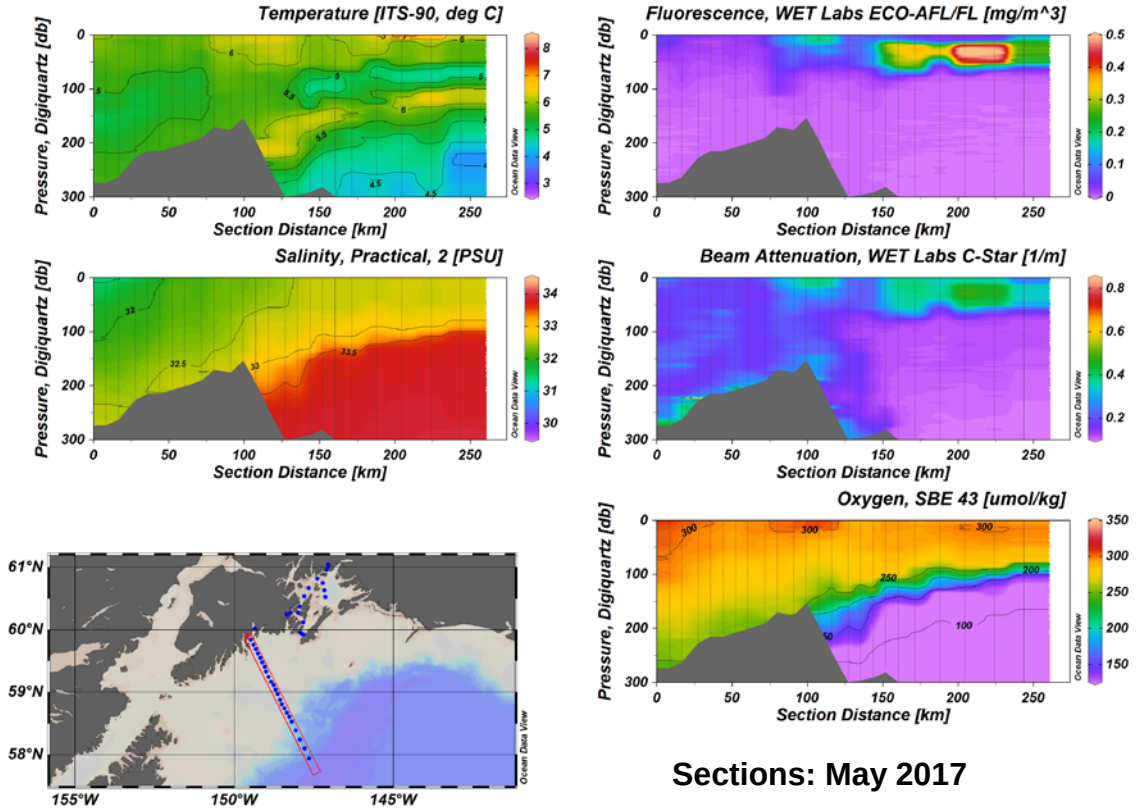

Figure 1. Physical oceanographic recordings on stations along the Seward Line (map in lower left) during May 2017.

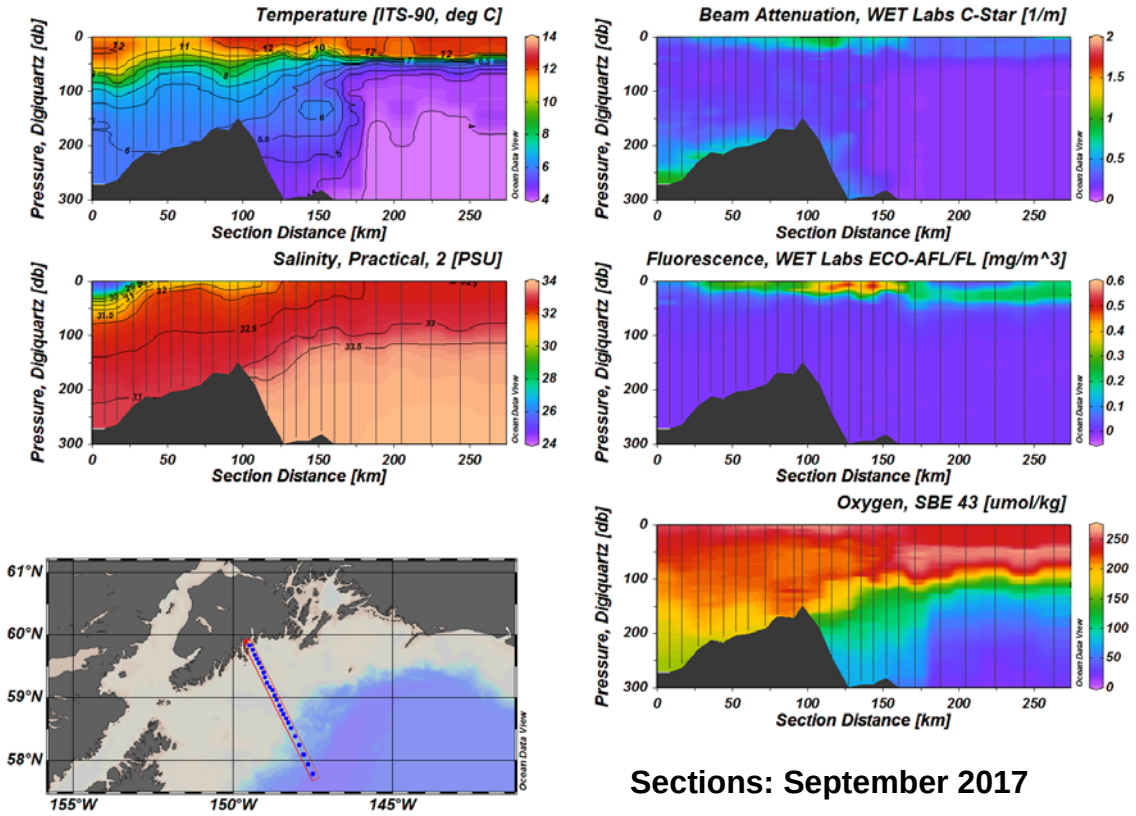

Figure 2. Physical oceanographic recordings on stations along the Seward Line (map in lower left) during September 2017.

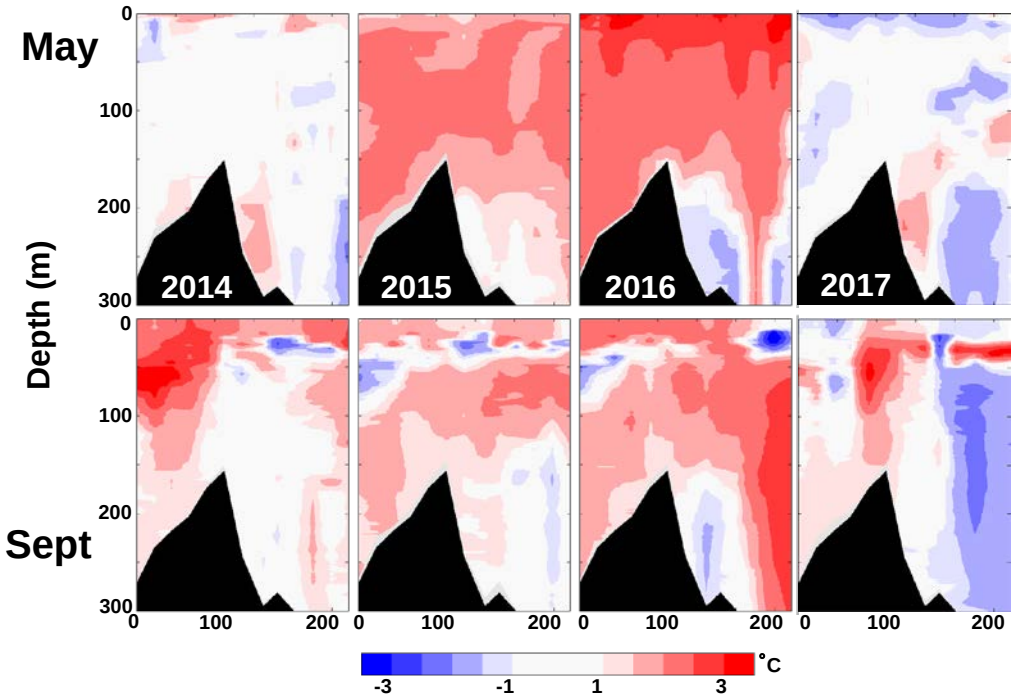

Figure 3. Temperature anomalies along the Seward Line during May (top) and September (bottom) during 2014-2017.

Phytoplankton biomass on the Seward Line was relatively low (compared to potential spring bloom levels) during the May 2017 sampling period, although most of the cells on the mid and outer line were >20 µm (Fig. 4). This contrasts strongly with the recent warm years (2015-16), when spring chlorophyll increases were mainly in the form of small (<20 um) cells (Fig. 5). The September 2017 Seward Line sampling encountered the highest fall chlorophyll concentrations seen at least since 2012. Many, if not most, of the >20 µm cells in this fall bloom were dinoflagellates, although diatoms were present as well.

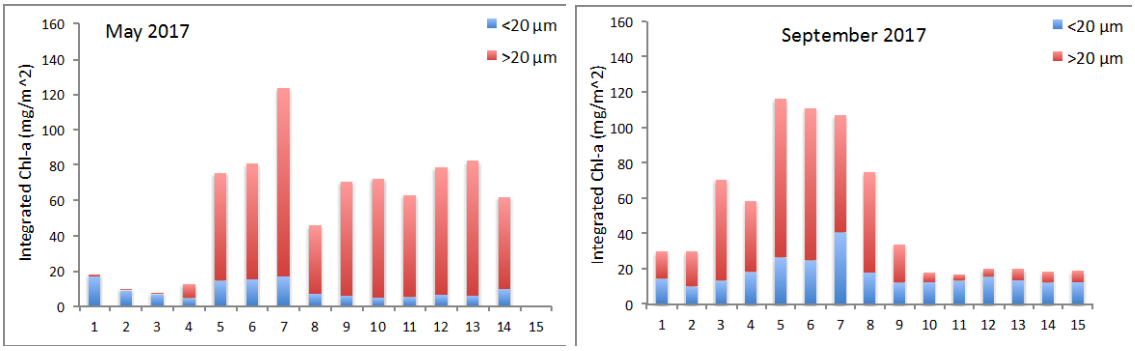

Figure 4. Chlorophyll concentrations in May (left) and September (right) 2017 at stations along the Seward Line.

Microzooplankton biomass on the Seward Line during May was exceptionally low during the warm years of 2015-16 (Fig. 5). The community largely comprised small ciliates, with occasional patches of large, chloroplast-retaining (mixotrophic) ciliates. Warm year effects were not consistently evident in September microzooplankton samples, although September

2016 had some of the highest microzooplankton biomass observations observed in the fall record. 2017 samples are still being processed.

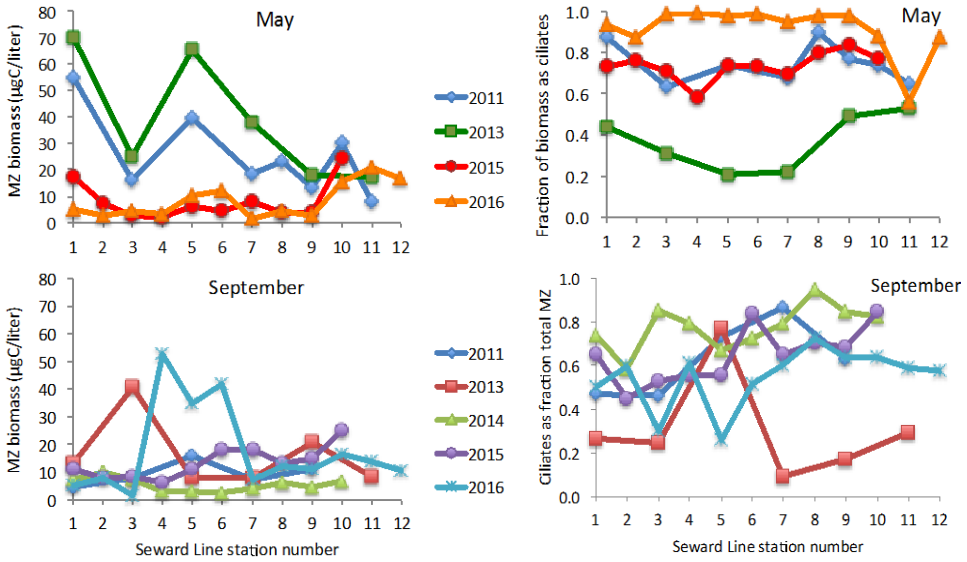

Figure 5. Microzooplankton biomass (left) and the fraction of the biomass comprised of ciliates (right) from 2011 through 2016 on the Seward Line recorded during May (top) and September (bottom).

Preliminary sample analysis confirm that during May of 2016 and 2017 a shift in relative abundance of two keystone copepods had occurred although their combined numbers were more typical: *Neocalanus flemingeri* was present only in low abundance, while *Neocalanus plumchrus* was unusually prominent (Fig. 6). In general, the high numbers of southern copepods observed in recent years were absent during May, but 2 of 4 species rebounded to high abundances by September 2017 (Fig. 7).

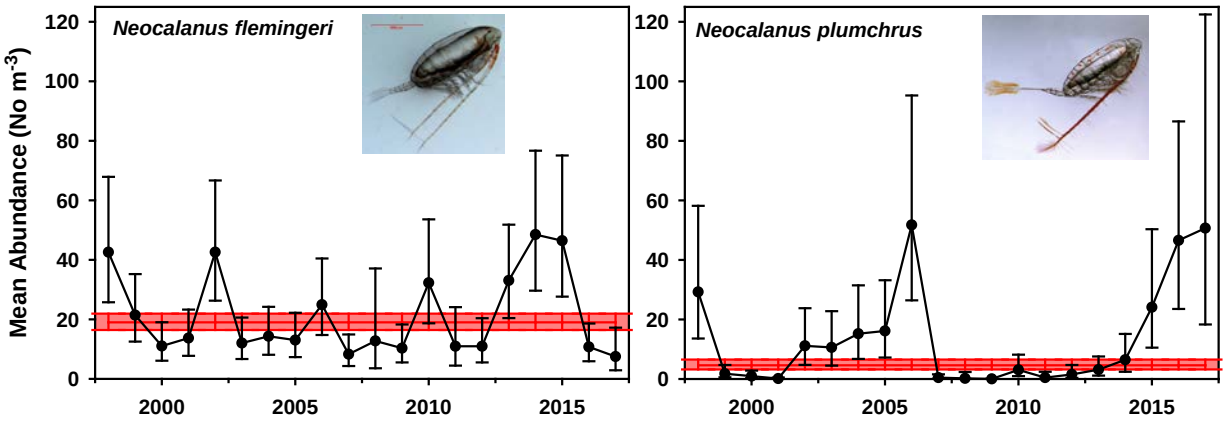

Figure 6. Mean abundance of *Neocalanus flemingeri* and *N. plumchrus* during May samples of the Seward Line from 1998 to 2017.

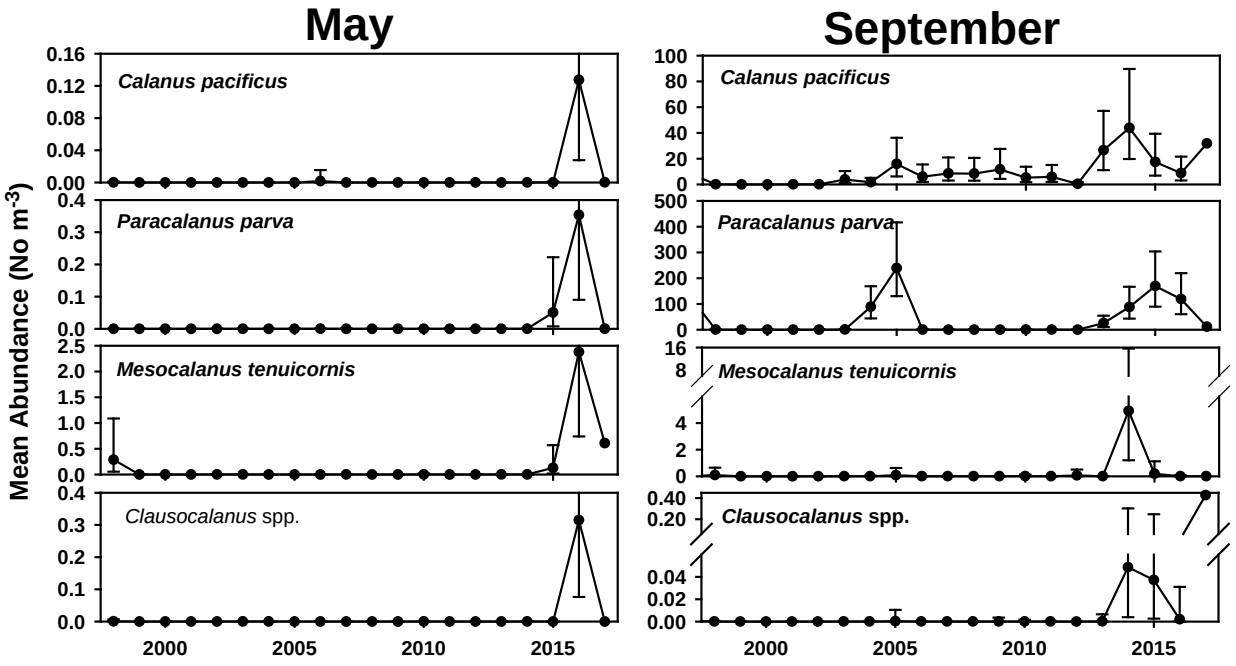

Figure 7. Mean abundance of southern copepod species recorded during May (left) and September (right) on the Seward Line from 1998 through 2017.

Seabird Surveys and Marine Mammal Observations

During May, seabird surveys covered 786 km during which we recorded 3,062 individuals of 41 bird species, with 11 additional species observed off-transect. As is typical in spring, the most abundant species were black-legged kittiwake (27%), common murre (19%), tufted puffin (14%), red-necked phalarope (10%), and fork-tailed storm-petrel (9%). Highest densities of seabirds occurred near breeding colonies at Cape Resurrection and East Amatuli Island. Several surface-feeding species, including kittiwakes (Fig. 8, top left) and phalaropes were feeding at tidal rips in Resurrection Bay and the southwestern passages of PWS. Along the Seward line, three areas had relatively high bird densities: near GAK1 (mainly kittiwakes and murres); near GAK4 (predominately fork-tailed storm petrels); and near the shelf break at GAK8 (storm petrels). Albatrosses aggregated near the shelf break or off shelf (Fig. 8, top right). We also observed 26 individuals of 6 species of marine mammals on transect, with 2 additional species off-transect; in nearshore areas these included sea otters, Steller sea lions, harbor and Dall's porpoises, and a humpback whale (Fig. 8, bottom). No marine mammals were observed elsewhere on the shelf, but northern fur seal and two large whales were recorded off shelf (Fig. 8, bottom right).

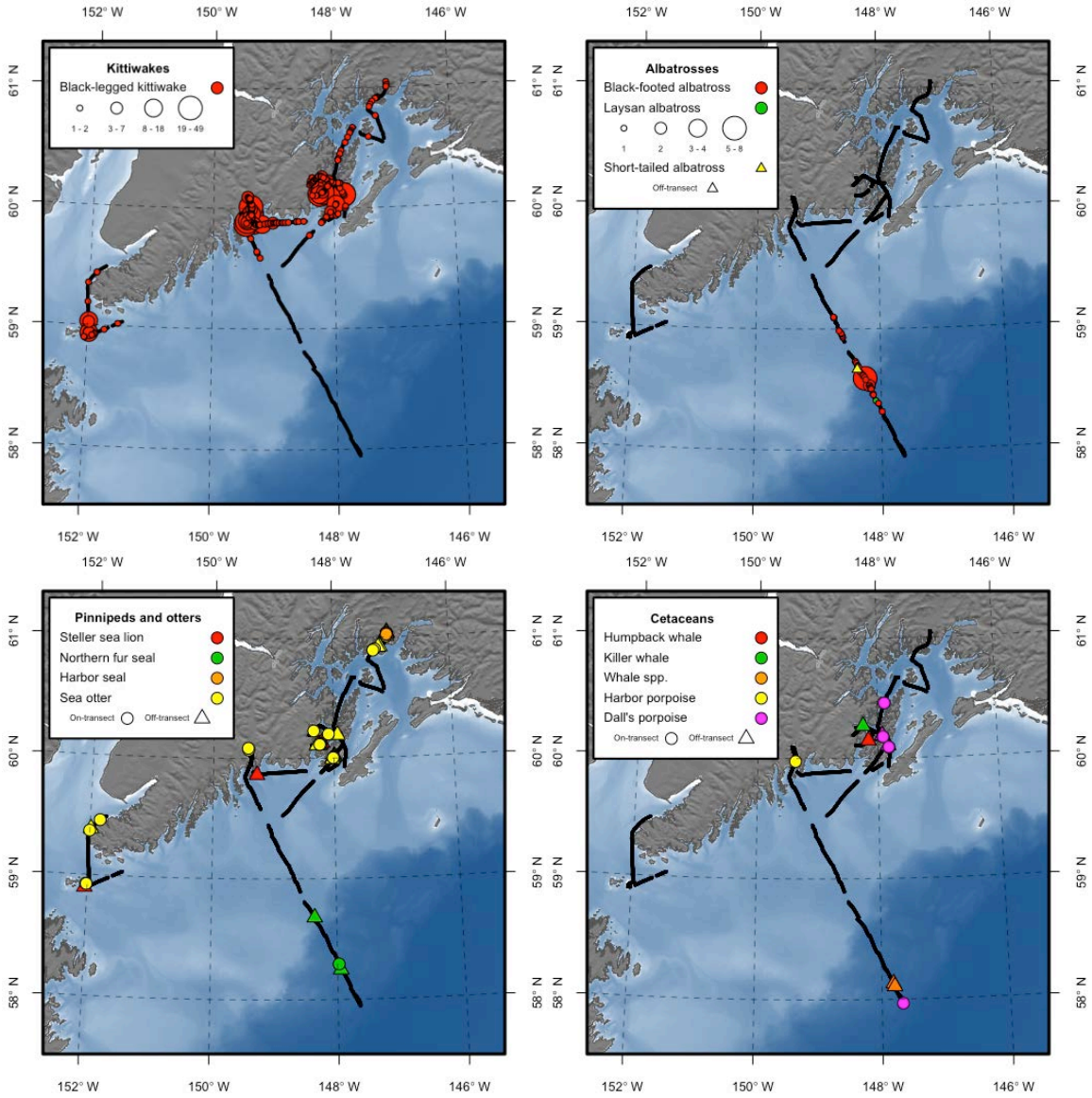

Figure 8. Kittiwakes (top left), albatross (top right), pinnipeds and sea otters (bottom left), and cetaceans (bottom right) observed during Seward Line surveys in May 2017.

Seabird surveys in September consisted of two legs, the first to recover offshore mooring for Scripps Institute of Oceanography, and the second for the Seward Line proper. They covered a total of 1,202 linear km of surveys, with 543 km during Leg I and 659 km during Leg II. On-transect, we observed a total of 1,666 individuals of 34 species of birds, with an additional 17 species observed off-transect during surveys or while at stations. The most abundant species of marine bird was the black-legged kittiwake (26%; Fig. 9, top left), followed by sooty shearwater (14%; Fig. 9, bottom right), common murre (12%; Fig. 9, bottom left), fork-tailed storm-petrel (9%; Fig. 9, top right), tufted puffin (9%), northern fulmar (8%), and horned puffin 7%); no other species comprised more than 5% of the total. The most widely-distributed species of marine bird were the black-legged kittiwake and the fork-tailed storm-petrel, both of which occurred from northern PWS to the seamount. Common murres were abundant in the inner shelf region, PWS, and Kachemak Bay, and did not occur beyond 50 km from the coast. While large flocks of sooty shearwaters were observed near the southwestern

Kenai Peninsula, small numbers were scattered across the shelf, slope, and Gulf of Alaska basin.

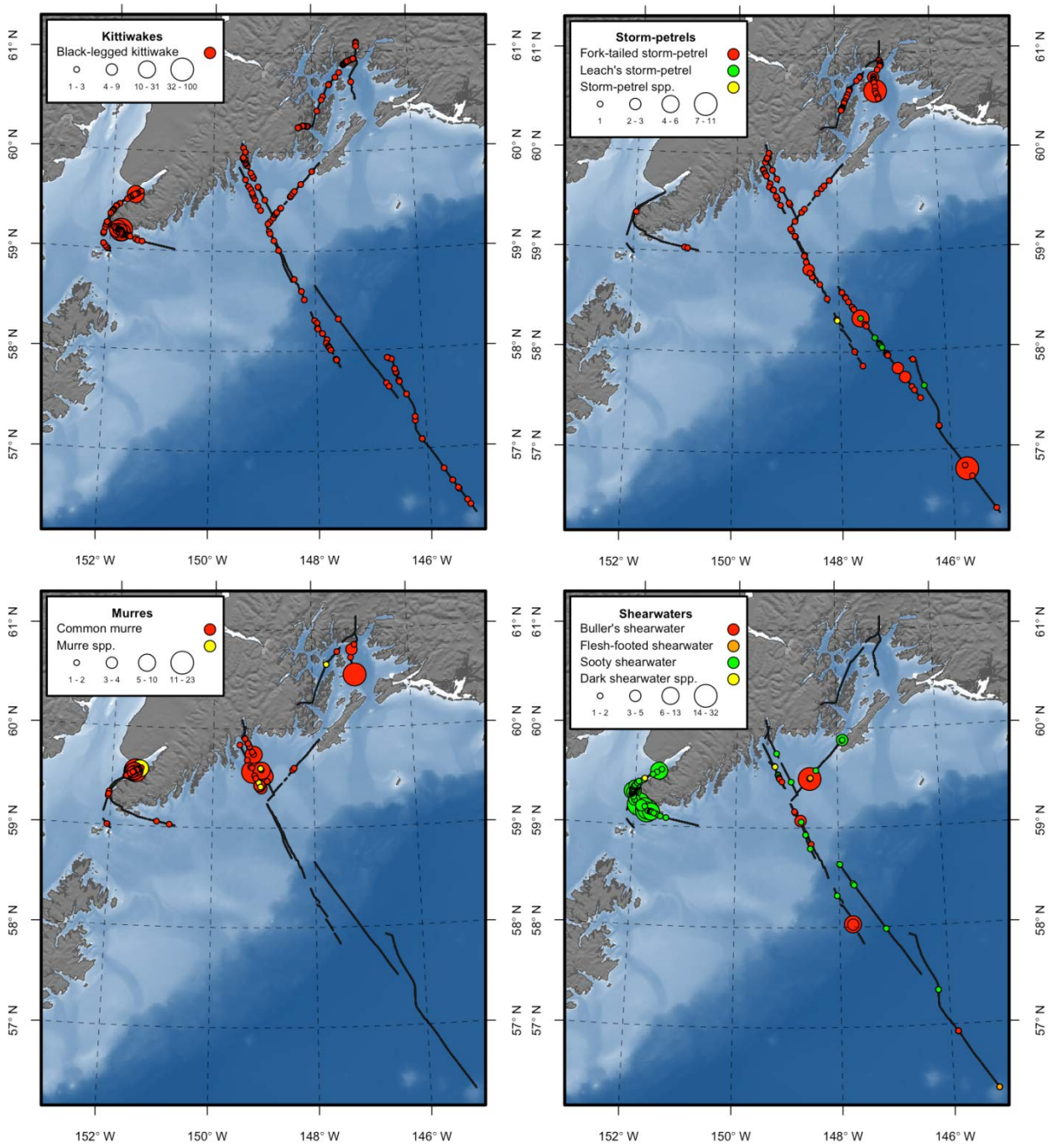

Figure 9. Kittiwakes (top left), storm-petrels (top right), murres (bottom left), and shearwaters (bottom right) observed during Seward Line surveys and offshore mooring recovery in September 2017.

During the surveys we recorded 55 marine mammals, most of which were off transect; these included four species of cetaceans, plus harbor seals and sea otters (Fig. 10).

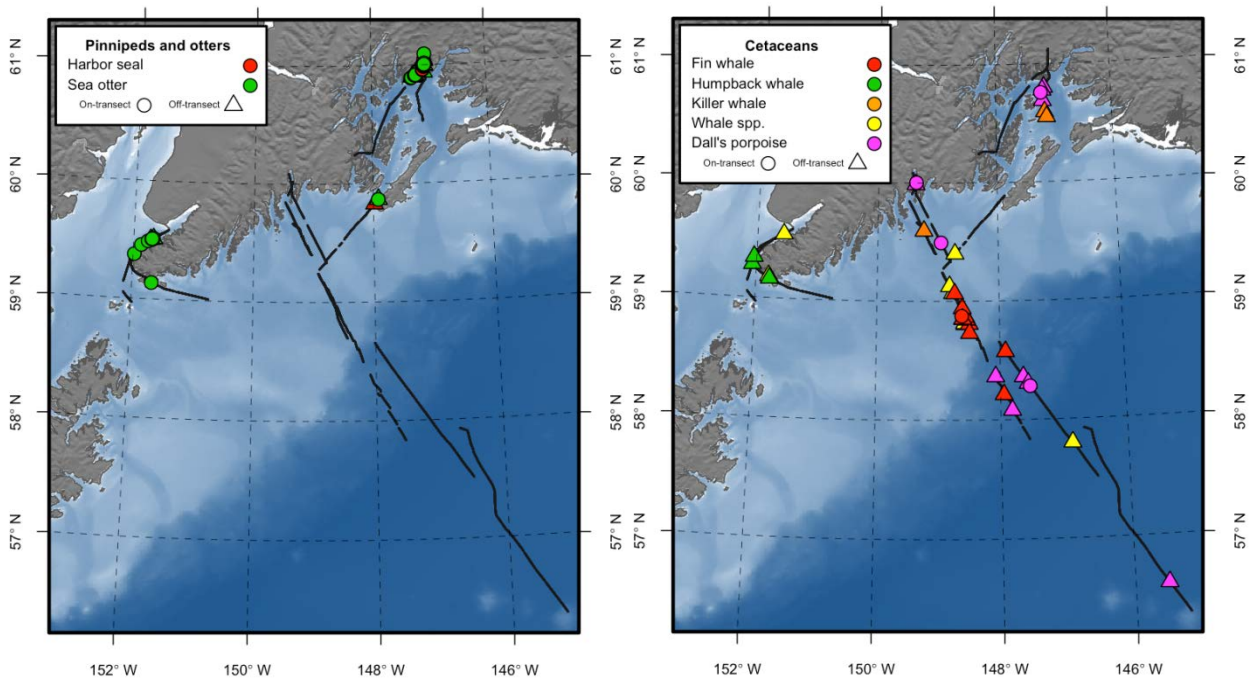

Figure 10. Pinnipeds and otters (left) and cetaceans (right) observed during Seward Line Surveys in September 2017.

8. Coordination/Collaboration:

A. Projects Within a Trustee Council-funded program

1. Within the Program

This project links tightly with the GAK-1 mooring (project 17120114-I), providing a cross shelf context for its observations. It complements the continuous plankton recorder (project 17120114-D), PWS (project 17120114-G), and Lower Cook Inlet/Kachemak Bay (project 17120114-J) long-term monitoring efforts by providing more detailed oceanographic evaluation of the Gulf of Alaska shelf and the major passages in PWS than is provided by the other programs. These components overlap relatively little in their sampling locations — enough to ensure comparability between datasets, but not enough to be duplicative and wasteful of resources. The addition of monthly sampling in Resurrection Bay aligns sampling periodicity with other Environmental Driver component projects. The additional monthly sampling in Resurrection Bay and at GAK-1 provide oceanographic context for Nearshore component project activities underway within Resurrection Bay.

2. Across Programs

a. Herring Research and Monitoring

The Seward Line makes physical and biological data available to the Herring Research and Monitoring program.

b. Data Management

We are coordinating with the Data Management team to upload data to the Research Workspace and make it available on the Gulf of Alaska data portal and review metadata and update for accuracy. In addition, we worked with Axiom to refine several visualization tools for the Seward Line data.

c. Lingering Oil

None

B. Projects not Within a Trustee Council-funded program

None

C. With Trustee or Management Agencies

The Seward Line PIs are working in partnership with the new National Science Foundation-funded long-term ecological research (LTER) program to increase the inter-disciplinary, temporal and spatial coverage of high-resolution continuous data collections in the northern Gulf of Alaska. The infrastructure of the LTER project represented a leverage opportunity to increase our mooring-based monitoring on the mid to outer shelf portion of the Seward Line. The LTER will include an additional "Ecosystem Observatory" mooring along the Seward line on the northern Gulf of Alaska shelf. This offers us the ability to take a significant step forward in the year-round monitoring of many physical, chemical, and biological factors. In addition to the Seward Line, new LTER oceanographic sampling lines will located south of Kodiak Island across Albatross Bank, off the Copper River Delta to Middleton Island (GWA Pelagic Component forage fish sampling site) and the continental shelf break, near Kayak Island, along with a high spatial resolution process sampling grid off the Copper River Delta. The LTER greatly expands spatial and temporal sampling of the GOA upstream and downstream of the Seward Line and other GWA components.

Like other Environmental Driver components, Seward Line data is available to the Alaska Department of Fish and Game for salmon forecasting, and provided to the National Oceanographic and Atmospheric Administration for their GOA Ecosystem Status reports.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

Batten, S.D., D.E. Raitsos, S. Danielson, **R.R. Hopcroft**, K.O. Coyle & A. McQuattors-Gollop. *In press*. Interannual variability in lower trophic levels on the Alaskan Shelf. Deep Sea Res. II. DOI:10.1016/j.dsr2.2017.04.023.

Roncallia, V., Cieslak, M.C., Sommer, S.A., **Hopcroft, R.R.** & Lenz, P.H. *In press. De novo* transcriptome assembly of the calanoid copepod *Neocalanus flemingeri*: A new resource for emergence from diapause. *Mar. Gen.* DOI:10.1016/j.dsr2.2017.04.023.

Hopcroft, R. R., S. L. Danielson, and S. L. Strom. 2018. The Seward Line: Marine ecosystem monitoring in the Northern Gulf of Alaska. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 16120114-J). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

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

Cushing, Kuletz, Hopcroft, Danielson, Labunski. Shifts in cross-shelf distribution of seabirds in the northern Gulf of Alaska under different temperature regimes, 2007-2015. **Poster Presentation**. Pacific Seabird Group, Tacoma, WA, Feb 2017

Hopcroft. 2017. Latest observations and collections made along the Seward Line, Alaska. **Oral presentation**. International Conference on Copepoda, Los Angeles. June.

Hopcroft, Coyle, Danielson, Danielson. The Seward Line - 2017. **Poster Presentation**. AMSS January 2018

Hopcroft, Coyle, Danielson & Strom. Twenty Years of Observations Along the Gulf of Alaska's Seward Line: Impact of Continued Warm Conditions. **Oral Presentation**. Kodiak Marine Science Symposium, Kodiak, April 2017

Hopcroft et al. Oceanography in the Northern Gulf of Alaska: the Seward Line. **Public Presentation** for Osher Lifelong Learning Institute, Fairbanks, December 2017.

Hopcroft, Strom, Coyle & Danielson: Three in a row: continued warm conditions along the Gulf of Alaska's Seward Line. **Oral Presentation**. ASLO, Honolulu - March 2017

Kaler, Kuletz, Dragoo, and Renner. 2017. Unusual observations of seabirds in the Gulf of Alaska following the 2015-2016 mass die-off. **Article**. Delta Sound Connections. http://pwssc.org/wp-content/uploads/2017/06/DSC-2017-web2.pdf.

Lenz, Roncalli, Hartline, Germano, Cieslak, Strom, & Hopcroft. The physiological ecology of the calanid copepod, *Neocalanus flemingeri* in the northern Gulf of Alaska. **Oral Presentation**. AMSS January 2018

Monson, Holderied, Campbell, Danielson, Hopcroft, Ballachey, Bodkin, Coletti, Dean, Iken, Kloecker, Konar, Lindeberg, Robinson, Weitzman, Suryan. Congruence of intertidal and pelagic water and air temperatures during an anomalously warm period in the northern Gulf of Alaska; the "Blob" washes ashore. **Poster Presentation**. AMSS January 2018

Roncalli, Mathews, Cieslark, Hopcroft, Hopcroft, & Lenz. Physiological changes in *Neocalanus flemingeri* females during the transition from diapause to reproduction. **Oral Presentation**. ASLO - Feb 2017

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

First 5 years of GWA data all published through AOOS/Axiom to DataONE.

Hopcroft, R. R. 2017. Seward Line Conductivity, Temperature, and Depth (CTD) Data, 2012 to 2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. Exxon Valdez Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1l.

Hopcroft, R. R. 2017. Prince William Sound Zooplankton Data, 1997 to 2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez Oil* Spill Trustee Council

Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1k.

Hopcroft, R. R. 2017. Prince William Sound Chlorophyll-A and Nutrient Data, 2012 to 2016, Gulf Watch Alaska Environmental Drivers Component. Dataset. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1j.

Kuletz, K. J. 2017. Seward Line and Lower Cook Inlet Marine Bird Survey Data, 2006-2016, Gulf Watch Alaska Nearshore Component. *Exxon Valdez* Oil Spill Trustee Council Long-Term Monitoring program, Gulf Watch Alaska. Research Workspace. https://doi.org/10.24431/rw1k1m.

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

2017 cruise plans posted to Research Workspace and processed CTD data added as scheduled. Draft Nutrient and Chlorophyll data added. Seabird data and reports have also been uploaded.

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comments and Responses on Revised FY17-21 Proposal, September 2016

In September 2016, the Science Panel commented: The Science Panel appreciates transfer of funds among projects to support additional sampling relevant to the spill area.

PI Response: Thank you for the comment.

Science Panel Comments and Responses on FY18 Work Plans, September 2017

In September 2017, the Science Panel commented: This is an important long-term data collection project that needs to continue. The Panel is enthusiastic about the incorporation of an LTER site to expand the scope of this project. The Panel is pleased to see that sampling will occur around Middleton Island, and that there will be integration with the predator-prey project.

PI Response: Thank you for the comment.

11. Budget:

Please see provided program workbook.

While compiling the FY17 cumulative budget spent for the Seward Line project we discovered internal accounting discrepancies for FY17. The accounting is in review and the discrepancies will be rectified in FY18.