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

Form Rev. 8.30.18

**1. Program Number:**

18120114-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, 2018-January 31, 2019

**5. Date of Report:**

April 1, 2019

**6. Project Website (if applicable):**

www.gulfwatchalaska.org

**7. Summary of Work Performed:**

In 2018 the Seward Line program began a greatly expanded spatial extent, and an additional cruise added to mid-summer due to elevation as a National Long-term Ecological Research (LTER) site through new funding from the National Science Foundation (NSF). All three cruises were blessed by relatively good weather, very successful and accomplished nearly all their objectives. For reporting efficiency not all data from the additional transects lines will be reported here, however, all the data will be available to Gulf Watch Alaska (GWA) through the workspace. Further details appear within the cruise reports

During May surface temperatures were roughly between 5.5-6°C, with temperatures averaged across the upper 100 m of the Seward Line near the 20-year mean. A chlorophyll bloom was underway just beyond the shelf break (Fig. 1).

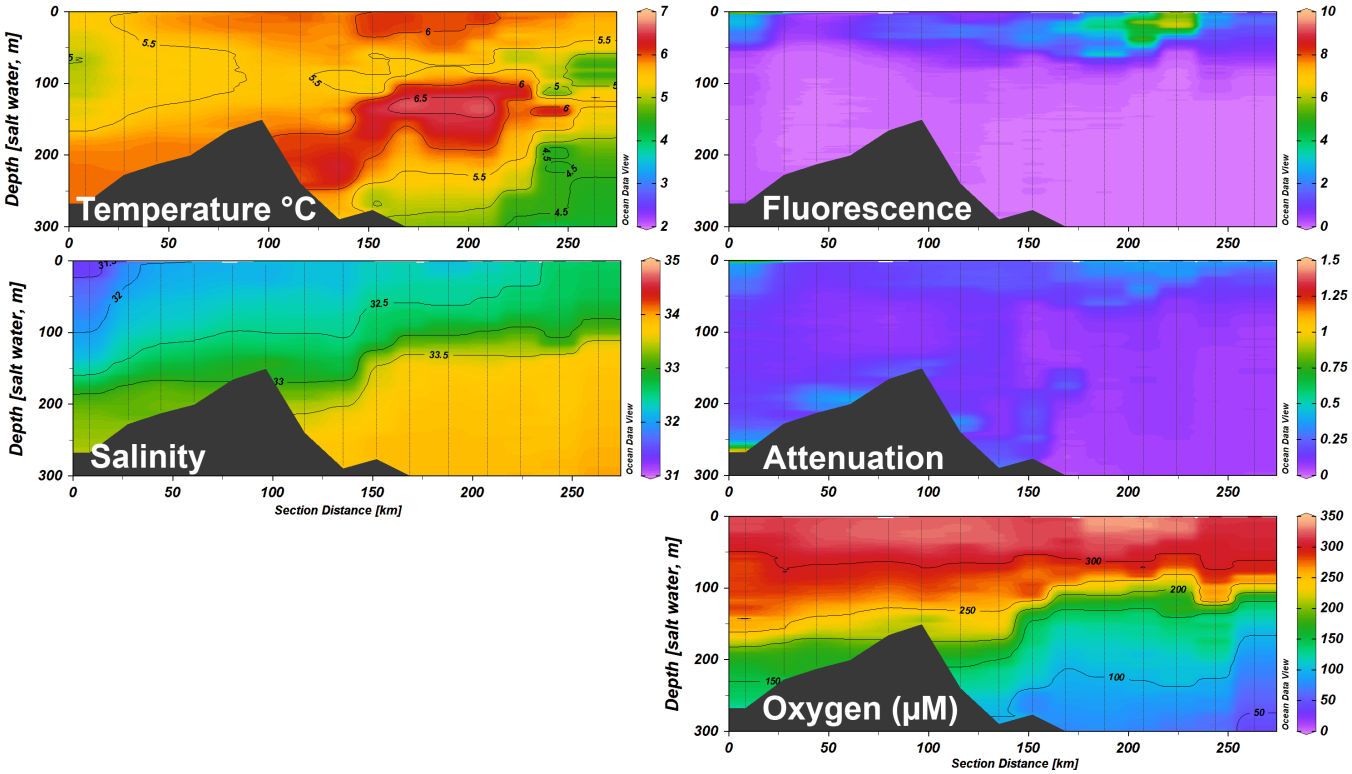


Figure 1. Hydrographic sections over upper 300 m of the Seward Line transect, May 2018.

By July, surface temperatures had warmed to 12-13°C, and the Alaska Coast Current has begun to intensify spreading across the shelf to at least shallow ridge at GAK6. A new addition for this season was an *in situ* nitrate sensor (SUNA) that allows us to assess the current state of nitrate depletion. By summer we can see the absence of nitrate in surface waters, except for GAK11, where a frontal feature appeared to exist. A subsurface chlorophyll maximum typical of summer had developed across the line (Fig. 2).

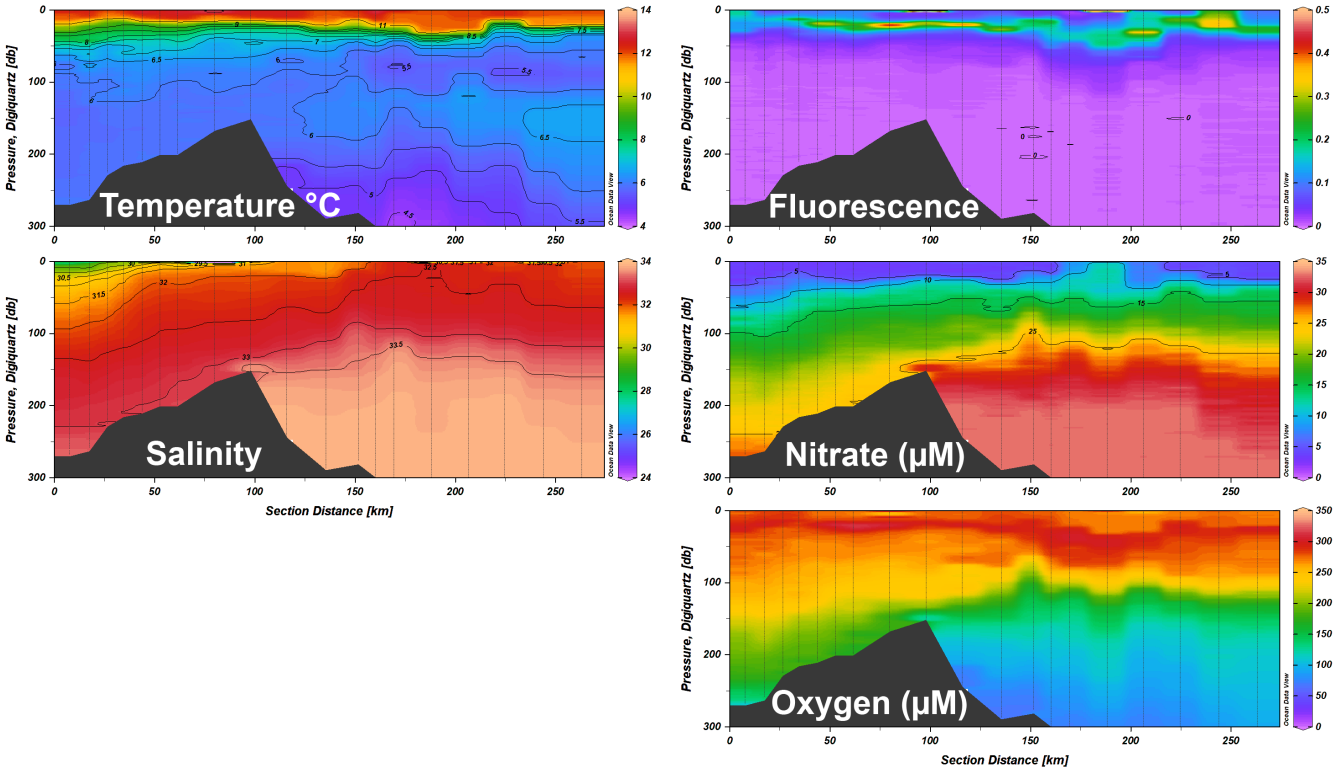


Figure 2. Hydrographic sections over upper 300 m of the Seward Line transect, July 2018.

Although cooling has typically begun by September, during 2018 temperature had continued to increase and were still 13-14°C, well above normal. Despite these warm surface temperatures, temperatures averaged across the upper 100 m were below normal over the shelf (particularly in the Alaska Coastal Current) but slightly above average off the shelf, resulting in an overall means across the line's upper 100m of 0.4°C below the 20 years mean. The Alaska Coastal Current remained apparent out to the mid-shelf. Nutrients remained depleted in the surface layer and a narrow and minor subsurface chlorophyll maximum was apparent across most of the line (Fig. 3).

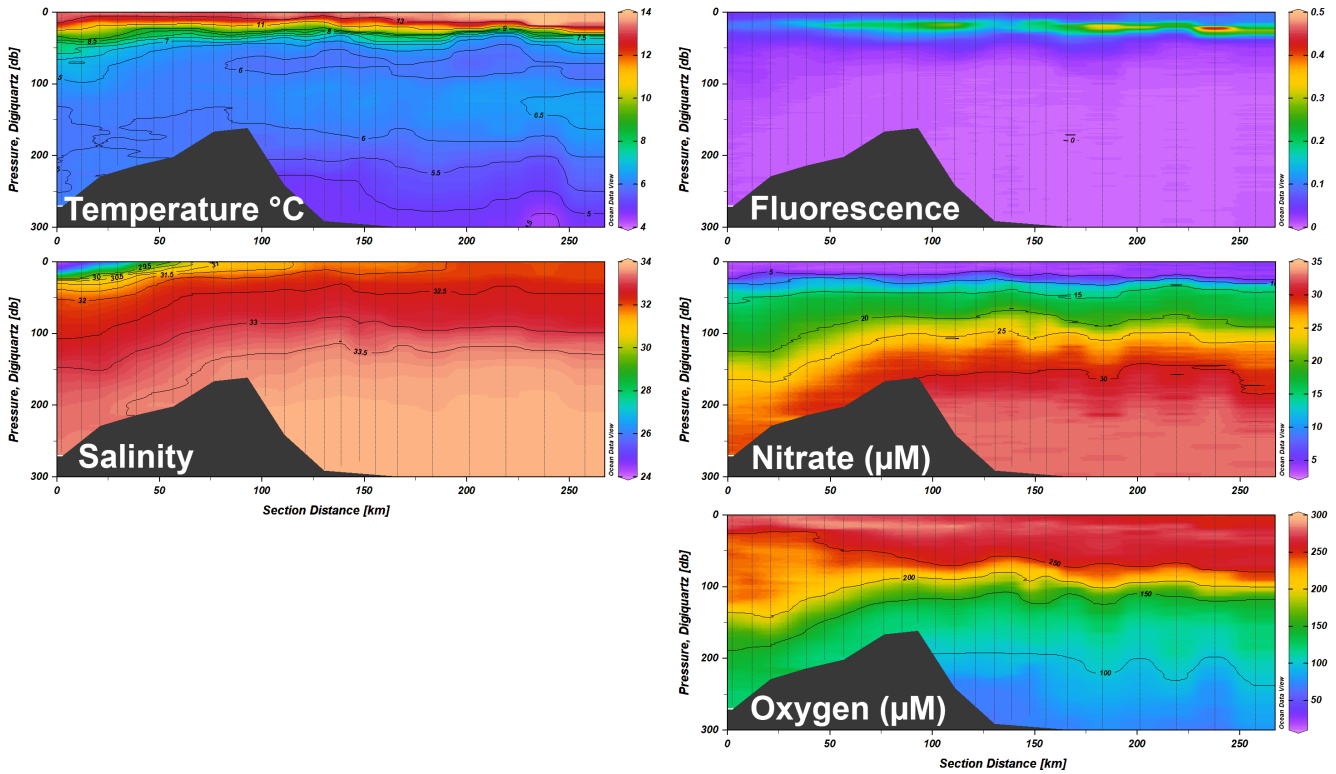


Figure 3. Hydrographic sections over upper 300 m of the Seward Line transect, September 2018.

Phytoplankton biomass on the Seward Line was generally relatively low (compared to potential spring bloom levels) during the May 2018 sampling period, although most of the cells on the mid and part of the outer line were >20 µm. During summer and September chlorophyll concentrations were low as is normal for these periods (Fig. 4). With an exception of an offshore peak in summer and several coastal stations during September most cells were small. These size related patterns applied across most of the expanded sampling domain.

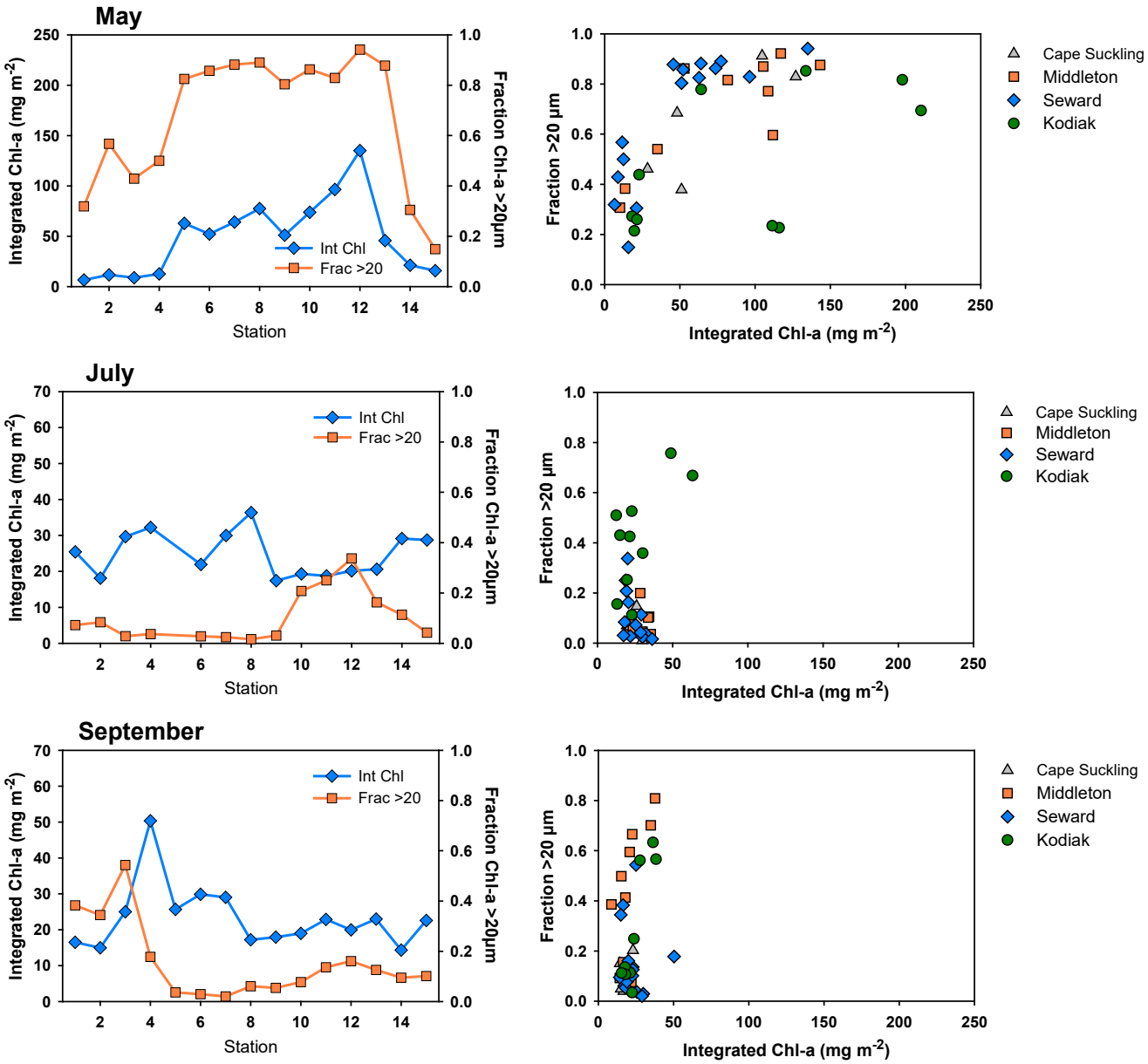


Figure 4. Chlorophyll-a concentrations (integrated Chl-a [mg $m^{-2}$] and fraction >20 µm) for summer (May and July) and September 2018 for Cape Suckling, Middleton, Seward, and Kodiak sites.

Microzooplankton biomass on the Seward Line in May 2018 remained low, similar to observations for recent warm years, but was more typical of prior years during the September cruise (Fig. 5). The community was comprised of a mixture of ciliate and dinoflagellate sizes, with dinoflagellates becoming more prominent during summer and fall.

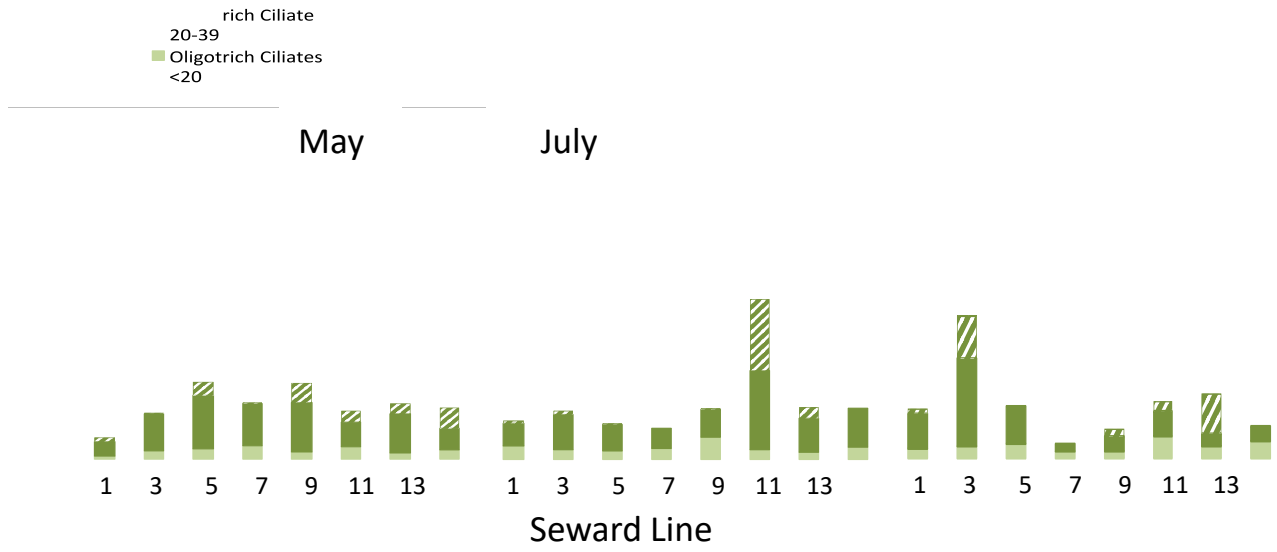


Figure 5. Microzooplankton biomass on the Seward Line in summer (May and July) and September 2018.

Preliminary sample analysis for 2018 continues to suggest a shift in relative abundance of two keystone copepods, from a dominance of *Neocalanus flemingeri* to *N. plumchrus*, although their combined numbers were relatively normal (Fig. 6). We plan to conduct a re-analysis of subsets of older samples during the summer of 2019 to determine if this shift is real, or our inability to separate the species accurately at the fourth copepodite stage earlier in the time-series.

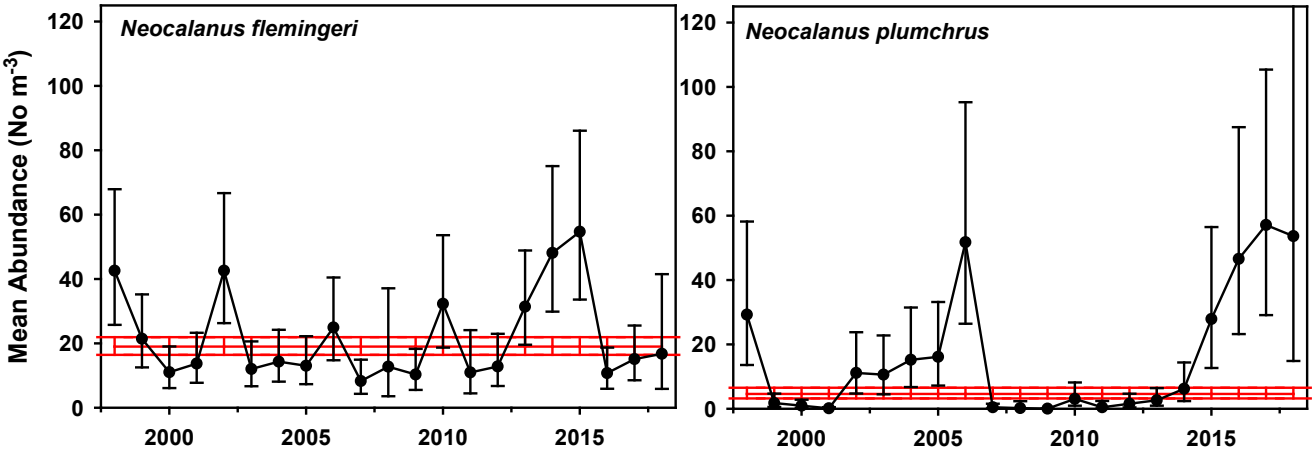


Figure 6. Mean abundance of copepod species *Neocalanus flemingeri* (left) and *N. plumchrus* (right) from 1998 to 2018 on the Seward Line.

The high numbers southern copepods observed in recent years were almost absent during May of 2018, suggesting a return to more normal community structure. September 2018 samples targeting these smaller copepods are still being processed (Fig. 7).

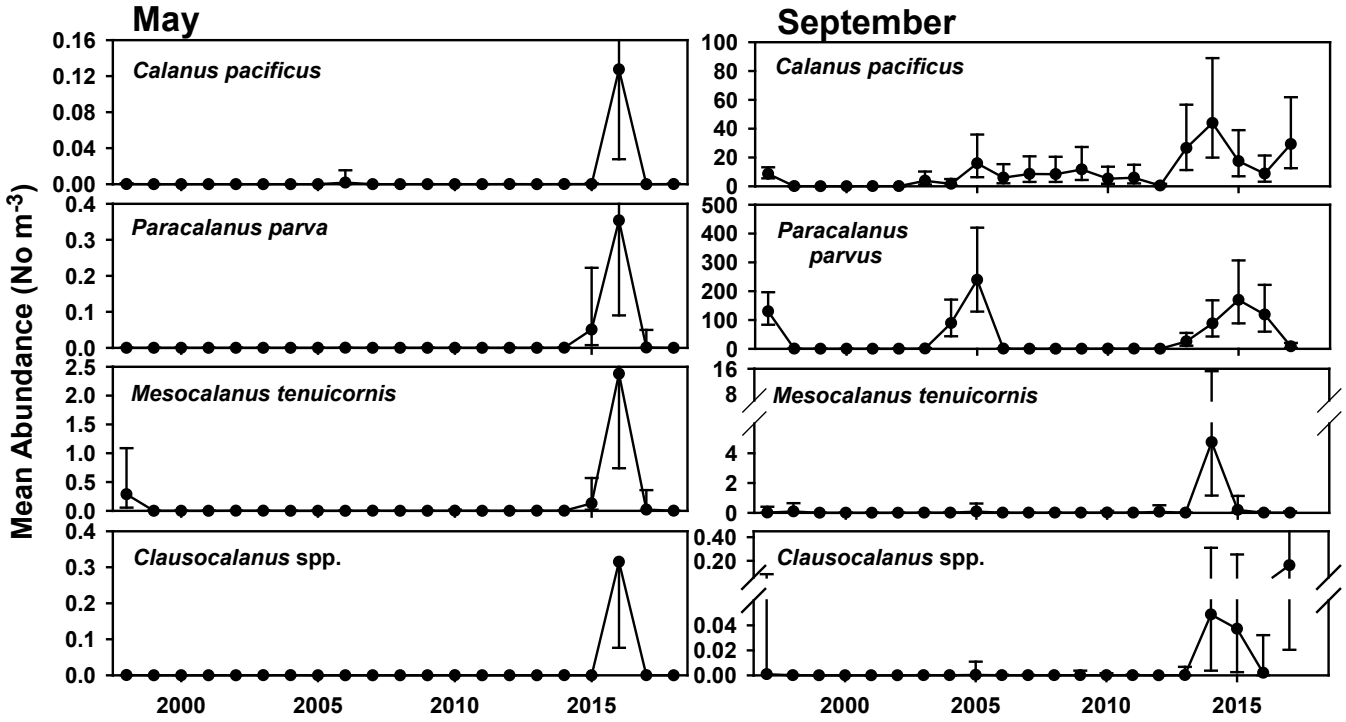


Figure 7. Mean abundance of southern copepod species recorded during May (left) and September (right) on the Seward Line from 1998 through summer of 2018.

New to 2018, we have begun using a large 5 $m^2$ Methot net to target macro jellies during summer and fall cruises in the surface layer. Results from the first year already suggest a much higher than expected biomass of these larger predators (Fig. 8). It is likely that the bycatch of forage fish obtained with this net can fill some information gaps of the Gulf of Alaska shelf.

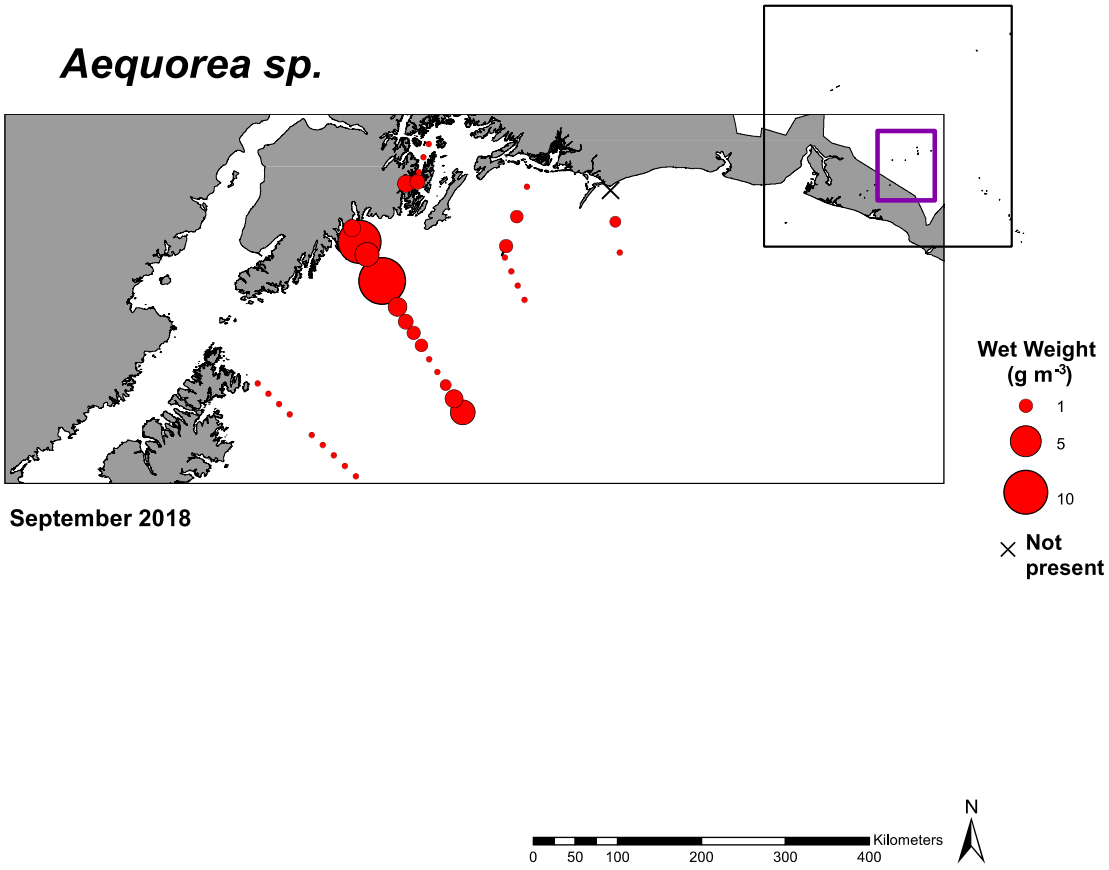


Figure 8. Macro jellies (*Aequorea* sp.) collected by using a large Methot net during Seward Line and LTER sampling during July and September 2018.

We conducted visual surveys for seabirds and marine mammals during three 2018 northern Gulf of Alaska LTER cruises, following standard U.S. Fish and Wildlife Service (USFWS) survey protocols. In total across the three seasonal surveys, we conducted a total of 5693 linear km of transects (Fig. 9). Averaged across all survey transects, the mean density (all bird species combined) was 9.7 birds $km^{-2}$, with lowest average density in spring, higher in summer, and highest density in fall (Table 1). Much of this seasonal increase in density was due to an influx of sooty and short-tailed shearwaters. Sooty and short-tailed shearwaters breed near New Zealand and Australia during the austral summer and undertake a trans-hemispheric migration to feed in the North Pacific during the austral winter, migrating north in April-May and returning south in October.

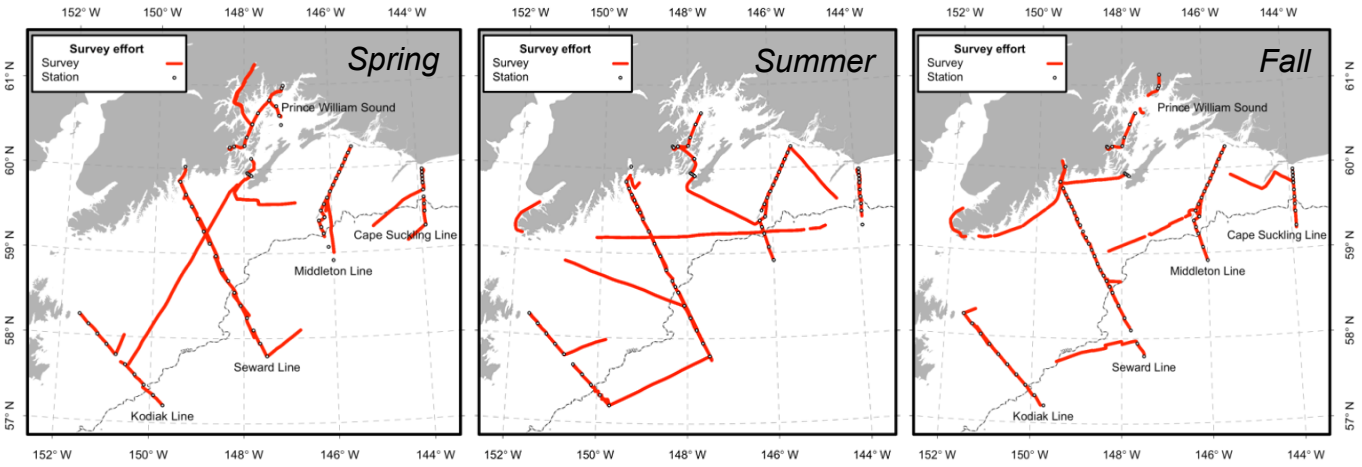


Figure 9. Transects sampled for marine birds and mammals during Seward Line and LTER sampling in May, July, and September, 2018.

Table 1. Summary of survey effort and observations during 2018 northern Gulf of Alaska LTER cruises.

| Cruise | Km surveyed | Mean birds km$^{-2}$ | No. bird species (on-transect / off-transect) | No. mammal species (on + off-transect) |
|---|---|---|---|---|
| April-May | 1919 | 6.2 | 36 / 20 | 9 |
| July | 2217 | 10.3 | 37 / 9 | 9 |
| September | 1557 | 13.0 | 29 / 22 | 12 |

Including both on- and off-transect observations, avian species richness was highest during spring, lowest during summer, and intermediate during fall. Terrestrial and aquatic bird species were observed migrating over the ocean, especially during spring, but also during other seasons. Omitting non-marine birds and including only seabirds, seaducks, and phalaropes, (both on- and off-transect) we observed 41 species in spring, 38 in summer, and 42 during fall (Fig. 10).

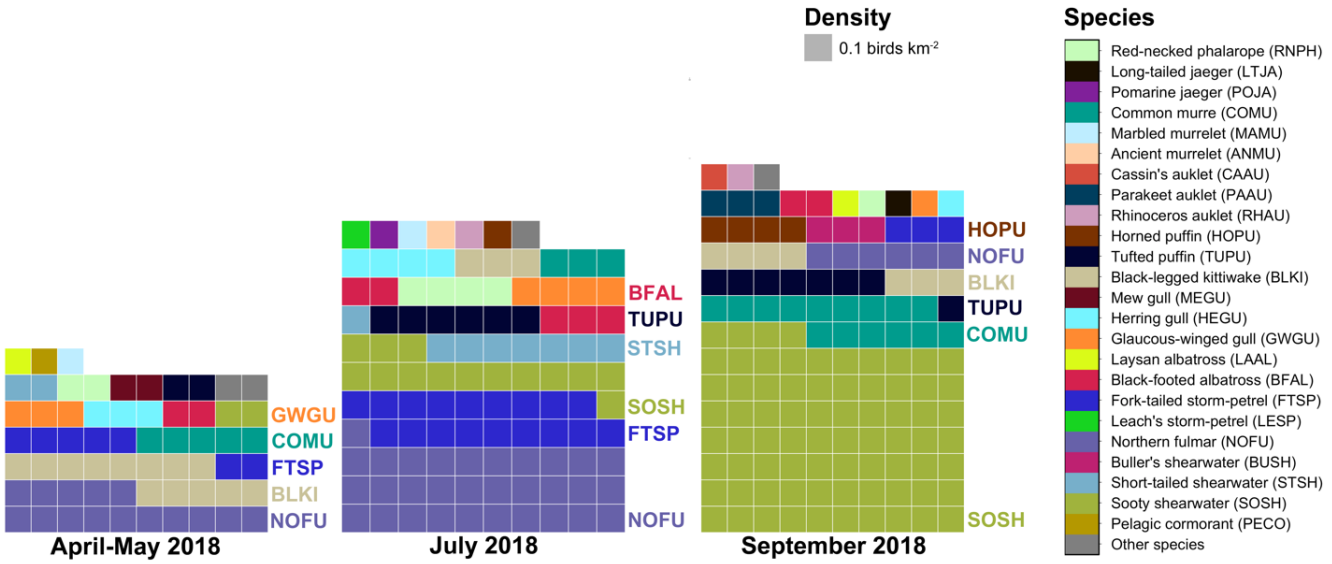


Figure 10. Seabird species composition and abundance during 2018 northern Gulf of Alaska LTER cruises.

During the three 2018 cruises, we observed examples of seasonally persistent spatial hot-spots of bird abundance, as well as locations where seasonal shifts in abundance occurred. During all three seasons, there were locations along the shelf-break with relatively high seabird abundance (Fig. 11). The immediate vicinity of Middleton Island also stood out as a multi-species hot-spot during all three seasons. Abundant species near Middleton included both species that do and those that do not breed on the island. In contrast, we observed a pronounced seasonal shift in many areas of the inner shelf; numbers increased from spring to summer, especially near locations of breeding colonies, such as at Resurrection Bay and the Copper River Delta, and then decreased during fall, as birds apparently dispersed from breeding sites. High densities of birds occurred over the shelf east of the Kodiak Archipelago during summer and fall, but not during spring. Albatross Bank in the fall had the highest seabird densities recorded, when thousands of shearwaters, murres and whales were observed feeding in the area, and whales and birds were also abundant over the bank during summer. During summer, we observed a mixed water column and a diatom bloom over Albatross Bank, suggesting that tidal pumping of nutrients may contribute to the productivity of this summer and fall hot-spot.

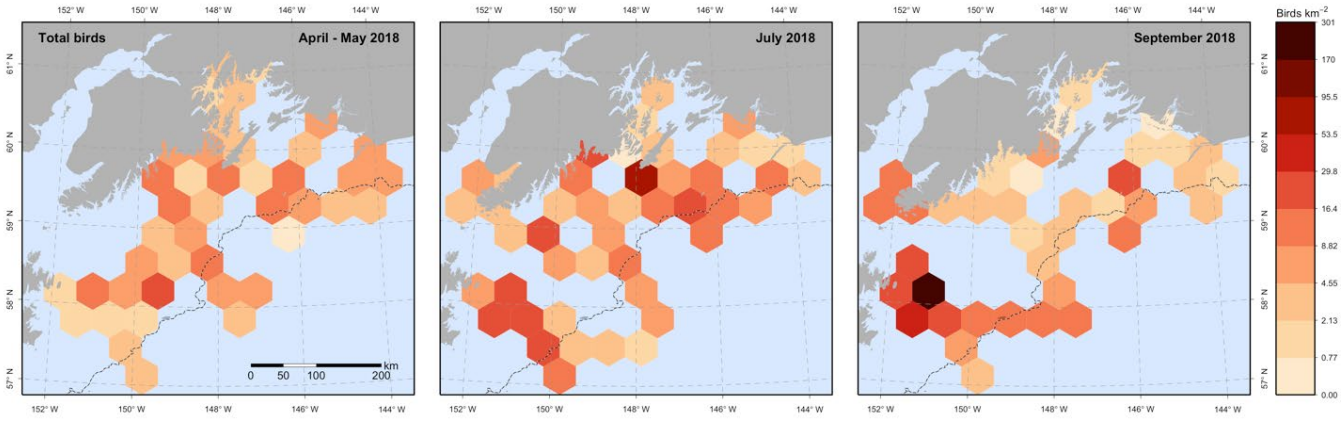


Figure 11. Seabird abundance observed on the northern Gulf of Alaska LTER surveys during spring, summer, and fall 2018.

We observed a total of 12 species of marine mammals during the fall cruise, compared to 9 during both spring and summer (Figs. 12-14). Exceptional were two pods of 20 Risso's dolphins observed over Hinchinbrook Canyon (southwest of Middleton Island), about 5 km north of the shelf-break. These Gulf of Alaska observations represent extralimital, but not unprecedented, records for this species. Risso's dolphins are distributed in temperate and tropical oceans in both hemispheres, primarily between 30° and 45° latitude, and are most abundant in slope and outer shelf habitats, especially areas of steep bathymetry.

In general, odontocete (toothed whale; X+3) species observed during all three cruises were dominated by Dall's porpoise, which was widely abundant on shelf and offshore regions, with lower abundance along the Kodiak line than elsewhere. Orcas were observed during summer and fall cruise and were encountered on the Kodiak Line, Seward Line, Middleton Line, and in Montague Strait in Prince William Sound. Sperm whales were observed along the Seward Line, at the shelf-break and beyond, and also on the shelf over Amatuli Trough (Fig. 12).

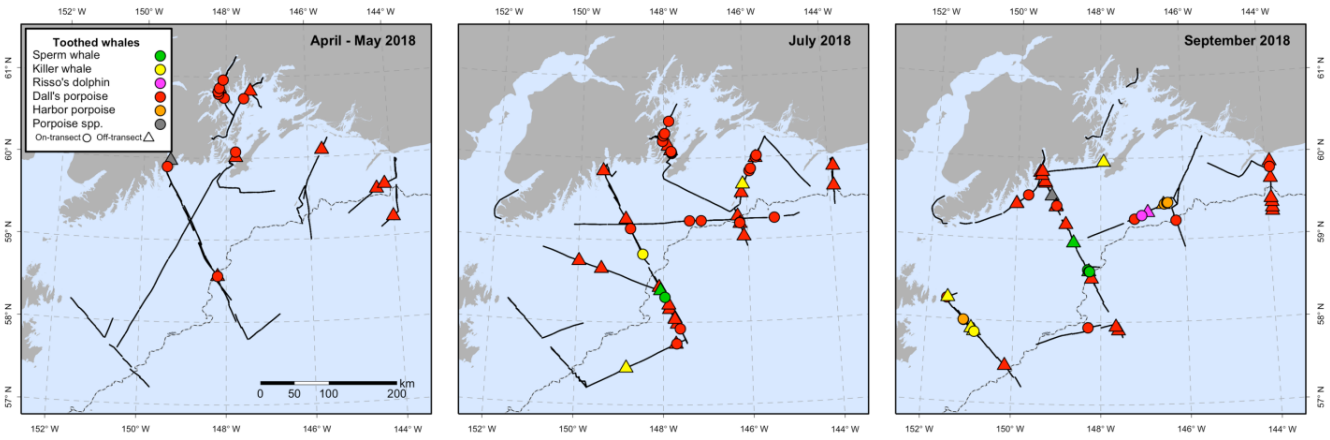


Figure 12. Odontocete whales observed on the northern Gulf of Alaska LTER cruises during spring, summer, and fall 2018.

Fin whales were typically the most abundant baleen whale. Most fin whales were observed over the outer shelf, and also occurred on the northwestern edge of Albatross Bank during fall, along with the large flocks of shearwaters and murres. Humpback whales were observed along the Kenai coastline during fall but were widespread during summer, including an aggregation over Albatross Bank. Minke whales were most common during spring (Fig. 13).

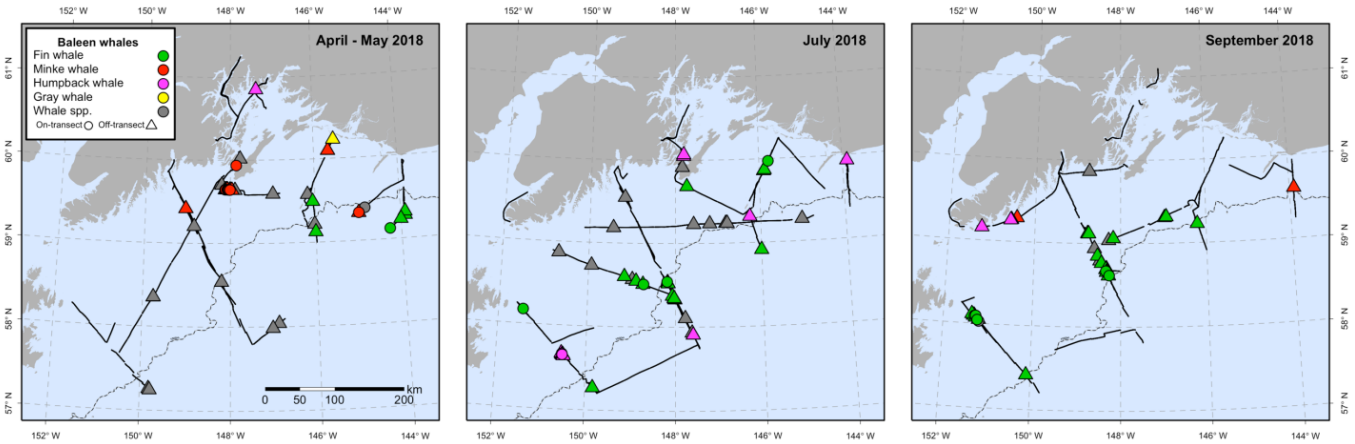


Figure 13. Baleen whales observed on the northern Gulf of Alaska LTER cruises during spring, summer, and fall 2018.

The most abundant pinniped was the harbor seal; the largest numbers were observed in Icy Bay, where groups of up to several hundred were hauled out on glacial ice in Nassau Fjord. Steller sea lions were observed hauled out at Cape St. Elias, Aialik Cape, and Middleton Island, and they were also observed at locations near the coast, east of Prince William Sound. Northern fur seals were widely distributed in shelf and offshore waters during spring and summer but were uncommon in fall. Sea otters were restricted to coastal waters (Fig. 14).

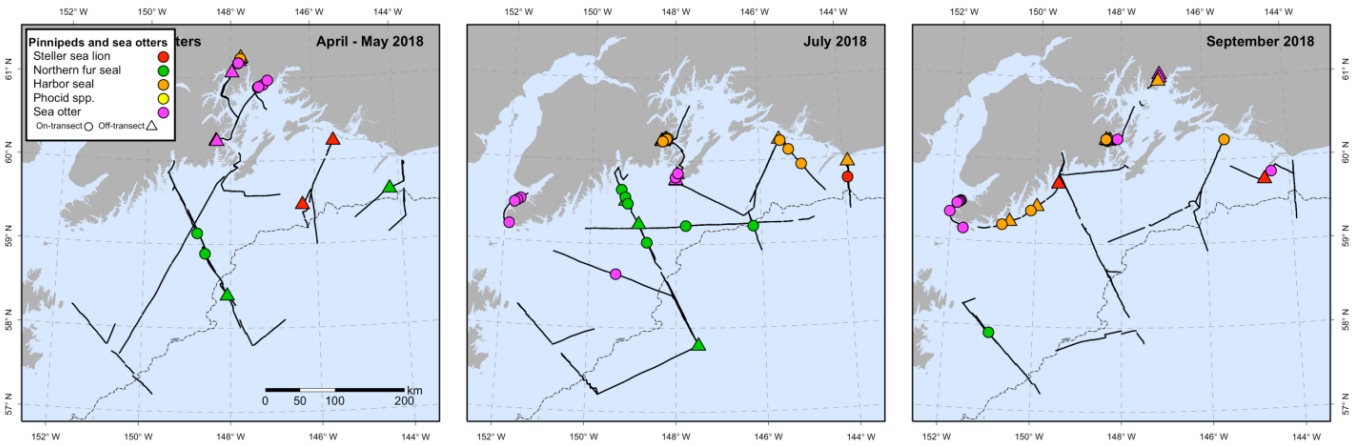


Figure 14. Pinnipeds and sea otters observed on the northern Gulf of Alaska LTER cruises during spring, summer, and fall 2018.

During September 2018, a total of five ocean sunfish (*Mola mola*) were sighted at or just below the surface during surveys. Though no photographs were obtained, ocean sunfish were observed by three individuals during the cruise and were also reported by a nearby commercial fishing vessel. As of 2002, there were 5 verified ocean sunfish records (with specimens or other vouchers) and an additional 3 unverified records (reports without vouchers) for the Gulf of Alaska, most of which occurred during El Niño years. Ocean sunfish typically occur in temperate or tropical waters of >10ºC, worldwide.

## 8. Coordination/Collaboration:

### A. Projects Within a Trustee Council-funded program

#### 1. Within the Program

Regular discussion with other Environmental Drivers projects on what each was observing over the year.

This project links tightly with the GAK-1 mooring, providing a cross shelf context for its observations. It complements the continuous plankton recorder, Prince William Sound, and Lower Cook Inlet/Kachemak Bay oceanographic long-term monitoring efforts by providing more detailed oceanographic evaluation of the Gulf of Alaska shelf and the major passages in Prince William Sound 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 the other Environmental Driver components

The additional monthly sampling in Resurrection Bay and at GAK-1 provide oceanographic context for the Gulf Watch Alaska nearshore activities underway within Resurrection Bay (Kenai Fjords). The new sampling line added through NGA-LTER funding now connects Middleton Island into the Environmental Drivers sampling domain.

#### 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

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

##### c. Lingering Oil

None

### B. Projects not Within a Trustee Council-funded program

None.

### C. With Trustee or Management Agencies

The Seward Line/LTER is co-funded by GWA, North Pacific Research Board, Alaska Ocean Observing System, and NSF, all sharing common goals of understanding environmental drivers on the Gulf of Alaska shelf and the major passages of Prince William Sound.

We provided a platform for visual seabird surveys and marine mammals during three 2018 northern Gulf of Alaska LTER cruises, in collaboration with U.S. Fish and Wildlife Service (USFWS) Kathy Kuletz.

Seward Line/LTER cruises provide bongo collections for larval fish assessment to National Oceanic and Atmospheric Administration (NOAA). LTER and NOAA share data on several projects.

Like other Environmental Driver component projects, Seward Line data are available to Alaska Department of Fish and Game biologists for salmon forecasting,

Contributed two indicators to NOAA's Gulf of Alaska Ecosystem Status Report to the North Pacific Fisheries Management Council (Zador and Yasumiishi 2018).

## 9. Information and Data Transfer:

### A. Publications Produced During the Reporting Period

Roncalli, V., S.A. Sommer, M.C. Cieslak, C. Clarke, **R.R. Hopcroft**, and P.H. Lenz. 2018. Physiological characterization of the emergence from diapause: A transcriptomics approach. *Nature Sci. Rep.* **8:** 12577

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

Strom and Hopcroft. Planktonic Communities in the Coastal Gulf of Alaska: Strong Dichotomies in Structure and Function. Presentation Ocean Sciences Meeting – Portland, OR (February 2018)

Coyle, Hermann, and Hopcroft. Modeled spatial-temporal distribution of production and biomass relative to field observations in the northern Gulf of Alaska. Presentation Ocean Sciences Meeting – Portland, OR (February 2018)

Roncalli, Hartline, Germano, Cieslak, Strom, Hopcroft, and Lenz. Consequences of regional heterogeneity on the physiology of a calanid copepod, *Neocalanus flemingeri,* in the northern Gulf of Alaska. Presentation Ocean Sciences Meeting – Portland, OR (February 2018)

The Northern Gulf of Alaska Long -term Ecological Research program. Poster Ocean Sciences Meeting – Portland, OR (February 2018)

Kuletz, Hopcroft, Danielson, Santora, Sydeman, Hoover, and Cushing. Seabird distribution relative to biophysical oceanographic properties in North Pacific ecosystems. Poster LTER All Scientists Meeting, Pacific Grove, CA (October 2018)

Climate Change at LTER sites. Workshop LTER All Scientists Meeting, Pacific Grove, CA (October 2018)

Barbeau, Hopcroft, Schofield, and Sosik. Pelagic LTER site: site overviews, inter-comparisons and synthesis planning. Workshop, LTER All Scientists Meeting, Pacific Grove, CA (October 2018)

Danielson, Aguilar-Islas, Fiechter, Hopcroft, Kuletz, Statscewich, and Strom. Acrobat Observations along the Gulf of Alaska Hydrographic Tightrope. Poster LTER All Scientists Meeting, Pacific Grove, CA (October 2018)

Hopcroft and Lindsay. Gelatinous zooplankton in Alaskan waters: from nets to ROVs. Invited PICES Anual Meeting, Yokohoma, Japan (October 2018)

Hopcroft, Strom, Aguilar-Islas, Danielson, and Fiechter. A new Long-term Ecological Research (LTER) site in the Northern Gulf of Alaska. Poster PICES Anual Meeting, Yokohoma, Japan (October 2018)

Suryan et al. Ecosystem variability and connectivity in the Gulf of Alaska. Presentation PICES Anual Meeting, Yokohoma, Japan (October 2018)

Roncalli, Cieslak, Hopcroft, and Lenz**.** Environmental heterogeneity in the northern Gulf of Alaska impacts physiological status in the copepod *Neocalanus flemingeri.* Poster AMSS (January 2019)

Strom, Bright, and Fredrickson. Mixotrophy in the Gulf of Alaska: Abundant plant-animal cells have major implications for ecology and biogeochemistry. Presentation AMSS (January 2019)

Cushing, Kuletz, Labunski, and Hopcroft, Seabird Studies During the Northern Gulf of Alaska Long Term Ecological Research Program. Poster AMSS (January 2019)

Hauri, Hedstro, Schultz, Danielson, Beamer, Dony, Hill, and Stock. Influence of Ocean Acidification and Climate Change on the Biogeochemistry in the Gulf of Alaska: A Regional Modeling Study. Presentation AMSS (January 2019)

Arimitsu et al. Still Awaiting Ecosystem Recovery Following the North Pacific Marine Heat Wave: Gulf Watch Alaska Pelagic Monitoring Update 2018. Poster AMSS (January 2019)

Strom, Hopcroft, Aguilar-Islas, Danielson, and Fiechter. Resilience Amidst a Sea of Change: The Northern Gulf of Alaska LTER Program. Keynote AMSS (January 2019)

Mendoza-Islas and Hopcroft. First year pollock and their zooplankton predators in the Gulf of Alaska. Poster AMSS (January 2019)

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

None beyond programmatic requirements.

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

The Seward Line project submits data on physics (CTD data), chemistry (chlorophyll and nutrients), phytoplankton and zooplankton, and seabirds (through USFWS). All datasets are on the Research Workspace and available on the Gulf of Alaska Data Portal now or by the end of April 2019, except for 2018 zooplankton data which require additional time for identification.

## 10. Response to EVOSTC Review, Recommendations and Comments:

**Science Panel Comment:** 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 has been rectified in FY18.

| Budget Category: | Proposed FY 17 | Proposed FY 18 | Proposed FY 19 | Proposed FY 20 | Proposed FY 21 | TOTAL PROPOSED | ACTUAL CUMULATIVE |
|---|---|---|---|---|---|---|---|
| Personnel | $83.2 | $85.2 | $87.2 | $89.3 | $91.4 | $436.3 | $166.4 |
| Travel | $3.9 | $4.0 | $4.1 | $4.3 | $4.4 | $20.7 | $8.5 |
| Contractual | $8.0 | $8.3 | $8.6 | $8.8 | $9.0 | $42.6 | $17.4 |
| Commodities | $2.3 | $2.4 | $2.5 | $2.7 | $2.8 | $12.7 | $5.3 |
| Equipment | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 |
| Indirect Costs (*25% of non-equip.*) | $24.4 | $25.0 | $25.6 | $26.2 | $26.9 | $128.1 | $48.6 |
| **SUBTOTAL** | $121.8 | $124.9 | $128.0 | $131.2 | $134.5 | $640.3 | $246.2 |
| General Administration (9% of | $11.0 | $11.2 | $11.5 | $11.8 | $12.1 | $57.6 | N/A |
| **PROJECT TOTAL** | $132.7 | $136.1 | $139.5 | $143.0 | $146.6 | $697.9 | |
| Other Resources (Cost Share Funds) | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | $0.0 | |

### Literature Cited

Zador, S. G., and E. M. Yasumiishi. 2018. Ecosystem Status Report 2018: Gulf of Alaska. Report, North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301. https://www.fisheries.noaa.gov/resource/data/2018-status-gulf-alaska-ecosystem