Aleutian Islands Ecosystem Assessment

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The primary intent of this assessment is to summarize and synthesize climate, biological, and fishing effects on the shelf and slope regions of the Aleutian Islands (AI) from an ecosystem perspective and to provide, where possible, an assessment of the possible future effects of climate and fishing on ecosystem structure and function. This serves the larger goal of the Ecosystem Status Reports (ESRs) to provide ecosystem context for tactical fisheries management decisions. This assessment ties together the myriad indicator data into a narrative of the current and likely future ecosystem state, including information based on new or unexpected observations that may have implications for groundfish management. Report cards are presented at the front of this ESR to provide a succinct summary of the state of the ecosystem based on a short list of indicators. Descriptions of the report card indicators are in the Ecosystem Indicators section (p. 33)

The Aleutian Islands ecosystem assessment area

The Aleutian Islands ecosystem assessment and report card are presented by three ecoregions. The ecoregions were defined based upon evidence of significant ecosystem distinction from the adjacent ecoregions by a team of ecosystem experts in 2011. The team also concluded that developing an assessment of the ecosystem at this regional level would emphasize the variability inherent in this large area, which stretches 1900 km from the Alaska Peninsula in the east to the Commander Islands in the west. For the purposes of this assessment, however, the western boundary is considered the US-Russia border at 170°E.

The three Aleutian Islands ecoregions are defined from west to east as follows (Figure 6). The Western Aleutian Islands ecoregion spans 170° to 177°E. These are the same boundaries as the

North Pacific Fishery Council fishery management area 543. This ecoregion was considered to be distinct from the neighboring region to the east by primarily northward flow of the Alaska Stream through wide and deep passes (Ladd, pers. comm.), with fewer islands relative to the other ecoregions.

The Central Aleutian Islands ecoregion spans 177°E to 170°W. This area encompasses the North Pacific Fishery Council fishery management areas 542 and 541. There was consensus among the team that the eastern boundary of this ecoregion occurs at Samalga Pass, which is at 169.5°W, but for easier translation to fishery management area, it was agreed that 170°W was a close approximation. The geometry of the passes between islands differs to the east and west of Samalga Pass (at least until Amchitka Pass). In the Central ecoregion the passes are wide, deep and short. The Alaska Stream, a shelf-break current, is the predominant source of water (Figure 7). There is more vertical mixing as well as bidirectional flow in the passes. This delineation also aligns with studies suggesting there is a biological boundary at this point based on differences in chlorophyll, zooplankton, fish, seabirds, and marine mammals (Hunt and Stabeno, 2005).

The Eastern Aleutian Islands ecoregion spans 170°W to False Pass at 164°W. The passes in this ecoregion are characteristically narrow, shallow and long, with lateral mixing of water and northward flow. The prominent source is from the Alaska Coastal Current, with a strong freshwater component. This area encompasses the NPFMC fishery management areas 518, 519 (EBS) and the western half of 610 (GOA).

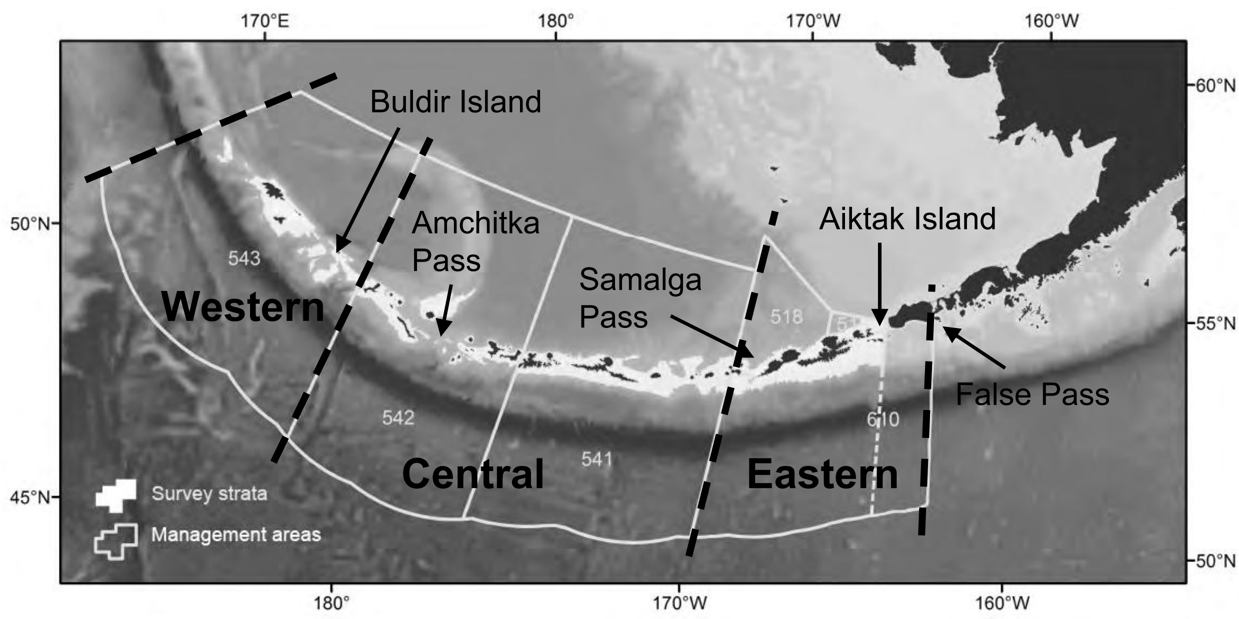

Figure 6: The three Aleutian Islands assessment ecoregions.

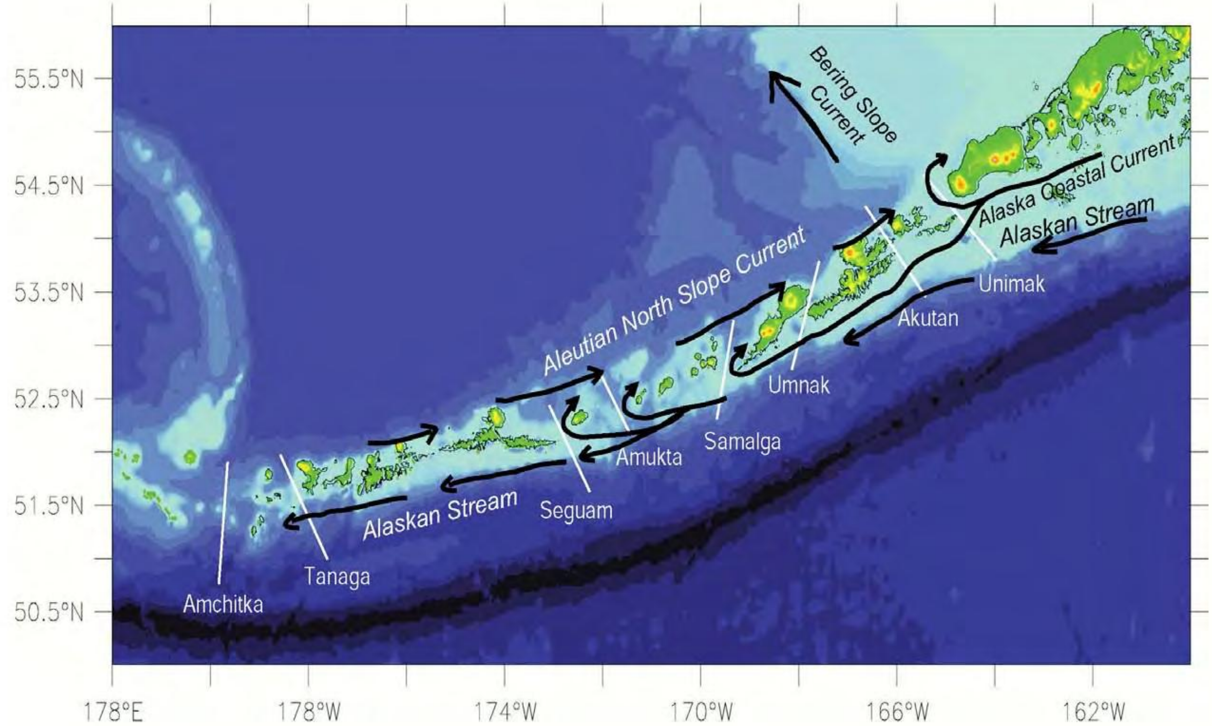

Figure 7: Ocean water circulation in the Aleutians. Currents are indicated with black lines. Passes are indicated with white lines. Image from Carol Ladd.

Current and Recent Ecosystem State

Most of what we can say about the Aleutians Islands ecosystem is based upon biological trends. There are large gaps in knowledge about the local physical processes and, as a result, their impact on biological processes. These gaps are largely due to geography. For example, persistent cloudiness had precluded obtaining comprehensive satellite-derived data, but this year we include a new contribution on satellite-derived sea surface temperature patterns (p. 50). Also, the sheer distances involved in surveying the island chain make comparing west-east trends in indicators such as bottom temperature difficult because of the difference in timing of oceanographic surveys across the region. Differences in survey timing may also affect detection of biological patterns. Integrative biological indicators such as fish or sea lion abundances may be responding to physical indicators such as bottom temperature, but are less sensitive to survey timing. Also, the extensive nearshore component of the ecosystem, narrow shelf relative to the entire ecosystem, as well as strong oceanographic input mean that some metrics commonly used as ecosystem indicators in other systems may not be as informative in the Aleutians. Therefore, our synthesis of ecosystem indicators necessarily includes speculation.

The North Pacific atmosphere-ocean system in 2017–2018 was similar to that from 2016–2017, as seen in the continuation of largely warm conditions that represent little change from the generally warm period that began in 2014. The Pacific Decadal Oscillation index shifted to a neutral state, reflecting a broad scale pattern of warmer than average temperature across the North Pacific. While the warm temperatures extended deep in the water column, the surface temperatures cooled. The broad high sea level pressure pattern over the Aleutians and related suppressed storminess from fall 2017 through winter 2018 likely helped to retain the heat in the water column. The Alaska Stream appears to have been relatively diffuse on the south side of the eastern Aleutian Islands. Eddy energy has remained low since 2012, indicating little flux of volume, heat, salt, and nutrient through Amukta Pass.

Overall, the Aleutian ecosystem has shown a response to the recent warm years that has similar characteristics to those in the Gulf of Alaska. As the water column and surface temperatures shifted to anomalously warm in 2013/2014, the mean size of the copepod community became smaller than the long term mean, indicating that smaller-bodied copepod species became relatively abundant as is expected (Figure 9). In general, planktivorous seabirds have had fewer reproductive failures during these warm years relative to piscivorous seabirds, indicating that zooplankton resources were largely sufficient while forage fish were periodically lacking.

The zooplankton community in the Aleutians is largely dominated by copepods, and the ecosystem itself is oceanic in nature. Based on bottom trawl survey data only (which in the eastern Aleutians ecoregion includes only the shelf area north of the islands), there is a larger biomass of pelagic foragers compared to that of apex predators across the AI. At the ecoregion scale, both the western and central Aleutians ecoregions have a larger total fish biomass of pelagic foragers compared to that of apex predators, while in the eastern Aleutians ecoregion the largest total biomass alternates between apex predators and pelagic foragers. This is consistent with higher reliance on zooplankton in the western Aleutians versus more piscivorous and invertivores towards the east. The largest total biomass of both apex predators and pelagic foragers is located in the Central Aleutians, the region with the largest shelf area down to 500m deep. The lowest apex predator biomass alternates between the western and eastern Aleutians whereas that of pelagic foragers is found in the eastern Aleutians. For comparison purposes with previous years, the northern portion of the shelf area in the eastern Aleutians has historically represented an average of 52% of the pelagic foragers (∼30–90%) and 32% on average (∼20–50%) of apex predators. This pattern has been constant since 1991, though individual species groups fluctuations do not necessarily follow the same behavior. Length-weight residuals of groundfish sampled during summer bottom trawl surveys to represent fish condition have shown below-average to average values for most pelagic and apex foragers ecosystem-wide, possibly indicating poor conditions for groundfish in general. We note however, that for Pacific Ocean perch (POP) and northern rockfish, intraspecific competition might be a contributing factor, as their abundance has increased and their condition has decreased more than that of Atka mackerel and pollock since 2012. Conditions for planktivorous predators may have slightly improved this year as discussed in the sections below.

Total pelagic foragers biomass is slightly under 1.8 million tons over the entire Aleutian archipelago, which is very similar to that of 2016, with some species decreasing in the western and central ecoregions and increasing in the eastern ecoregion. There is a consistent long term trend whereby the proportion of rockfish biomass (Pacific Ocean perch, POP, and northern rockfish shown in purple tones in Figure 8) has been consistently increasing compared to that of Atka mackerel and pollock combined. What in the early 1990s was a system where two thirds of the pelagic foragers biomass was made up of Atka mackerel and pollock (shown in grey tones in Figure 8), is now half or even two thirds composed by rockfish. This may cause several minor but consistent disruptions in the structure of the system. For example, Atka mackerel and pollock are shallow foragers distributed mostly between 100–200m depth, while northern rockfish and POP are found in generally deeper waters between 100–300m. This is relevant because they are an important fish prey for seabirds (such as for tufted puffins preying upon age-0 rockfish), marine mammals (such as

Steller sea lions), and a variety of other fish. Most pelagic piscivorous predators will complement their diets with squid and myctophids, however for central place foragers, that implies longer trips from their respective colonies and haul outs.

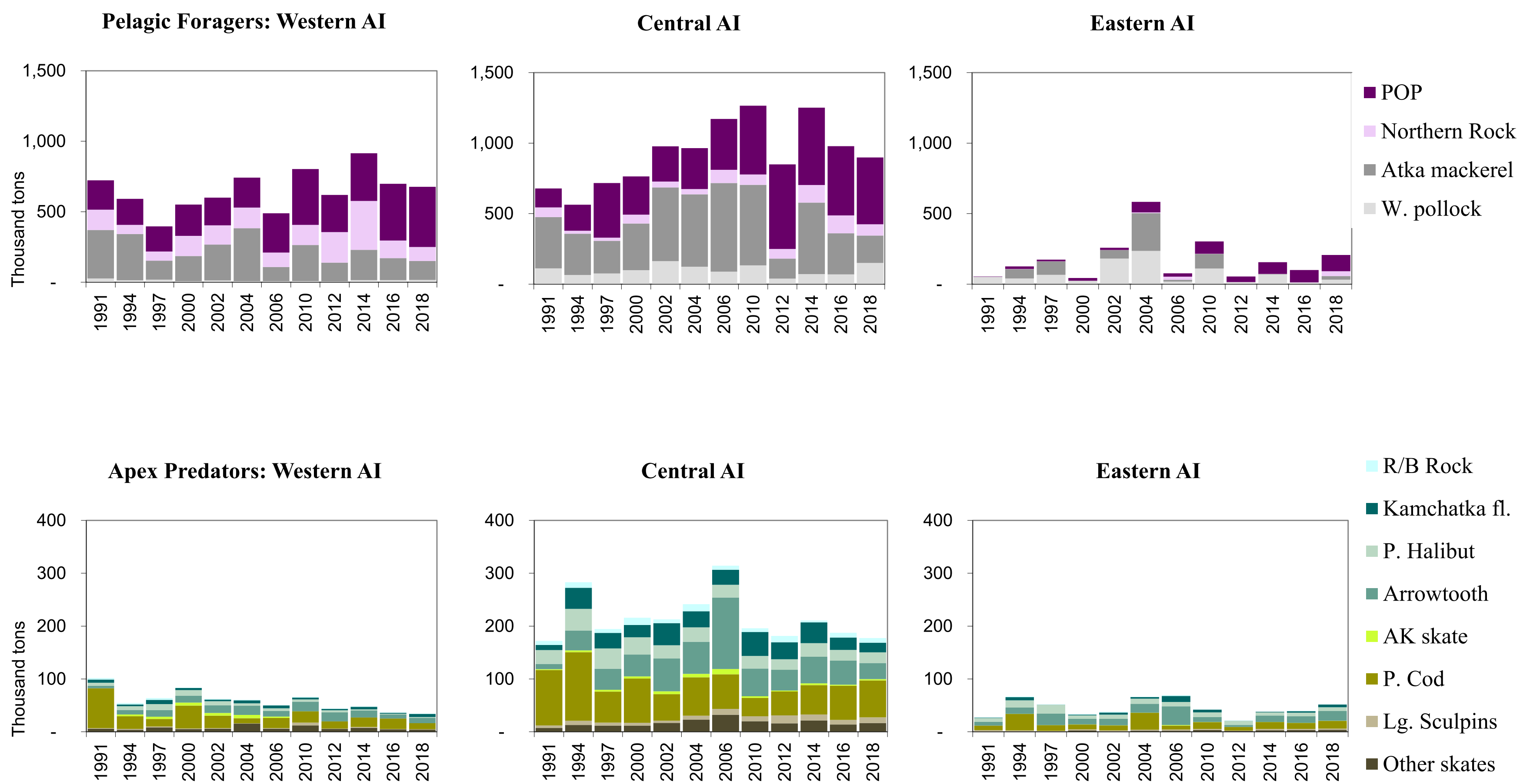

Figure 8: Estimated survey biomasses of fish apex predators and pelagic foraging guilds aggregated by Aleutian Islands ecoregions.

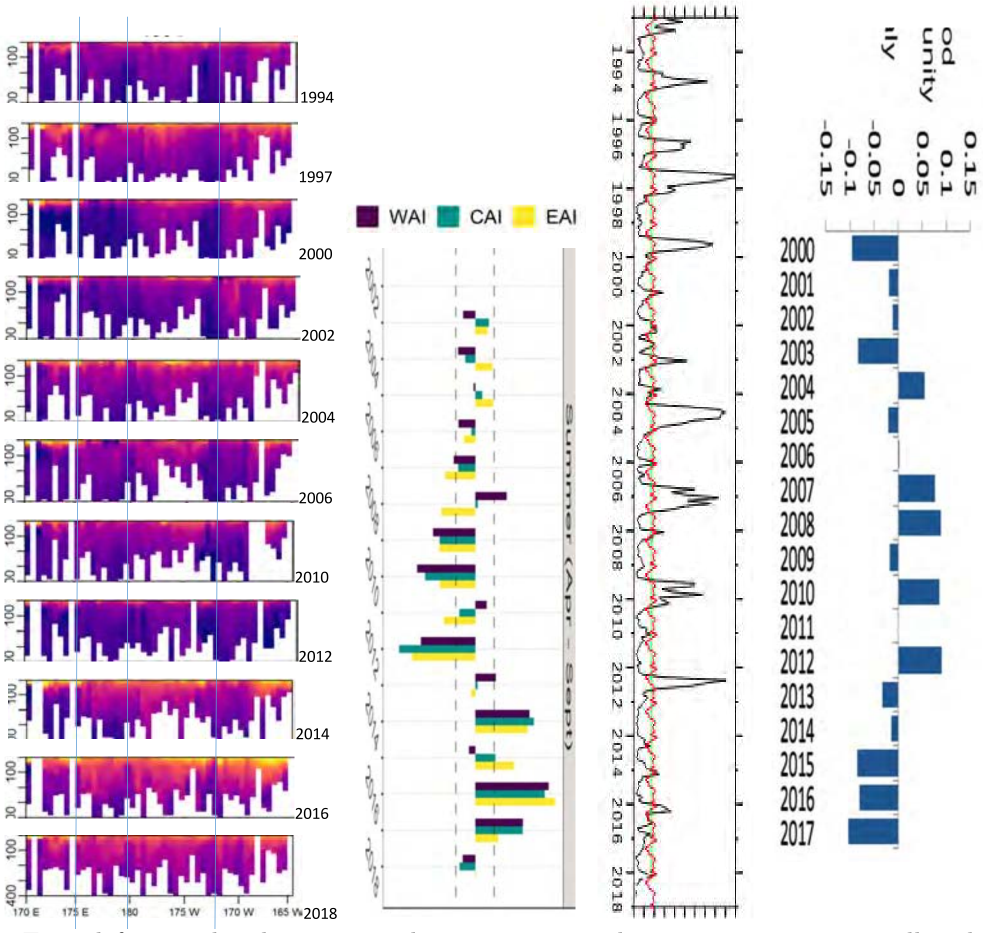

Figure 9: From left to right: bottom trawl survey water column temperatures, satellite-derived sea surface temperatures, eddy kinetic energy near Amukta Pass, mean copepod community size from the Continuous Plankton Recorder in the southern Bering Sea, north of the Aleutian Islands.

Overall apex predator fish biomass is also very similar this year compared to that of 2016. Both Pacific cod and Arrowtooth flounder continue to be the largest component of the apex predator guild. The apex predator fish guild can be roughly separated into three trophic preferences: those that eat primarily fish, fish and crustaceans/invertebrates or primarily crustaceans and invertebrates. Large rockfish and large flatfish eat mostly fish (shown in blue tones in Figure 8), Pacific cod and Alaska skates feed approximately equal parts fish and crustaceans (Alaska skate less so) (shown in olive green tones), while large sculpins and other skates (shown in brown tones) feed primarily on crustaceans and invertebrates. Piscivorous apex predators make up the largest proportion in the eastern Aleutians decreasing towards the western Aleutians, where the shelf is wider and there are more apex predators feeding on crustaceans and invertebrates. Pacific cod, being able to switch equally between fish and crustacean/invertebrates availability, though shown here as an apex predator within fish, is in fact a prey source to a few other fish and marine mammals, so fluctuations in its biomass affect both prey and predators as well. This means that perhaps more important than the sheer biomass of apex predator fish, is their composition, as several of the piscivorous fish consume Atka mackerel and pollock and may be impacted by the larger proportion of rockfish in the system.

Western Ecoregion In the western ecoregion specifically, the reproductive success of planktivorous auklets, serving as indicators of zooplankton production, has been above average from 2015 to 2018. Increases from 2017 to 2018 were seen in both crested auklets, which feed their chicks mainly euphausiids and copepods, and least auklets, which focus on copepods. Thus, we can speculate that sufficient zooplankton were available to support reproductive success. Positive length-weight residuals of Atka mackerel and pollock (both feeding on zooplankton) would seem to further support the good conditions for planktivorous predators in 2018. Forage fish trends as indicated in tufted puffin chick meals have varied over the long term. In general, *Ammodytes* (sand lance) have been absent since 2010, and age-0 gadids (pollock and cod) uncommon; neither were observed this year. Instead, squid were the most common prey fed to chicks, while hexagrammids (age-0 Atka mackerel) were present in average values this year. It is still unknown whether the high number of hexagrammids seen in 2013 and 2014 possibly indicated high recruitment in Atka mackerel, as 80% of the hexagrammids in 2013 and 100% in 2014 were Atka mackerel. Atka mackerel and POP drive the biomass trend and on average make up 80% of the pelagic foragers biomass with the rest comprised mostly of northern rockfish. POP has been increasing (rebuilding) since 1991, although Atka mackerel and northern rockfish decline in 2018 relative to 2016. Steller sea lion non-pup estimates from 2016 are the lowest in the time series. The declining sea lion trends are topics of active research on these apex piscivores whose diet consists primarily of commercially-fished species. The habitat area disturbed by trawls continued to increase in 2018 following the sea lion protection measures that were in effect in 2012–2014. Recent changes in economics, ownership, and fishing effort allocation may be contributing to this trend.

Central Ecoregion Recent trends in auklet reproductive success in the central ecoregion are unknown due to the disruption of the monitored colony in 2008, when the volcano on Kasatochi Island erupted and the seabird research field camp and the monitored colonies were covered with ash. A suitable replacement indicator has not yet been identified. Forage fish trends as captured by puffins are not available from this ecoregion because puffins are not as numerous and nests are not monitored regularly. Both fish apex predator and pelagic foraging guild biomasses have decreased since the previous trawl survey in 2016. Arrowtooth flounder, POP, Atka mackerel, and northern rockfish are contributing to this trend. Recent sea lion estimates are low, but the rate of decline has stabilized. School enrollment has declined over the past 2 years, approaching the 10-student threshold that risks closure of the schools, which would have negative impacts on the communities. The amount of habitat disturbed by trawls was above average, continuing an increasing trend in habitat disturbance by trawls after 2011–2014, when habitat recovery estimates following the sea lion closures took effect. Also, recent changes in economics, ownership, and fishing effort allocation may be contributing to this trend. It is important to keep in mind, however, that the trawlable shelf area in the Aleutians in a minor part of the sea floor landscape, as most is quite rocky and steep.

Eastern Ecoregion Planktivorous auklets are not as numerous in the eastern ecoregion as in the central and western ecoregion and are not monitored in the eastern ecoregion. However, surface-foraging storm-petrels have shown consistent reproductive success (while below average for Leach's storm-petrels, reproductive success was over 60%), indicating, that zooplankton resources were sufficient to support reproduction. Relative abundances of gadids and *Ammodytes* (sand lance) in prey brought back to feed puffin chicks have shown opposite trends over time. This pattern continued in 2018 with above average sand lance and below average (although still plentiful) age-0 gadids. Hexagrammids comprise a low proportion of chick diets relative to those in the western ecoregion. Chick-provisioning patterns suggest puffins are responding to changes in forage fish availability, such as providing support for multiple reports of high numbers of age-0 pollock in 2017. All fish foraging guilds fluctuate largely in this ecoregion which has the lowest total biomass of pelagic foragers. However, all pelagic foragers species biomasses increased this year; apex predators increased overall. Together these suggest that foraging conditions for fish and birds were largely more positive than in previous years. School enrollment had increased in the past 2 years, primarily due to schools in the largest community in Unalaska, whereas the small communities have either closed schools (Nikolski) or are at risk of closure (False Pass and Akutan). School closure can have a destabilizing impact in small communities.