Ecosystem Status Report 2018

Aleutian Islands

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Bering Sea, Aleutian Islands, and Gulf of Alaska

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Aleutian Islands 2018 Report Card

Region-wide

- The North Pacific Index (NPI) was strongly positive from fall 2017 into 2018 due to the relatively high sea level pressure in the region of the Aleutian Low, which was displaced to the northwest, over Siberia, and caused **persistent warm winds from the southwest**. Positive NPI is expected during La Niña, but its magnitude was greater than expected.
- The Aleutians Islands region experienced **suppressed storminess through fall and winter 2017/2018** across the region.
- The **Alaska Stream appears to have been relatively diffuse** on the south side of the eastern Aleutian Islands.
- Although the **sea surface temperatures cooled in 2018, relative to the 2014–2017 warm period, the overall temperature was still warm** due to heat retention throughout the water column.

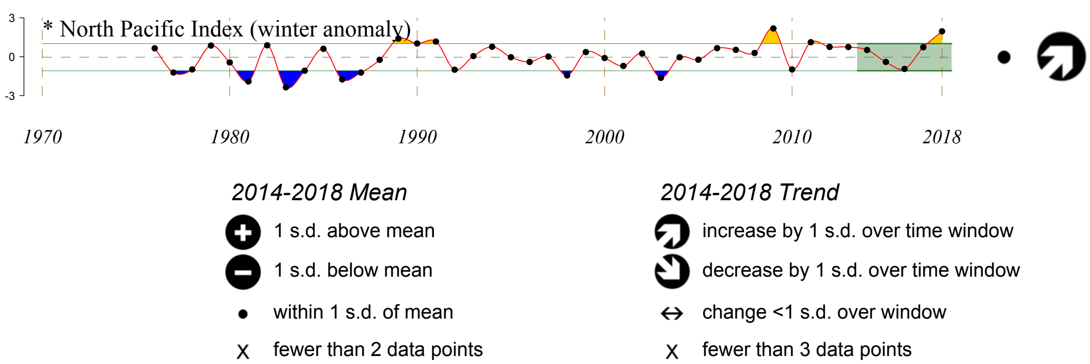

Figure 1: The winter North Pacific Index time series. * indicates time series updated in 2018.

Western Aleutian Islands Ecoregion 2018

- While sea surface temperature declined relative to 2016, the **warm water extended more deeply in 2018 than 2016**.
- The reproductive success of five planktivorous seabird species at Buldir Island was average to above average in 2018, indicating that **overall zooplankton availability was sufficient to support successful chick-fledging in 2018**.
- Forage fish trends as indicated in tufted puffin chick meals have varied over the long term, with episodic peaks lasting 1–2 years. In general, sand lance have been absent since 2009, and age-0 gadids have not been seen in great abundance since 2006. Tufted puffins experienced reproductive failures in 2017 and 2018, so there were few forage fish samples. The failures suggest that **sufficient forage fish to support chick-rearing was limiting in 2017-2018**. Squid were the most common prey delivered to chicks.
- The **pelagic fish foraging guild biomass decreased slightly** from 2016 to 2018. The decreasing trend was primarily due to declines in Atka mackerel and northern rockfish biomass, as the biomass of Pacific ocean perch increased from that in 2016.
- The **overall biomass of the fish apex predator foraging guild continued its long term decline** to the lowest level of the time series, which began in 1991. The largest declines were noted in Pacific cod, while Kamchatka and arrowtooth flounder biomasses increased.
- The most recent data available for **otters show no trend**, in contrast to the steep decline during the early 2000s.
- Steller **sea lions remain below their long-term mean** in this ecoregion, although there has been no significant trend in the past 5 years. The 2016 estimate was the lowest in the time series.
- The **amount of area trawled has increased since 2012**, which was the last year of a dramatic 4-year decline following measures aimed at increasing protection for Steller sea lions during 2012–2014. Also, commercial fishing patterns may reflect recent changes in economics, ownership, and fishing effort allocation.
- There are no schools in the western Aleutian Islands ecoregion.

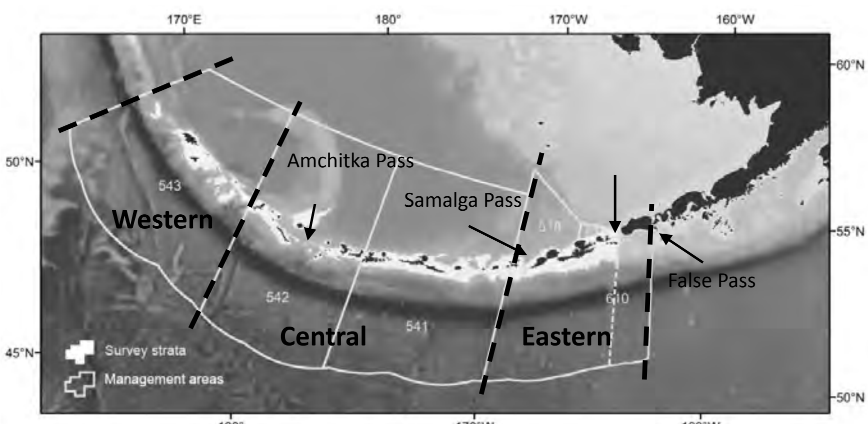

Figure 2: The Aleutian Islands ecoregions.

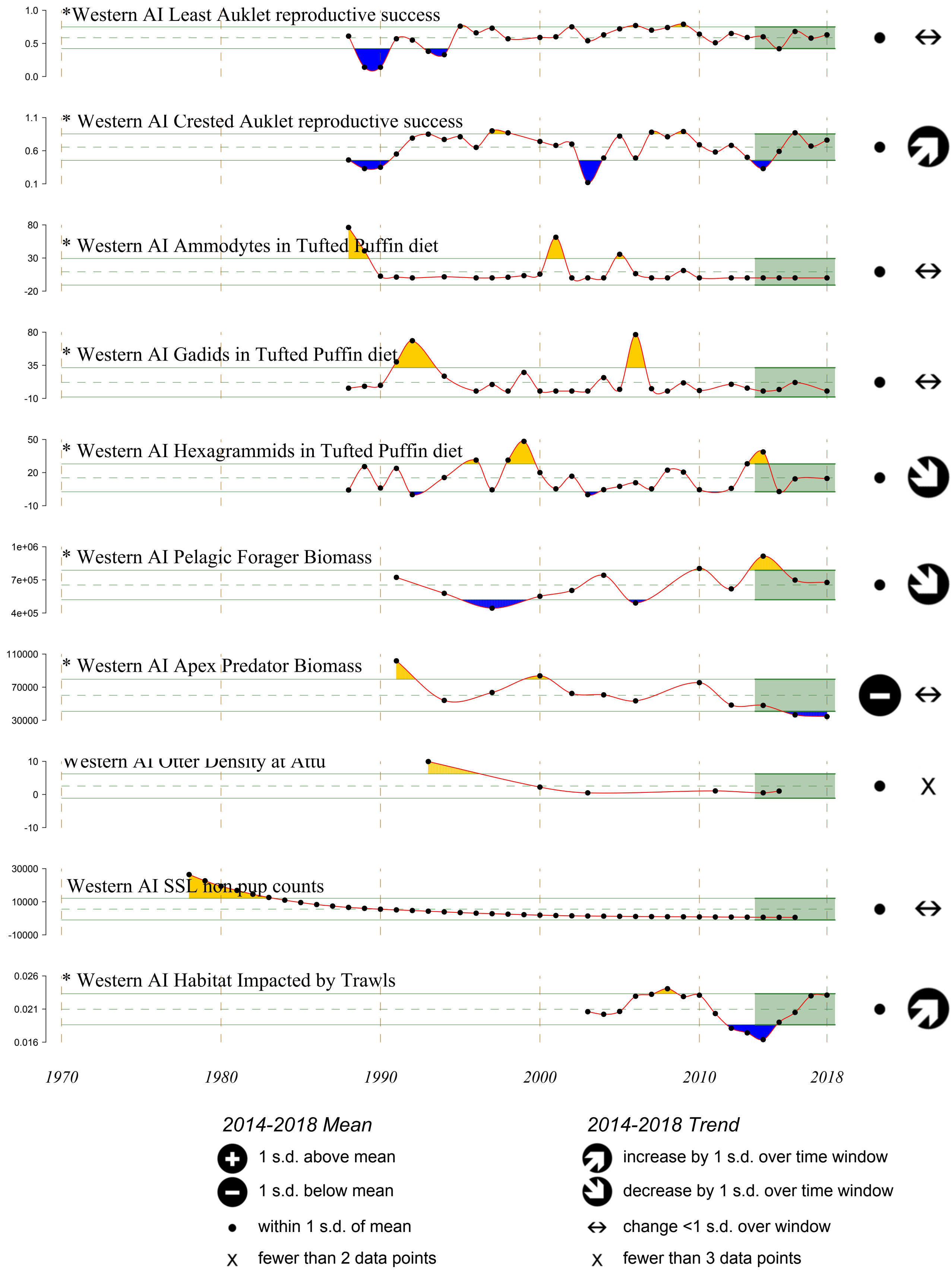

Figure 3: Western Aleutian Islands ecoregion indicators. * indicates time series updated in 2018.

Central Aleutian Islands Ecoregion 2018

- The **pelagic fish foraging guild biomass declined** overall from 2016 to 2018. Decreases were seen in all species but walleye pollock.
- The **slight decrease in the fish apex predator foraging guild biomass** from 2016 to 2018 was largely driven by arrowtooth and Kamchatka flounder.
- The most recent data available for **otters show no trend**, in contrast to the steep decline during the early 2000s.
- Counts of non-pup **Steller sea lions remain below the long term mean** although there is no significant trend in the past 5 years.
- Both Adak and Atka **schools in the central Aleutian Islands have experienced declining enrollment** 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 area trawled has increased since 2012**, which was the last year of a dramatic 4-year decline following measures aimed at increasing protection for Steller sea lions during 2012–2014. Also, commercial fishing patterns may reflect recent changes in economics, ownership, and fishing effort allocation.

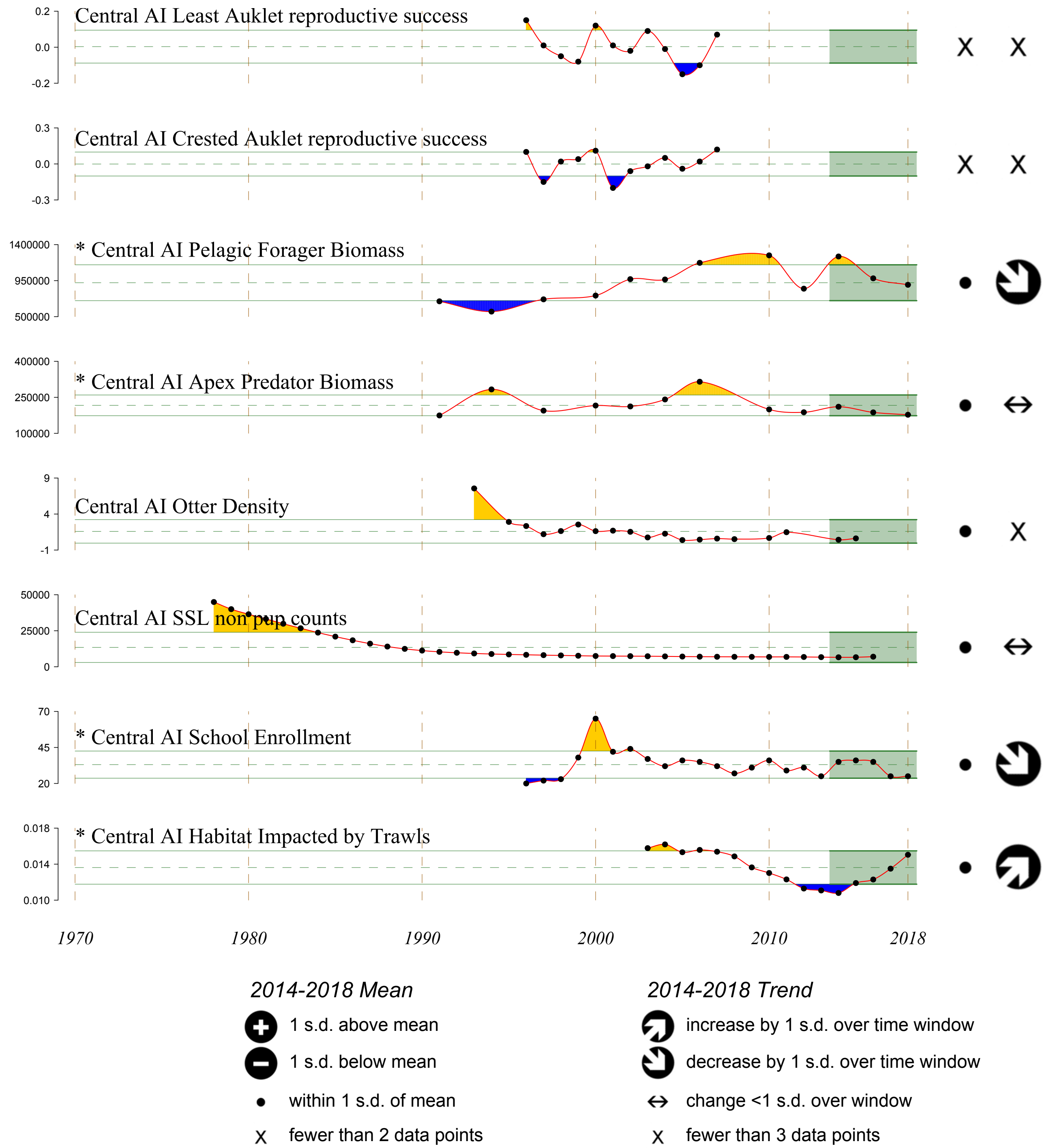

Figure 4: Central Aleutian Islands ecoregion indicators. * indicates time series updated in 2018. See Figure 3 for legend.

Eastern Aleutian Islands Ecoregion 2018

- Relative abundances of **gadids and *Ammodytes* (sand lance)** in prey brought back to feed puffin chicks **have shown opposite trends. Sand lance were above the long-term average in 2018**. Puffins also had high reproductive success, indicating that forage fish were sufficient to support chick-rearing.
- Pollock, Atka mackerel, Pacific ocean perch, and northern rockfish all contributed to the **increase in fish pelagic forager biomass** from 2016 to 2018. This represents a gradual increase since the low estimate in 2012.
- **Fish apex predator foraging guild biomass increased** from the low values in 2012. Pacific cod and arrowtooth flounder contributed most to the increase.
- There are no available data for otters in the eastern Aleutians ecoregion.
- In contrast to the other ecoregions, **non-pup counts of Steller sea lions remained high** during the last count in 2015. The recent estimates have been above the long-term mean and are continuing an increasing trend. Counts were largely stable through the 1990s, but increased at a rate of 3% per year between 2000 and 2008.
- **School enrollment increased overall in the past 2 years**, although there is still an overall decrease in the 5-year trend because of the steep decline in enrollment in 2016. The increase in the past 2 years is primarily due to Unalaska, whereas the small communities have either closed schools (Nikolski) or are at risk of closure (False Pass and Akutan).
- The **amount of area trawled increased slightly in 2018** to above the long-term average.

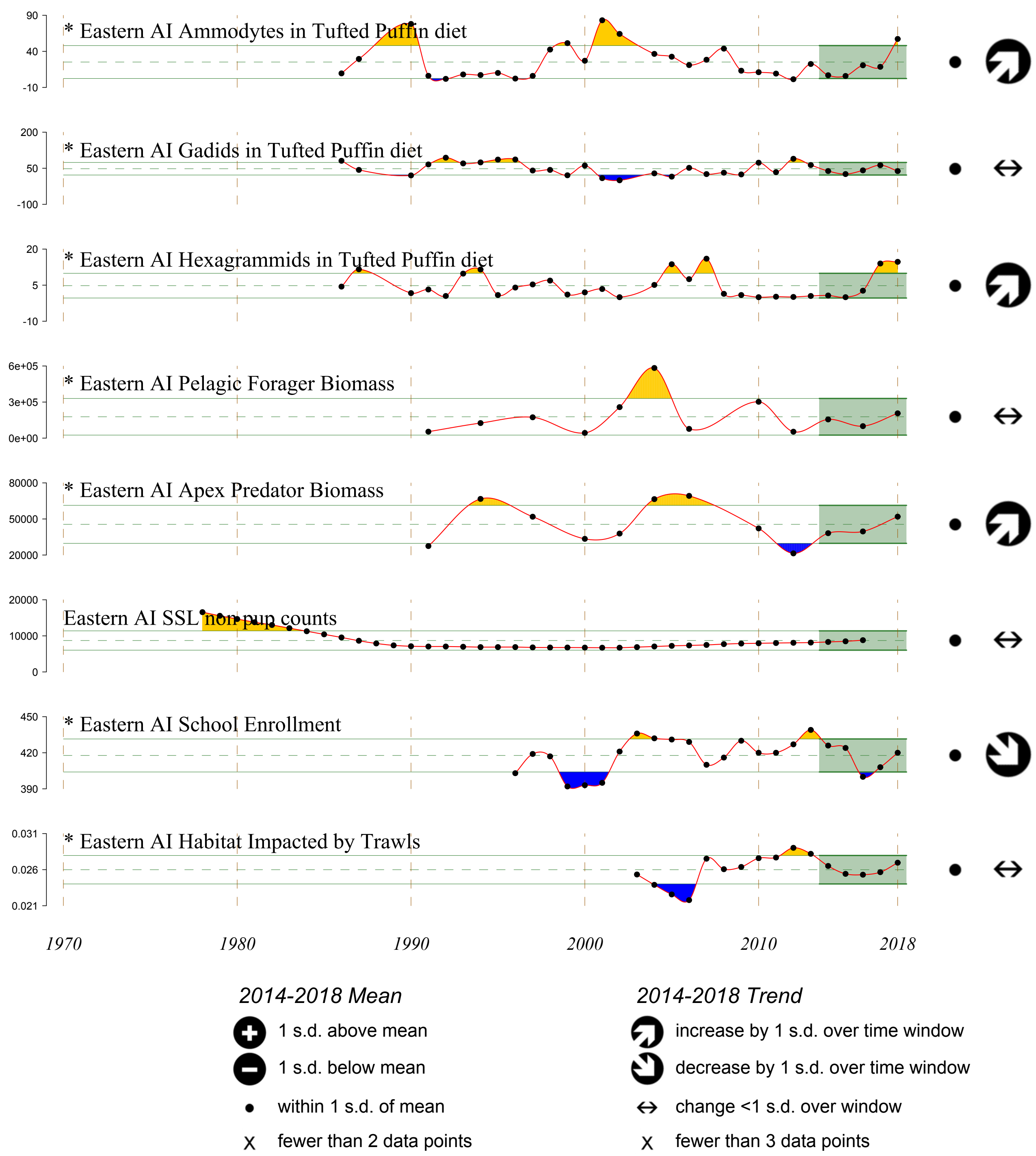

Figure 5: Eastern Aleutian Islands ecoregion indicators. * indicates time series updated in 2018. See Figure 3 for legend.

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).

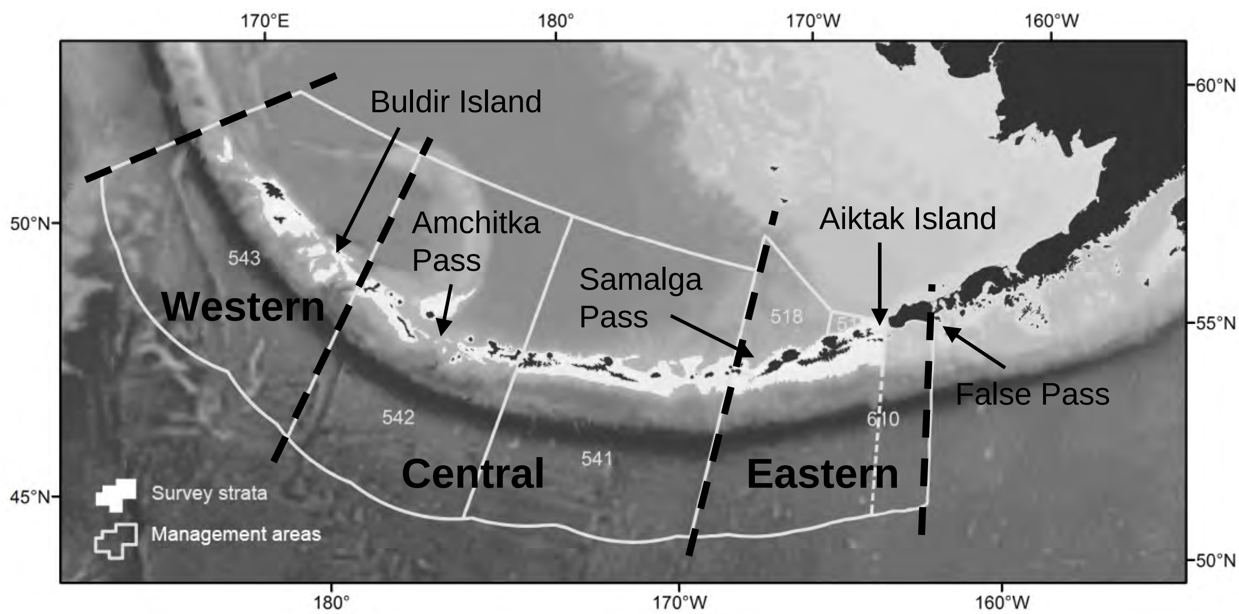

Figure 6: The three Aleutian Islands assessment ecoregions.

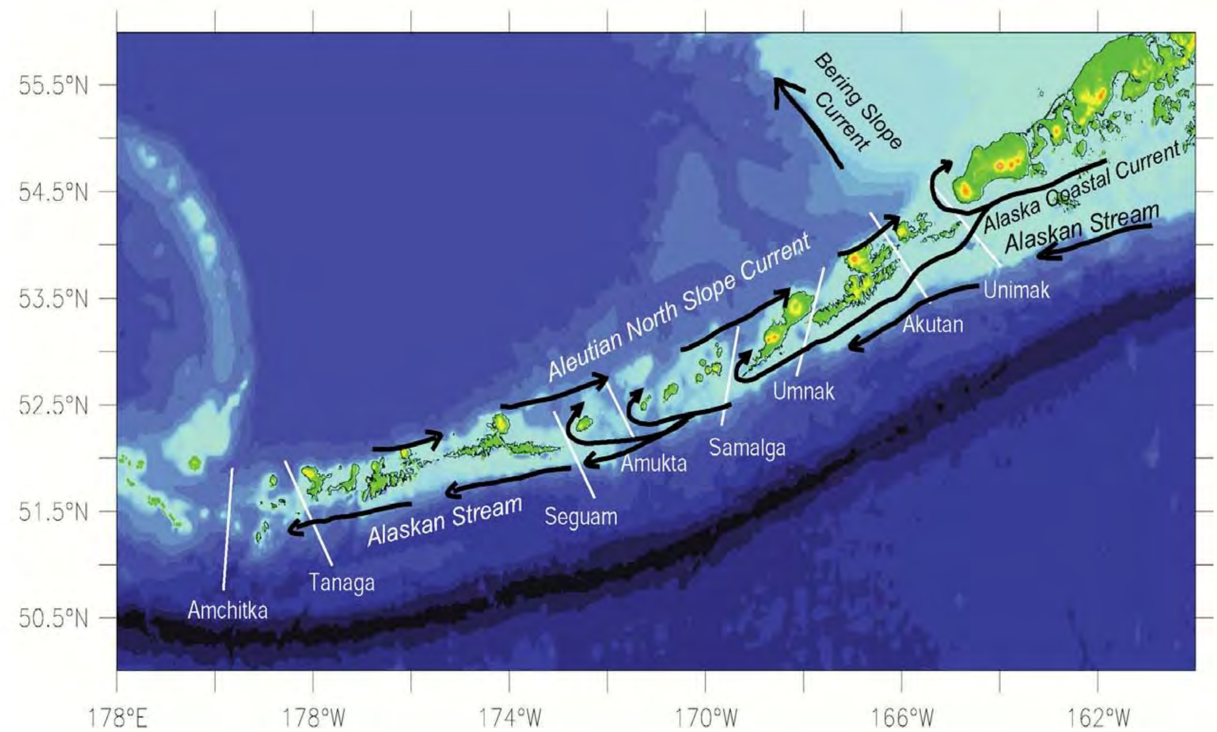

Figure 7: Ocean water circulation in the Aleutians. Currents are indicated with black lines. Passes are indicated with white lines. Image from Carol Ladd.

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.

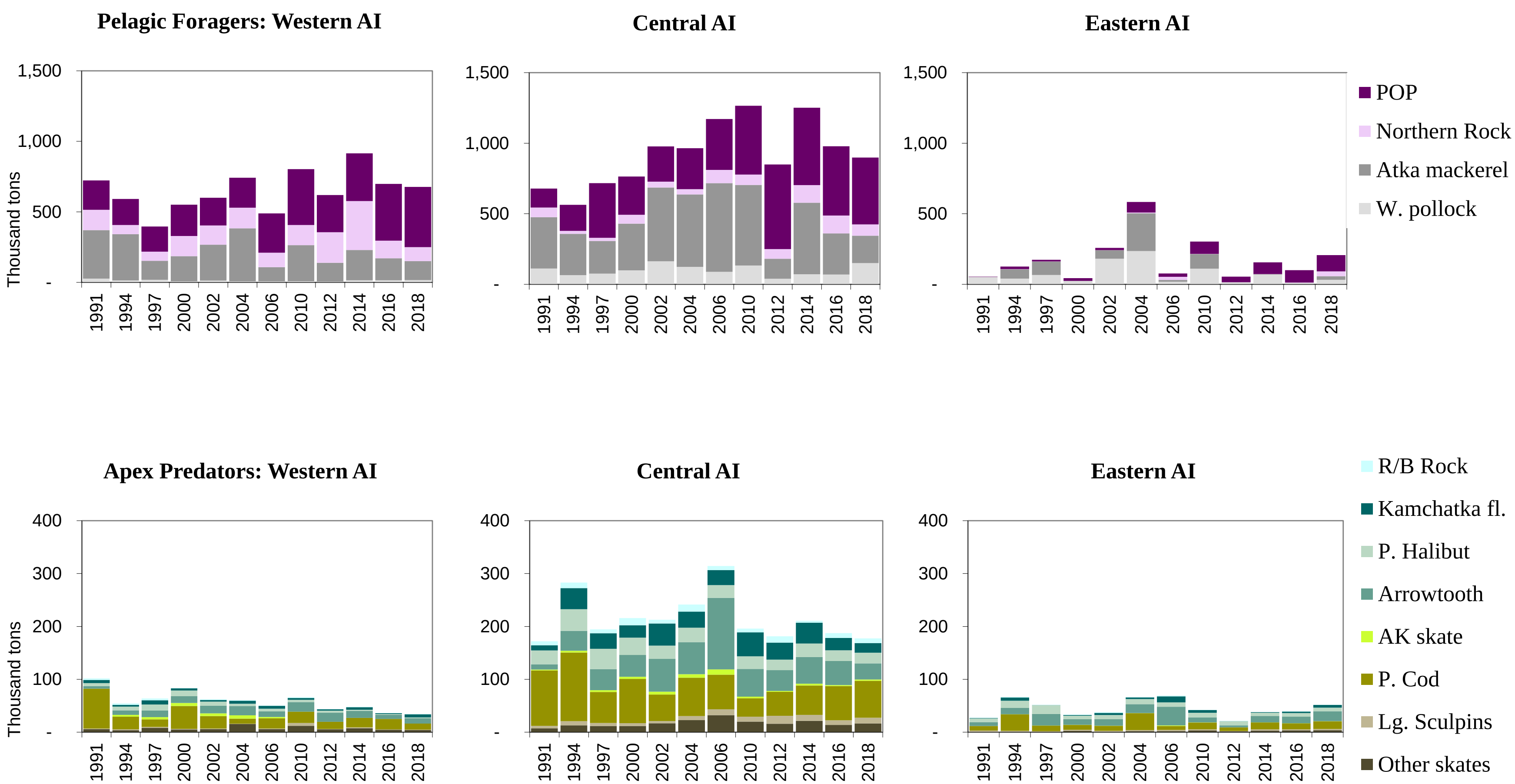

Figure 8: Estimated survey biomasses of fish apex predators and pelagic foraging guilds aggregated by Aleutian Islands ecoregions.

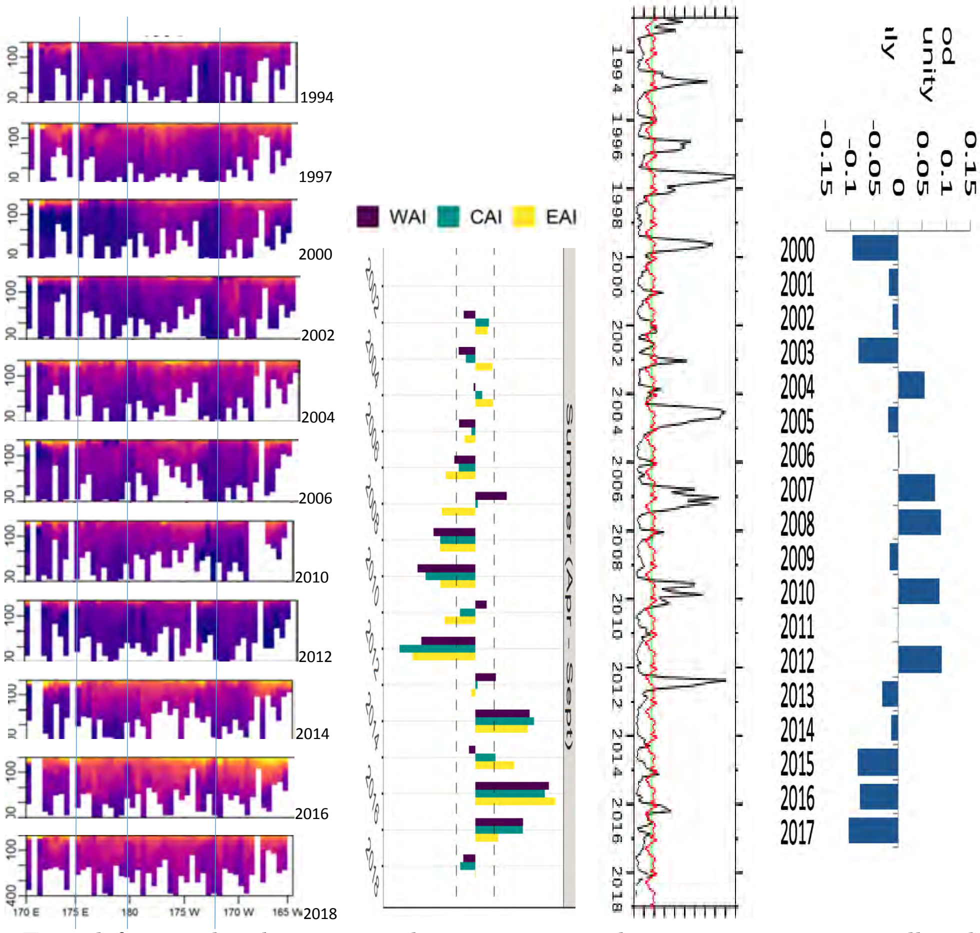

Figure 9: From left to right: bottom trawl survey water column temperatures, satellite-derived sea surface temperatures, eddy kinetic energy near Amukta Pass, mean copepod community size from the Continuous Plankton Recorder in the southern Bering Sea, north of the Aleutian Islands.

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.

Executive Summary of Recent Trends in the Aleutian Islands

This section contains links to all new and updated information contained in this report. The links are organized within three sections: Physical and Environmental Trends, Ecosystem Trends, and Fishing and Fisheries Trends.

Physical and Environmental Trends

North Pacific

- The North Pacific atmospheric-ocean climate system during fall 2017 to summer 2018 was similar to that during 2016–2017 (p. 40).
- The prominent sea surface temperature anomalies during 2017-18 tended to be positive, with persistent warmth in the subtropical eastern North Pacific Ocean (p. 40).
- A weak La Niña developed during winter 2017–2018 along with a weaker than normal Aleutian Low, similar to the previous year (p. 45).
- The Pacific Decadal Oscillation (PDO) was slightly positive during the past year, with a decline to near zero in the summer of 2018 reflecting the wide-scale warm pattern across the North Pacific Ocean (p. 45).
- The North Pacific Index (NPI) was strongly positive from fall 2017 into 2018 due to the relatively high sea level pressure in the region of the Aleutian Low, which was displaced to the northwest, over Siberia, and causing persistent warm winds from the southwest over the Bering Sea last winter (p. 41).
- The North Pacific Gyre Oscillation (NPGO) declined from a small to a large negative value from 2017 to early 2018, implying that flows in the Alaska portion of the Subarctic Gyre weakened and low nitrate levels along Line P extending from Vancouver Island to Station PAPA (p. 45).
- The climate models used for seasonal weather predictions are indicating about a 70% chance of a weak-moderate El Niño for the winter of 2018-19, and warmer than normal SSTs in both the western and eastern mid-latitude North Pacific in early 2019 (p. 45).

Aleutian Islands

- The Aleutians Islands region experienced suppressed storminess through fall and winter 2017/2018 with predominant winds from the southwest (p. 40).

- The Alaska Stream appears to have been relatively diffuse on the south side of the eastern Aleutian Islands (p. 40).
- Eddy energy in the Aleutian Islands region has been low from the fall 2012 through 2018, indicating the likelihood of smaller than average fluxes of volume, heat, salt, and nutrient fluxes through Amukta Pass (p. 49).
- A new satellite-derived SST indicator presents seasonal anomalies over time in the Aleutian Islands ecoregions. There was a general consistency in temperature anomalies within each year for the central and eastern Aleutian Island areas, whereas the western Aleutian Island region was more likely to diverge from the other areas in the direction of temperature anomaly within a season. The indicator shows that summer and winter temperatures were anomalously warm from 2014–2017, then cooled during summer 2018 (p. 50).
- Sea surface temperature values were moderately warm from fall 2017 through spring 2018 but then cooled to normal during summer 2018 (p. 41).
- The temperature anomaly profiles from the biennial AI bottom trawl survey suggests that there was a return to slightly cooler conditions in 2018 relative to 2016, but that 2018 is still amongst the warmer years over the survey time series, with warm anomalies penetrating deeper and distributed more extensively across the Aleutian archipelago than in 2014 (p. 52).

Ecosystem Trends

- The Aleutian islands bottom trawl survey of structural epifauna showed variable distributions. Sponges are caught in most tows in the AI west of the southern Bering Sea. Abundance of coral in all areas has declined since about 1991-1993 surveys and is at generally low levels in all areas, but the frequency of occurrence has remained steady. Soft corals occur in relatively few tows, except in the eastern Aleutian Islands. Sea anemones are common, but sea pen abundance is low (p. 56).
- In the Bering Sea region north of the Western and Central Aleutian Islands that is sampled by the Continuous Plankton Recorder, spring diatom abundances have remained above average 2013–2017 (p. 60).
- However, copepod community size anomalies have remained negative from 2014–2017 indicating a community biased towards smaller species than is typical in this ecosystem (p. 60).
- Jellyfish mean catch per unit effort in the biennial AI bottom trawl survey is typically higher in the western and eastern AI than in the central AI. Catches and frequency of occurrence steadily increased across the AI from 2012 to 2016, but decreased in 2018 (p. 63).
- Length-weight residuals (a measure of groundfish condition) in 2014 and 2016 were negative for all species except arrowtooth flounder in 2014 and southern rock sole in 2016. In 2018, condition continued to be strongly negative for Pacific cod, northern rockfish, Pacific Ocean perch and arrowtooth flounder (p. 65)
- The depth distributions of rougheye rockfish, Pacific ocean perch, shortraker rockfish, and northern rockfish have been shallower in the most recent bottom trawl surveys of the Aleutian Islands. The mean spatial distribution of northern rockfish is trending westward. There are no significant trends in mean-weighted temperature distributions for any rockfish species (p. 67).
- Benthic communities and other non-target species sampled incidentally in the biennial bottom trawl survey. There has been a notable decline in eelpout biomass in the western AI in the last 4 surveys. Echinoderms and poachers have been increasing in the eastern AI ecoregion in the last 3 surveys (p. 71).

- The overall biomass in the summer bottom trawl survey in 2018 was very similar to that in 2016. The largest difference was a decrease in arrowtooth flounder, which occured in the central Aleutian Islands ecoregion (p. 8).
- Pacific cod showed a large decrease in the western Aleutian Islands ecoregion, but the overall pattern was balanced by increases in the eastern and central Aleutian Islands ecoregion (p. 8).
- The long term trend reflects a continuing shift in the pelagic foraging biomass from that dominated by Atka mackerel and pollock to that dominated by rockfish (p. 8)
- In general, seabirds in the Aleutians did not experience widespread failures like they did in the Gulf of Alaska during the marine heat wave of the past few years. However many piscivorous seabirds did poorly in 2018 at Buldir (western AI) and had mixed success at Aiktak (eastern AI), while planktivorous seabirds have remained generally successful. This pattern suggests that zooplankton availability was sufficient to support chick-rearing at both colonies, but that forage fish prey were insufficient to support chick-rearing at Buldir (p. 73).
- The western AI Steller sea lion adult population decreased rapidly at approximately 7% per year and sub-area population trends improved to the east through the western Gulf of Alaska, where the annual trend increased approximately 4% per year. Regional trends in pup production are similar to trends in non-pup counts, with continued relatively steep declines in the western AI, a less steep decline in the central AI, and improvement in the eastern AI (p. 2).
- A new indicator demonstrates that the stability (inverse biomass coefficient of variation) of groundfish biomass in the Aleutian Islands bottom trawl survey has been relatively constant from 2010–2018. There has been a gradual decrease over this time, but with a non-significant linear trend that is influenced by variability in Atka mackerel biomass (p. 76).
- A new indicator tracks fluctuations in the size of groundfish sampled over time by the Aleutian Islands bottom trawl survey. The mean length of the groundfish community in 2018 is the highest value over the time series, but in general has remained stable over time (p. 77).
- A new indicator tracks the mean life span of the groundfish sampled by the Aleutian Islands bottom trawl survey over time. This indicator serves as a proxy for the mean turnover rate of species and communities" and is intended to reflect ecosystem stability and resistance to perturbations. The mean lifespan in 2018 is above the long term mean, but has been largely stable over the time period with some interannual variation due to high biomass estimates of pollock or Atka mackerel (p. 79).

Fishing and Fisheries Trends

- Since 1993 discards and discard rates of groundfish in federally-managed Alaskan groundfish fisheries have generally declined across the trawl pollock, non-pollock trawl, and fixed gear sectors in the Aleutian Islands. To date in 2018, discard levels across all sectors appear to be consistent with levels during the previous 5-year period (p. 81).
- In 2017, non-target catch of Scyphozoan jellyfish in trawl fisheries in the Aleutian Islands increased substantially from that in 2016. The catch of structural epifauna (sponges, corals, and bryzoans) is variable and was the third highest in 2017. The catch of assorted invertebrates (mainly seastars) has been level from 2015–2017 (p. 84).
- The incidental catch of seabirds in Aleutian Islands groundfish fisheries in 2017 was the highest estimate in the 2007–2017 time series. This was primarily due to a large increase in the numbers of shearwaters caught (p. 86).
- With the Arctic FMP closure included, almost 65% of the U.S. EEZ of Alaska is closed to bottom trawling (p. 90).

- At present, no Bering Sea/Aleutian Islands groundfish stock or stock complex were subjected to overfishing, known to be overfished, or known to be approaching an overfished condition (p. 96).
- The percent of area disturbed due to commercial fishing interactions (pelagic and non-pelagic trawl, longline, and pot) has decreased slightly or remained steady in the Aleutian Islands (p. 92).
- Landings (pounds) are used in a new indicator to characterize commercial seafood production. Landings in the Aleutian Islands are primarily composed of pelagic foragers and apex predators. Atka mackerel dominate the pelagic forager catch. Landings of apex predators decreased in 2011 due to a decrease in Pacific cod catches (p. 101).
- Subsistence salmon harvest in the eastern Aleutian Islands has varied over time, but has been declining in the central Aleutian Islands, with none reported to have been caught in the most recent year, 2016. Subsistence halibut catches have also been generally declining since 2004, but this trend may be related to subsistence survey methodology (p. 103).
- Economic values of 5 functional groups (apex predators, benthic foragers, motile epifauna, pelagic foragers, and salmonids) are presented in a new indicator. Ex-vessel values have been increasing for pelagic foragers since 2010 primarily due to Atka mackerel and rockfish and decreasing for Pacific cod. First-wholesale value shows similar trends. Contrary to the Gulf of Alaska and Eastern Bering Sea, the first-wholesale total catch unit value in the Aleutian Islands has an increasing trend since 2009, with the value in 2017 being close to the all-time high of 2011–2012 (p. 106).
- Unemployment rates in Aleutian Islands fishing communities from 1990 to 2017 were lower than state and national rates, reflecting stability in the commercial fishing and seafood processing industries (p. 110).
- As of 2017 the total population including all Aleutian Island communities was 5,755 people. The eastern AI has had the most steady population increase between 1880 and 2015, whereas the central and western AI experienced fluctuations. The western AI has had no residents wince 2011 (p. 114).
- While Unalaska schools in the eastern Aleutian Islands have maintained relatively stable enrollment since 1996, Nikolski, Akutan, and False Pass have diminished dramatically and are no longer viable. Both Adak and Atka schools in the central Aleutian Islands have experienced declining enrollment (p. 117).

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† indicates new contribution

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General Introduction and Background

The goals of the Ecosystem Status Reports are to (1) provide stronger links between ecosystem research and fishery management and to (2) spur new understanding of the connections between ecosystem components by bringing together the results of diverse research efforts into one document. Beginning in 2016, we split the report into four separate documents, one for the Gulf of Alaska, Aleutian Islands, eastern Bering Sea, and the Arctic[1]. This year, we present updated reports for the Gulf of Alaska, Aleutian Islands, and eastern Bering Sea. Each report contains four main sections:

- Report Card(s)
- Ecosystem Assessment
- Executive Summary
- Ecosystem Indicators

The purpose of the first section, the Report Card(s), is to summarize the status of the top indicators selected by teams of ecosystem experts to best represent each ecosystem. Time series of indicators are presented in figures formatted similarly to enable comparisons across indicators. Recent trends in climate and the physical environment, ecosystems, and fishing and fisheries are highlighted in bulleted lists. The selected list of indicators is intended to be revisited regularly. The eastern Bering Sea indicators were selected in 2010 and will be updated as part of the Fishery Ecosystem Plan currently being developed. The Aleutian Islands indicators were selected in 2011. The Gulf of Alaska indicators were selected in 2015.

The purpose of the second section, the Ecosystem Assessment, is to synthesize historical climate and fishing effects on Alaskan marine ecosystems using information from the Ecosystem Status and Management Indicators section and stock assessment reports. An ongoing goal is to produce ecosystem assessments utilizing a blend of data analysis and modeling to clearly communicate the current status and possible future directions of ecosystems. In 2017 we expanded the Fishing and Human Dimensions section to more broadly reflect aspects of our role in the ecosystem. In doing so, we organized this new section around a proposed set of ecosystem-scale objectives derived from U.S. legislation and current management practices.

The purpose of the third section, the Executive Summary, is to provide a concise summary of new or updated information contained in each report. Page links to sections with more detail are provided.

The purpose of the fourth section, Ecosystem Indicators, is to provide detailed information and updates on the status and trends of ecosystem components. The indicators are broadly grouped into Ecosystem Status Indicators, organized by trophic level, and Fishing and Human Dimensions Indicators, organized around objective categories derived from U.S. legislation and current management practices. Descriptions of the Report Card indicators and "Noteworthy" items that capture unique occurrences are highlighted at the beginning. Indicators are also intended to track performance in meeting the stated ecosystem-based management goals of the NPFMC, which are:

[1]The Arctic report is under development

1. Maintain biodiversity consistent with natural evolutionary and ecological processes, including dynamic change and variability
2. Maintain and restore habitats essential for fish and their prey
3. Maintain system sustainability and sustainable yields for human consumption and non-extractive uses
4. Maintain the concept that humans are components of the ecosystem

History of the ESRs Since 1995, the North Pacific Fishery Management Councils (NPFMC) Groundfish Plan Teams have prepared a separate Ecosystem Status (formerly Considerations) Report within the annual SAFE report. Each new Ecosystem Status Report provides updates and new information to supplement the original report. The original 1995 report presented a compendium of general information on the Gulf of Alaska, Bering Sea, and Aleutian Island ecosystems as well as a general discussion of ecosystem-based management. The 1996 edition provided additional information on biological features of the North Pacific, and highlighted the effects of bycatch and discards on the ecosystem. The 1997 edition provided a review of ecosystem-based management literature and ongoing ecosystem research, and provided supplemental information on seabirds and marine mammals. The 1998 edition provided information on the precautionary approach, essential fish habitat, effects of fishing gear on habitat, El Niño, local knowledge, and other ecosystem information. The 1999 edition again gave updates on new trends in ecosystem-based management, essential fish habitat, research on effects of fishing gear on seafloor habitat, marine protected areas, seabirds and marine mammals, oceanographic changes in 1997/98, and local knowledge.

In 1999, a proposal came forward to enhance the Ecosystem Status Report by including more information on indicators of ecosystem status and trends and more ecosystem-based management performance measures. The purpose of this enhancement was to accomplish several goals:

1. Track ecosystem-based management efforts and their efficacy
2. Track changes in the ecosystem that are not easily incorporated into single-species assessments
3. Bring results from ecosystem research efforts to the attention of stock assessment scientists and fishery managers,
4. Provide a stronger link between ecosystem research and fishery management
5. Provide an assessment of the past, present, and future role of climate and humans in influencing ecosystem status and trends

Each year since 1999, the Ecosystem Status Reports have included some new contributions and will continue to evolve as new information becomes available. Evaluation of the meaning of observed changes should be in the context of how each indicator relates to a particular ecosystem component. For example, particular oceanographic conditions, such as bottom temperature increases, might be favorable to some species but not for others. Evaluations should follow an analysis framework such as that provided in the draft Programmatic Groundfish Fishery Environmental Impact Statement that links indicators to particular effects on ecosystem components.

In 2002, stock assessment scientists began using indicators contained in this report to systematically assess ecosystem factors such as climate, predators, prey, and habitat that might affect a particular stock. Information regarding a particular fishery's catch, bycatch, and temporal/spatial distribution can be used to assess possible impacts of that fishery on the ecosystem. Indicators of concern can be highlighted within each assessment and can be used by the Groundfish Plan Teams and the Council to justify modification of allowable biological catch (ABC) recommendations or time/space allocations of catch.

We initiated a regional approach to the ESR in 2010 and presented a new ecosystem assessment for the eastern Bering Sea. In 2011, we followed the same approach and presented a new assessment for the Aleutian Islands

based on a similar format to that of the eastern Bering Sea. In 2012, we provided a preliminary ecosystem assessment on the Arctic. Our intent was to provide an overview of general Arctic ecosystem information that may form the basis for more comprehensive future Arctic ecosystem assessments. In 2015, we presented a new Gulf of Alaska report card and assessment, which was further divided into Western and Eastern Gulf of Alaska report cards beginning in 2016. This was also the year that the previous Alaska-wide ESR was split into four separate report, one for the Gulf of Alaska, Aleutian Islands, eastern Bering Sea, and the Arctic[2].

The eastern Bering Sea and Aleutian Islands ecosystem assessments were based on additional refinements contributed by Ecosystem Synthesis Teams. For these assessments, the teams focused on a subset of broad, community-level indicators to determine the current state and likely future trends of ecosystem productivity in the EBS and ecosystem variability in the Aleutian Islands. The teams also selected indicators that reflect trends in non-fishery apex predators and maintaining a sustainable species mix in the harvest as well as changes to catch diversity and variability. Indicators for the Gulf of Alaska report card and assessment were also selected by a team of experts, via an online survey first, then refined in an in-person workshop.

Originally, contributors to the Ecosystem Status Reports were asked to provide a description of their contributed index/information, summarize the historical trends and current status of the index, and identify potential factors causing those trends. Beginning in 2009, contributors were also asked to describe why the index is important to groundfish fishery management and implications of index trends. In particular, contributors were asked to briefly address implications or impacts of the observed trends on the ecosystem or ecosystem components, what the trends mean and why are they important, and how the information can be used to inform groundfish management decisions. Answers to these types of questions will help provide a "heads-up" for developing management responses and research priorities.

This report represents much of the first three steps in Alaska's IEA: defining ecosystem goals, developing indicators, and assessing the ecosystems (Figure 10). The primary stakeholders in this case are the North Pacific Fishery Management Council. Research and development of risk analyses and management strategies is ongoing and will be referenced or included as possible.

Figure 10: The IEA (integrated ecosystem assessment) process.

[2]The Arctic report is under development

It was requested that contributors to the Ecosystem Status Reports provide actual time series data or make them available electronically. The Ecosystem Status Reports and data for many of the time series presented within are available online at: `http://access.afsc.noaa.gov/reem/ecoweb/index.php`. These reports and data will also be available through a new NOAA-wide IEA website in early 2019.

Past reports and all groundfish stock assessments are available at: `http://www.afsc.noaa.gov/refm/stocks/assessments.htm`

If you wish to obtain a copy of an Ecosystem Considerations report version prior to 2000, please contact the Council office (907) 271-2809.

Ecosystem Indicators

Report Card Indicator Descriptions

The suite of indicators that form the basis for the Aleutian Islands Report Cards was selected to provide a comprehensive view of the Aleutian Island ecosystem reflecting across trophic levels from the physical environment to top predators and humans, as well as both the nearshore and offshore. Ideally, they could be regularly updatable across all ecoregions (Western, Central and Eastern), thereby characterizing a global attribute with local conditions. Although a single suite of indicators were chosen for the entire ecosystem, not all are available or applicable in each of the three ecoregions. The final selection reflected the limitations of available data sets for the Aleutian Islands ecosystem.

1. Winter North Pacific Index anomaly relative to the 1961–2000 mean
2. Reproductive anomalies of planktivorous least auklet and crested auklets as indicators of zooplankton productivity
3. Proportions of *Ammodytes*, gadids, and hexagrammids in tufted puffin chick diets
4. Apex predator and pelagic forager fish biomass indices
5. Sea otter counts
6. Steller sea lion non pup counts (juveniles and adults)
7. Percent of shelf <500m deep trawled
8. K-12 enrollment in Aleutian Islands schools

Winter North Pacific Index The North Pacific Index (Trenberth and Hurrell, 1994), the area weighted mean sea level pressure over the region 30°–65°N, 160°E–140°W, is a widely used measure of the intensity of the Aleutian Low. A negative winter (November–March) NPI anomaly implies a strong Aleutian Low and generally stormier conditions. It has been suggested that correlations between a strong Aleutian Low and decreased seabird productivity in the Aleutian Islands may be due to decreased prey (zooplankton) availability (Bond et al., 2011). The winter index is the average NPI from November through March (year of January), and the anomalies are normalized by the mean (8.65) and standard deviation (2.23) for 1961–2000.

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Reproductive anomalies of planktivorous least auklet and crested auklets Least auklets (*Aethia pusilla*) and crested auklets (*A. cristatella*) are small, abundant seabirds that nest in the Aleutian Islands. The USFWS stations field biologists to monitor auklet chick diets and reproductive success annually

at Buldir Island and less frequently at other islands on which they occur. Both species are planktivorous and dive to capture their prey. Least auklet chick diets are mainly composed of *Neocalanus cristatus*, *N. plumchrus*, and *N. flemingeri*. Crested auklet chick diets consist of mainly Euphausiacea and *N. cristatus*. Due to the lack of time series of direct measurements of zooplankton in the Aleutian Islands, the team selected reproductive anomalies of least and crested auklets as indicators of copepod and euphausiid abundance, respectively. Reproductive anomalies were selected as the metric of interest instead of chick diets because reproductive success is an integrative indicator of ecosystem productivity and forage for planktivorous commercially-fished species.

Reproductive success is defined as the ratio of number of nest sites with a fledged chick to the number of nest sites with eggs. In the Western ecoregion, reproductive success of least and crested auklets were recorded annually at Buldir Island from 1988-2010 with the exception of 1989 and 1999. In the Central ecoregion, reproductive success was monitored annually at Kasatochi Island from 1996-2007. In 2008 a volcanic eruption covered the monitored colony in ash, disrupting breeding. It is unknown when auklets will nest there again and if so, whether observations will continue. Data were extracted from reports produced by the Alaska Maritime National Wildlife Refuge.

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Proportions of hexagrammids, gadids, and *Ammodytes* in tufted puffin chick diets
Tufted puffins (*Fratercula cirrhata*) are medium-sized diving seabirds that nest in varying densities throughout the Aleutians. The USFWS stations field biologists to monitor puffin chick diets annually at Buldir and Aiktak Islands (Figure 6) and less frequently at other Aleutian islands on which they occur. Puffins carry multiple prey items in their bills when they return to their colonies to feed their chicks. Forage fish and squid comprise most of puffin chick diets. In the absence of direct measures of forage fish abundance, time series of percent composition of hexagrammids, gadids, and *Ammodytes* in puffin chick meals were selected as indicators of forage fish recruitment and system-wide productivity. Values are the percentage of total individual prey items comprised by each prey item identified in the field or lab.

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Apex predator and pelagic forager fish biomass indices We present two foraging guilds to indicate the status and trends for fish in the Aleutian Islands: apex predators and pelagic foragers. Each is described in detail below. This guild analysis was based on the time series available as part of the NOAA summer bottom trawl survey for the Aleutian Islands (Western and Central ecoregions) and the Aleutian Islands and Gulf of Alaska combined (Eastern ecoregion). These two guilds are based on the aggregation of Aleutian species by trophic role, habitat and physiological status. The species included in each guild are listed in Table 1.

Time series for the Western and Central ecoregions are based on data collected from the AI bottom trawl survey. The Eastern ecoregion time series is a composite of the Aleutian Islands survey, which samples the northern portion of the islands, and the Gulf of Alaska survey, which samples the southern portion. Since surveys in these two areas are conducted in different years, the biomass estimates represent the closest pair of years pooled together to get a total biomass estimate for the shelf region (0–500m). This time series excludes deep-water species such as sablefish and grenadiers, as most are found deeper than the trawl survey samples. The Team acknowledges that these would be good to include, but that the trawl survey does not sample them well.

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Table 1: Species included in foraging guild-based fish biomass indices for the Aleutian Islands

Fish Apex Predators	Pelagic Fish Foragers
Pacfic cod	Atka mackerel
Pacific halibut	Northern Rockfish
Arrowtooth flounder	Pacific ocean perch
Kamchatka flounder	Walleye pollock
Rougheye rockfish	
Blackspotted rockfish	
Large sculpins	
Skates	

Sea otter counts Sea otters (*Enhydra lutris*) counts were selected as a representative of the nearshore Aleutian environment. The >300 islands which make up the Aleutian chain provide extensive nearshore habitat. Sea otters are an integral component of the coastal ecosystems in which they occur. Sea otter predation limits the distribution and abundance of their benthic invertebrate prey, in particular herbivorous sea urchins. Otter-induced urchin declines increase the distribution and abundance of kelp in Alaska (Estes and Duggins, 1995) and in other areas of their range (Breen et al., 1982; Kvitek et al., 1998). This trophic cascade initiated by sea otters has indirect effects on other species and processes. Kelp forests are more productive than habitat without kelp (a.k.a. "sea urchin barrens"), fixing 3-4 times more organic carbon through photosynthesis (Duggins et al., 1989). This increased primary production results in increased growth and population size of consumers such as mussels and barnacles (Duggins et al., 1989). Rock greenling (*Hexagrammos lagocephalus*), a common fish of the kelp forests of the Aleutian Islands, are an order of magnitude more abundant in kelp forests than in sea urchin barrens (Reisewitz et al., 2006). Kelp forests likely function as nearshore habitat for other Aleutian Islands fish, such as the related Atka mackerel (*Hexamgrammos monopterygius*). Sea otter impacts on kelp forests also influence the behavior and foraging ecology of other coastal species such as glaucous-winged gulls (Irons et al., 1986) and bald eagles (Anthony et al., 2008).

Sea otter survey methods are detailed in Doroff et al. Doroff et al. (2003). Skiff-based surveys of sea otters were conducted intermittently at Amchitka Island, Kiska and Little Kiska Islands, Attu Island, Agattu Island, Rat Island and the Semichi Islands when viewing conditions were good to excellent (Beaufort sea state of 1-2, and .1 km of clear visibility at sea level). Two or more observers counted sea otters from a 5.2m skiff as it was run parallel to shore along the outer margins of kelp (*Alaria fistulosa*) beds at 15–22 km/h. Sea otters were counted with the unaided eye, using binoculars to confirm sightings or to count animals in large groups. The shoreline of each island was divided into contiguous segments, each 3–10 km in length and separated by distinctive topographic features (e.g., prominent points of land). Counts were recorded separately for each section. Reported values are mean densities, calculated as otter counts per km surveyed averaged across islands in each ecoregion.

Contributed by Tim Tinker, formerly of USGS

Steller sea lion non pup counts Counts of adult and juvenile Steller sea lions (*Eumetopias jubatus*) are used in the Aleutian Island ecosystem assessment to represent the status of an apex piscivorous predator whose diet consists primarily of commercially-fished species. The Steller sea lion inhabits coastal regions of the North Pacific Ocean, breeding in summer on terrestrial rookeries located from California north throughout the Gulf of Alaska, the eastern Bering Sea, the Aleutian Islands, Kamchatka Peninsula, Sea of Okhotsk, and the Kuril Islands (NMFS, 2010). The Steller sea lion is the world's largest member of the Otariidae family of pinnipeds. On average, Steller sea lions consume 6–10% of their body weight per day, but during lactation, energy intake by adult females may increase by as much as 3-fold (Keyes, 1968; Winship et al., 2002; Williams,

2005). Steller sea lions are generalist predators and consume a wide variety of fish and cephalopods in habitats ranging from nearshore demersal to offshore epi-pelagic, with local diets reflecting the species composition of the local fish community (Pitcher and Fay, 1982; Riemer and Brown, 1997; Sinclair and Zeppelin, 2002; Waite and Burkanov, 2006; Trites et al., 2007; McKenzie and Wynne, 2008; Fritz and Hinckley, 2005). In the Aleutian Islands, the diet consists largely of Atka mackerel, followed by salmon, cephalopods, Pacific cod, sculpins and walleye pollock (Sinclair and Zeppelin, 2002). Unlike phocid pinnipeds, otariids do not have large blubber (energy) stores, and as a consequence, require reliable access to predictable, local prey aggregations to thrive (Williams, 2005; Sigler et al., 2009).

Status and trends of Steller sea lion populations in Alaska are assessed using aerial photographic surveys of a series of "trend" terrestrial haul-outs and rookeries that have been consistently surveyed each summer breeding season, when the proportion of animals hauled out is the highest during the year (Sease and York, 2003). Since 2004, NMFS has used high-resolution vertical photography (computer-controlled camera mounted in the belly of the plane) in its sea lion surveys in Alaska. This replaced the oblique, hand-held photographic techniques used from the first surveys in the 1960s and 1970s through 2002. Counts from vertical high resolution photographs were found to be 3.6% higher than those from oblique photos, necessitating the use of a correction factor to correctly compare recent counts with the rest of the time series (Fritz and Hinckley, 2005). Trend sites include the vast majority (>90%) of animals observed in each survey. Adults and juvenile (non-pup) numbers used for population trend assessment are sums of counts at trend sites within sub-areas or across the range of the western DPS in Alaska (NMFS, 2010). Replicate surveys conducted in the summers of 1992 and 1994 indicated that sub-area trend site counts of non-pups are stable within each breeding season (coefficients of variation of ∼5%; NMFS, unpublished data).

In our Aleutian Island ecosystem assessment, counts of adult and juvenile Steller sea lions at trend sites are used to indicate of the "health" of apex piscivores whose diet consists primarily of commercially-fished species. The survey sites used in the assessment are:

- Western (172-177°E; 10 sites in the Near Island group and Buldir west of Kiska),
- Central (177°E to ∼170°W; 62 sites in the Rat, Delarof, and Andreanof Island groups, plus the Islands of Four Mountains), and
- Eastern ecoregions (163-170°W; 30 sites in the Fox and Krenitzen Islands, on Unimak Island, and on and near Amak Island in the southeastern Bering Sea)

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Habitat disturbance from trawls This new indicator uses output from the Fishing Effects (FE) model to estimate the habitat reduction of geological and biological features over the Bering Sea domain, utilizing spatially-explicit VMS data. The effects are cumulative, incorporating both estimated recovery time and disturbance. The time series for this indicator is available since 2003, when widespread VMS data became available. The monthly value in September is used as an annual indicator.

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K-12 enrollment in Aleutian Islands schools The number of children enrolled in schools was selected as an indicator of vibrant, sustainable communities in the Aleutian Islands ecosystem. Community residents are closely tied to the ecosystem through sense of place and daily experience and activity. Enrollment statistics for kindergarten through twelfth (K–12) grades by school and region were compiled for the years 1996 through 2014 (`http://www.eed.state.ak.us/stats/`). School enrollment numbers fluctuate widely and serve to highlight the difficulties in maintaining sustainable communities within the Aleutian Islands ecosystem.

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Noteworthy (formerly Hot Topics)

This section replaces the previously-named Hot Topics. We include information here that is deemed of relevance to ecosystem considerations of fisheries managers, but does not fit our typical indicator format. Information included here is often new, a one-time event, qualitative, or some other type of non-standard ecosystem indicator.

Federal fishery changes in the Aleutian Islands

Earlier in April of 2018, the NPFMC created a Purpose and Need statement to modify Amendment 113 to the BSAI FMP, which under certain conditions sets aside 5,000 mt exclusively for harvest by vessels participating in directed fishing for AI Pacific cod and delivering their catch for processing to AI shoreplants west of 170°W from January 1 through March 15 (mainly Adak). At issue was the February 28 deadline by which 1,000 mt had to be fished in order to lock the 5,000 mt set aside. Vessels caught a portion and delivered it to processors other than the AI shoreplant, effectively triggering the closure of all the federal Pacific cod catcher vessel sectors (except jig gear) for directed fishing in the A season on the BSAI region on February 11. A resolution is expected on December 2018.

Following numerous ownership changes since 1999, the Adak shoreplant reopened in 2017 and continued to ship live golden King crab to Shanghai in 2018 .

Contributed by Ivonne Ortiz

Local Environmental (LEO) Network

The NMFS AFSC is interested in documenting and learning from citizen science observations that may be incorporated into Ecosystem Status Reports (ESRs). We identified the LEO Network as a potential platform for tracking these observations in the 2017 ESR and were encouraged by the Council and SSC to continue exploring the utilization of this framework in future reports. Other citizen science efforts exist in Alaska, but to our knowledge these efforts are mostly project specific (e.g., bird spotting and identification) or community specific.

The LEO Network was launched in 2012 by the Alaska Native Tribal Health Consortium (ANTHC) as a tool for local observers in the Arctic to share information about climate and other drivers of environmental change (see: https://www.leonetwork.org/en/docs/about/about). Anyone may join the network and provide observations, and the network now spans the globe. Consultants with relevant expertise often, but not always, review the observations and provide feedback. The observations are of unusual environmental events or notable environmental changes, reported by geographic location and date, and classified by relevant category (or multiple relevant categories) such as weather, land, fish, sea mammals, ocean/sea, etc.

Figure 11 shows LEO Network observations from January 1, 2017 to August 1, 2018 in the Aleutian Islands (AI) LME with the frequency by category. These categories are based on analysis of the 7 total observations in 2017 and 2018 (through August 1st) in the AI and are not limited to the marine environment. The observations in Figure 12 were made in one community.

In response to the Council's and SSC's previous comments on the use of LEO Network observations in this report, AFSC is currently developing a LEO Network project to solicit observations from community

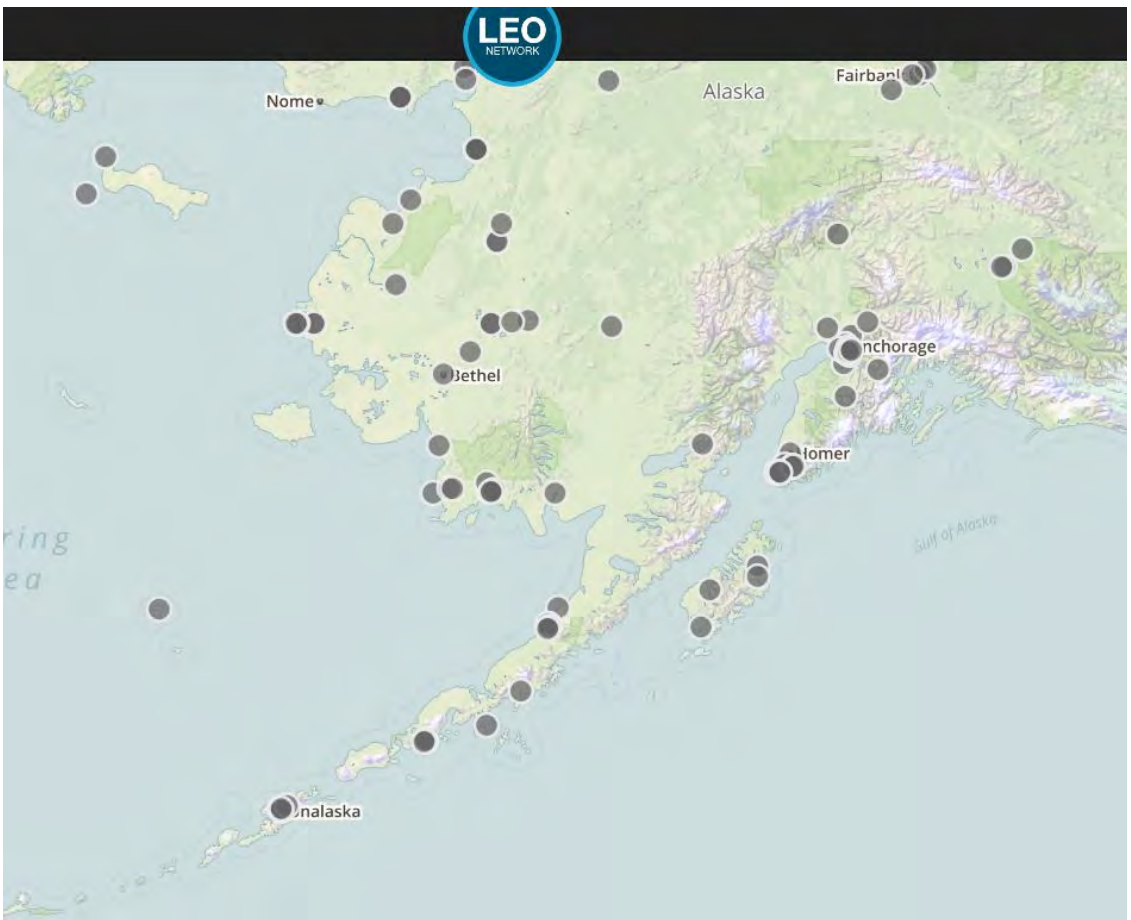

Figure 11: LEO Network Observations in Alaska for 2017 and 2018 (through August 1st), source: `https://www.leonetwork.org`.

members on specific ecological questions. Alaska State agencies, non-profit organizations, universities, and U.S. federal agencies have similarly developed projects on the network to track observations specific to their area of interest, e.g., weather events, fish pathology, subsistence harvests, etc. AFSC is also actively pursuing opportunities to examine ways of incorporating local and traditional knowledge into fisheries management in the North Pacific with the Councils Bering Sea Fishery Ecosystem Plan and Social Science Planning Team and through targeted research efforts.

Contributed by Marysia Szymkowiak

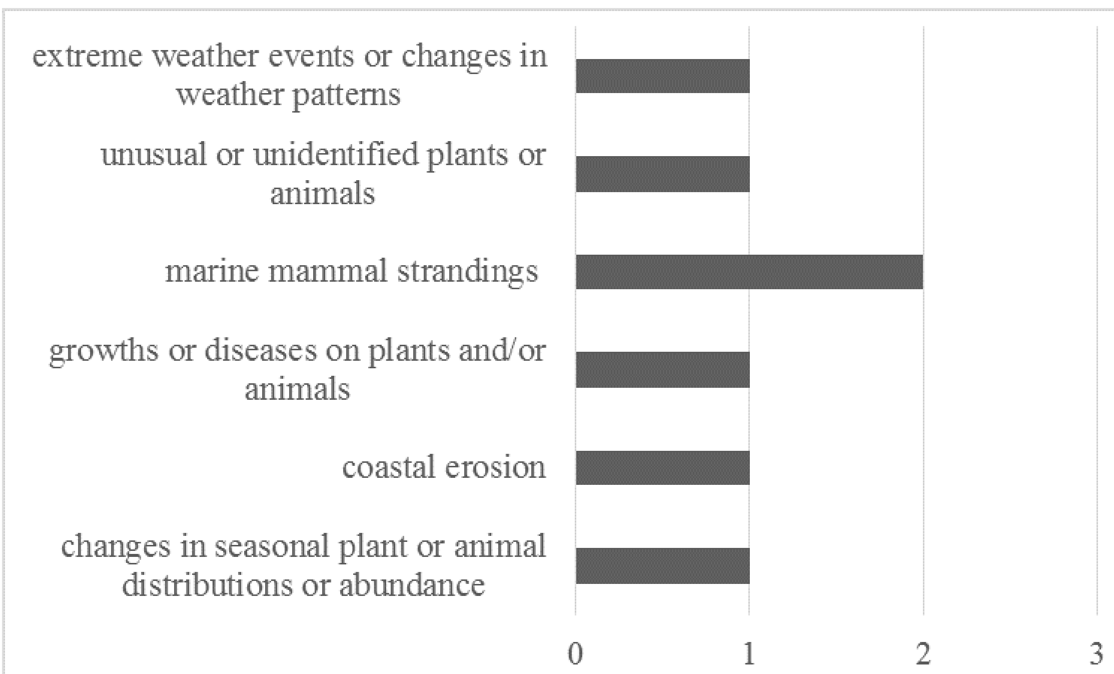

Figure 12: Distribution of 2017 and 2018 (through August 1st) LEO Network Observations in one AI community.

Ecosystem Status Indicators

Indicators presented in this section are intended to provide detailed information and updates on the status and trends of ecosystem components. Older contributions that have not been updated are excluded from this edition of the report. Please see archived versions available at: `http://access.afsc.noaa.gov/reem/ecoweb/index.php`

Physical Environment

North Pacific Climate Overview

Contributed by Nick Bond (UW/JISAO)
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Last updated: August 2018

Summary: *The state of the North Pacific atmosphere-ocean system during 2017-2018 was rather similar to that during 2016-17. Both winters featured La Niña and weaker than normal Aleutian lows (positive sea level pressure, SLP anomalies). The more prominent sea surface temperature (SST) anomalies during 2017-18 tended to be in the positive sense, with persistent warmth in the subtropical eastern North Pacific, increasing positive anomalies in the Bering Sea, and the expansion of warm waters off the east coast of Asia. The Pacific Decadal Oscillation (PDO) was slightly positive during the past year, with a decline to near zero in the summer of 2018. The climate models used for seasonal weather predictions are indicating about a 70% chance of a weak-moderate El Niño for the winter of 2018-19, and warmer than normal SSTs in both the western and eastern mid-latitude North Pacific in early 2019.*

Regional Highlights:

Arctic. The winter of 2017/18 was relatively warm in the Arctic, and included an extreme "heat wave" (for the season) in the central Arctic during February. The Arctic's maximum ice extent in mid-March 2018 was the 2^{nd} lowest on record. On the other hand, the decline in sea ice coverage during the late spring and early summer of 2018 was on the slow side, primarily in association with relatively low SLP in the central Arctic and cool and cloudy weather. The west winds accompanying this circulation pattern helped maintain a wide band of ice near the coast east of Pt. Barrow. Relatively rapid losses in sea ice concentrations and coverage occurred here in late July 2018. The edge of the pack ice in the Chukchi Sea was well north of its usual position during the summer of 2018. At the time of this writing, it appears that the minimum ice extent for the Arctic as a whole will be well below of climatological norms, but more akin to the years of 2013 and 2014 rather than the extreme minimum ice cover year of 2012.

Bering Sea. The Bering Sea had the least amount of sea ice in the observational record back to 1979. This can be attributed to the delayed start of winter (Being Strait was still open on 1 January) and then very mild temperatures with strong winds from the southwest, particularly in February 2018. An important consequence was a cold pool in summer 2018 of exceedingly small areal extent. The weather during summer 2018 was stormier than usual on the southeast Bering Sea shelf; at the time of this writing it is unknown if those conditions helped sustain primary production later into the warm season than usual. In the region of the M2 mooring the thermal stratification during summer 2018 was somewhat less than observed during recent years; the vertically integrated heat content was the second greatest on record, topped by 2016.

Alaska Peninsula and Aleutian Islands. The weather of this region included suppressed storminess during the fall of 2017 and the following winter of 2017/18. The regional wind anomalies were from the southwest in an overall sense. Based on synthetic data from NOAA's Global Ocean Data Assimilation System (GODAS),

the Alaska Stream appears to have been relatively diffuse, as opposed to concentrated into a narrower, high velocity flow, on the south side of the eastern Aleutian Islands. The eddy activity in this region was on the low side (p. 49).

Gulf of Alaska. The weather of the coastal GOA featured warmer than normal air temperatures from late fall 2017 into winter and then again in the following summer of 2018. There was generally less precipitation than usual in the coastal watersheds of the eastern GOA from winter into summer 2018. The freshwater runoff in this region appears to have been enhanced during the winter of 2017/18 and suppressed during the spring of 2018. The GOA coastal winds anomalies were in a clockwise sense during the winter of 2017/18; they were still in the downwelling-favorable sense, but to a lesser extent than normal. These winds were reflected in the surface currents estimated with NOAA's Ocean Surface Current Simulator (OSCURS), which tended to indicate relatively weak south to north flow in the eastern GOA. More on this subject is provided in the Ocean Surface Currents PAPA Trajectory Index (see Gulf of Alaska Ecosystem Status Report).

West Coast of Lower 48. This region experienced generally warmer than normal ocean temperatures from late 2017 into 2018 followed by cooling in the north relative to seasonal norms, and continued warmth south of Pt. Conception. The winter of 2017/18 was wetter and slightly cooler than normal in the Pacific Northwest, and relatively warm and dry in California. The abundant snowpack in the Pacific Northwest melted rapidly in May in association with unusually warm weather. The coastal wind anomalies were upwelling-favorable for the states of Oregon and Washington during the late spring and early summer raising concerns about hypoxia developing to a greater extent than usual. Many streams in the Pacific Northwest had above normal temperatures due to the combination of low flows and hot air temperatures. Mostly upwelling-favorable wind anomalies occurred along the northern and central portions of California. Strong downwelling-favorable winds developed in early summer in the Southern California Bight, resulting in a thin layer of very warm water in the immediate vicinity of the coast. The SST at the Scripps Pier in La Jolla, CA observed the warmest SST (25.9°C) in its entire historical record extending back to 1916. There were sightings of large assemblages of pyrosomes in the coastal waters of the Pacific Northwest for the second year in a row.

Sea Surface Temperature and Sea Level Pressure Anomalies

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Last updated: September 2018

Description of indices: The state of the North Pacific climate from autumn 2017 through summer 2018 is summarized in terms of seasonal mean sea surface temperature (SST) and sea level pressure (SLP) anomaly maps. The SST and SLP anomalies are relative to mean conditions over the period of 1981–2010. The SST data are from NOAA's Optimum Interpolation Sea Surface Temperature (OISST) analysis; the SLP data are from the NCEP/NCAR Reanalysis project. Both data sets are made available by NOAA's Earth System Research Laboratory (ESRL) at `http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl`.

Status and trends: The eastern portion of the North Pacific ocean experienced during 2014–16 one of the most extreme marine heat waves in the observational record (Scannell et al., 2016); the interval summarized here can be considered a transition period between that event and a more climatologically normal SST distribution on the basin-scale. More detail on the evolution of the SST and SLP from a seasonal perspective is provided directly below.

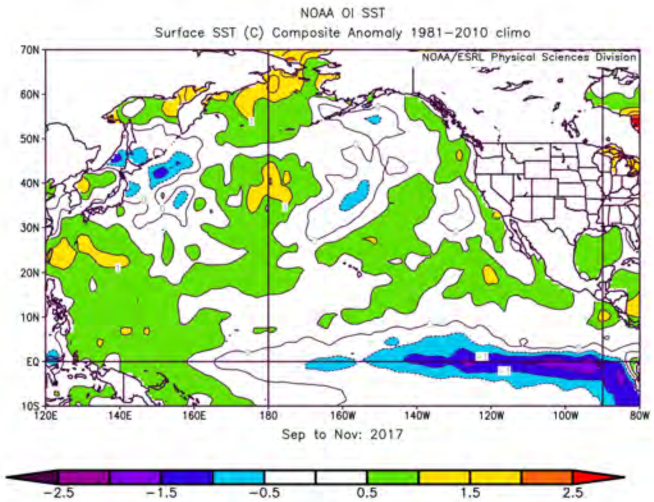
The SST during the autumn (Sep–Nov) of 2017 (Figure 13a) was warmer than normal across almost the entire North Pacific Ocean. Greater positive (> 1°C) anomalies occurred in the Chukchi Sea and northwest Bering Sea in the northern and eastern Bering Sea, resulting in a delayed onset of sea ice the following winter. The SST anomalies were negative in the eastern equatorial Pacific in association with the development of La

Niña. The SLP pattern during autumn 2017 featured prominent positive anomalies over the north central portion of the North Pacific Ocean, with the greatest departures from normal over the open ocean south of the western tip of the Alaska Peninsula (Figure 14a). This SLP distribution implies an enhanced storm track along the east coast of Asia, and suppressed storminess from the Aleutians into the Gulf of Alaska (GOA).

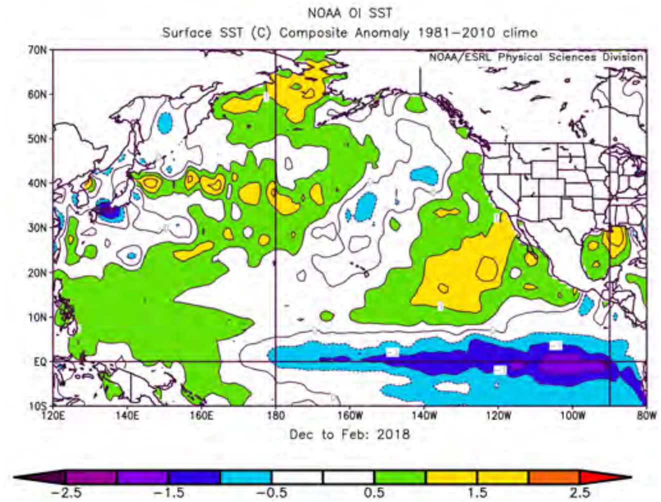
The North Pacific atmosphere-ocean system during winter (Dec–Feb) of 2017-18 reflected to large extent a continuation of the previous fall season. The distribution of SST anomalies (Figure 13b) was quite similar, with some additional warming in the subtropical northeastern Pacific extending southwestward from southern California. The equatorial Pacific was characterized by weak/moderate La Niña conditions with the strongest negative SST anomalies well east of the dateline. The SLP during this period (Figure 14b) featured an expansion of the pattern of the season before in terms of both magnitude and area, with substantial positive anomalies from about 160°E to western North America north of about 30°N. This relatively high SLP in combination with negative SLP anomalies over the East Siberian Sea resulted in a pressure pattern that supported extremely strong wind anomalies ($\sim$3 to 4 m s^{-1}) from the southwest across the Bering Sea.

The distribution of anomalous SST in the North Pacific during spring (Mar–May) of 2018 (Figure 13c) was similar to that during the previous winter season. Exceptions were warming relative to seasonal normal in the eastern Bering Sea and in an east-west band from 25° to 40°N from Japan to the dateline. The SST anomalies in the tropical Pacific were of minor amplitude with the ending of La Niña. The SLP anomaly pattern (Figure 14c) for spring 2018 featured bands of lower than normal pressure from eastern Siberia to northwestern Alaska and higher pressure from south of the Aleutian Islands to the GOA, resulting in another season of warm, southwesterly flow anomalies across the Bering Sea. The atmospheric circulation in the northeast Pacific promoted relatively upwelling-favorable winds in the coastal GOA.

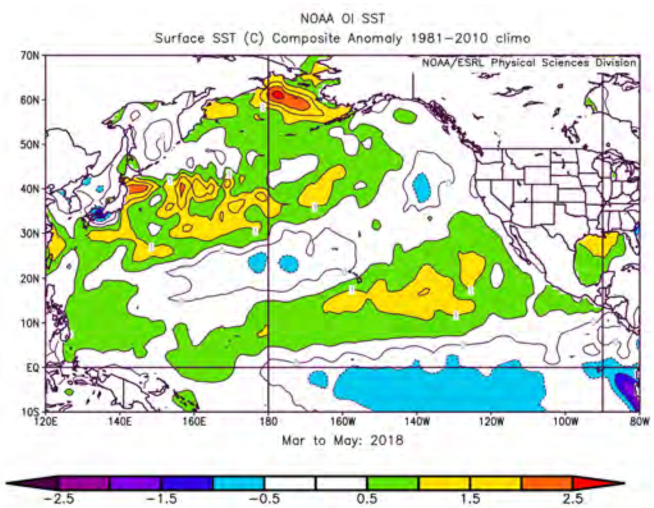
The SST anomaly pattern in the North Pacific during summer (Jun–Aug) 2018 is shown in Figure 13d. Positive anomalies continued in a broad band extending from Japan to the southeastern GOA and from the northern Bering Sea into the Chukchi Sea. In the latter area, particularly strong positive temperature anomalies (exceeding 2°C) developed in the vicinity of Bering Strait. Near normal SSTs were present along most of the west coast of North America from Vancouver Island to southern California. Warmth continued in the subtropical eastern North Pacific from Baja California to the equatorial Pacific east of the dateline, where temperatures were roughly 0.5°C above normal. The distribution of anomalous SLP (Figure 14d) during summer 2018 included mostly just weak anomalies, which is typical for the season. A band of higher than normal pressure extended from the western North Pacific north of about 30°N into the GOA. Lower pressure extended from northwestern Canada across interior Alaska into the Bering Sea.



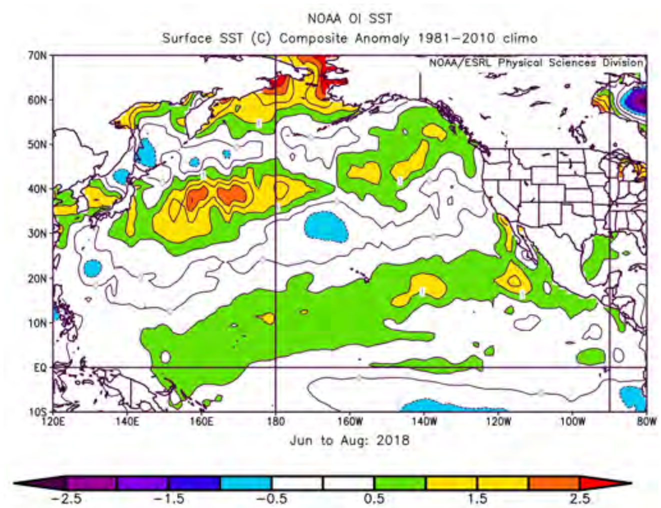
(a) Autumn



(b) Winter

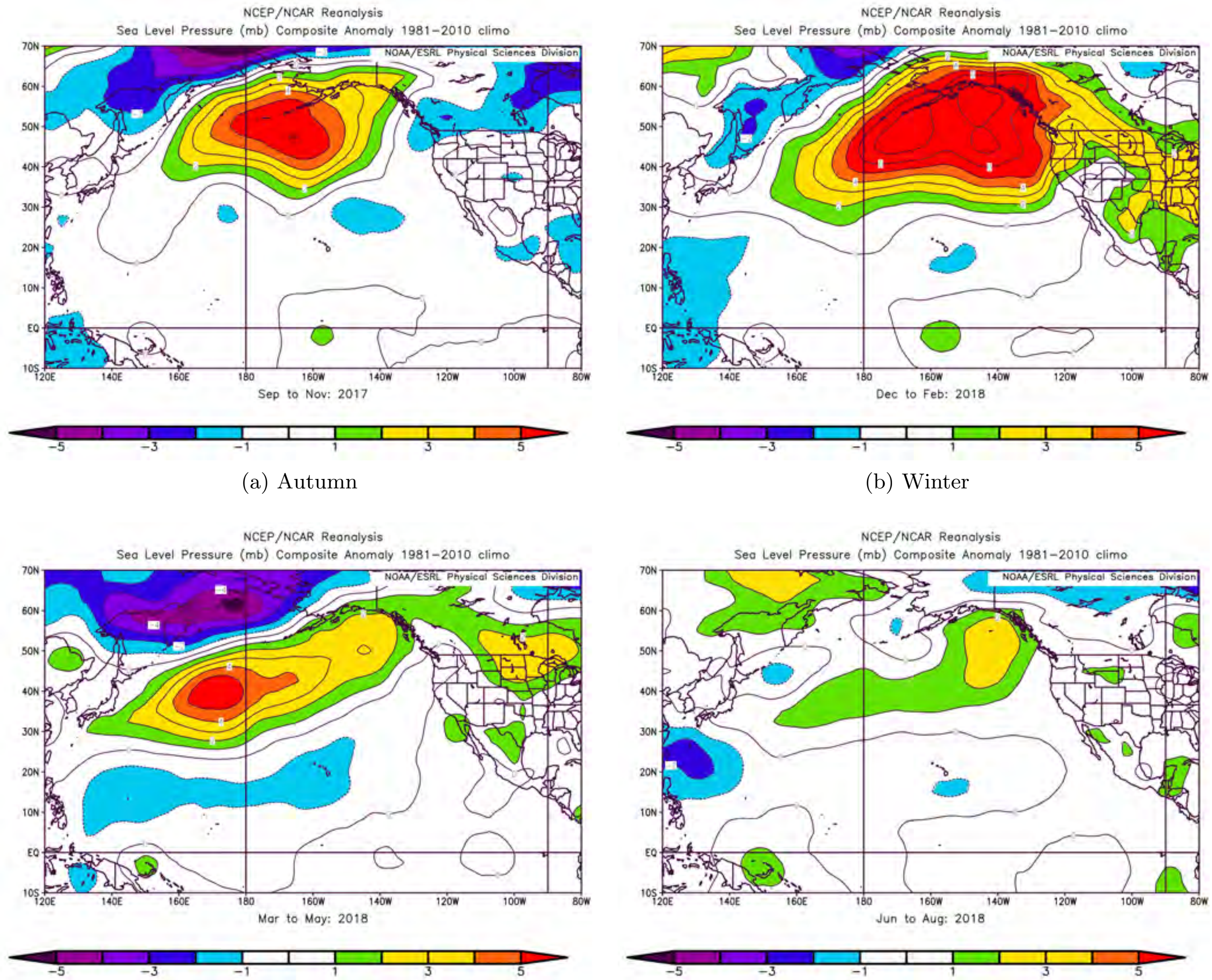


(c) Spring



(d) Summer

Figure 13: SST anomalies for autumn (September–November 2017), winter (December 2017–February 2018), spring (March–May 2018), and summer (June–August 2018).



(a) Autumn

(b) Winter

(c) Spring

(d) Summer

Figure 14: SLP anomalies for autumn (September–November 2017), winter (December 2017–February 2018), spring (March–May 2018), and summer (June–August 2018).

Climate Indices

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Description of indices: Climate indices provide an alternative means of characterizing the state of the North Pacific atmosphere-ocean system. The focus here is on five commonly used indices: the NINO3.4 index for the state of the El Niño/Southern Oscillation (ENSO) phenomenon, Pacific Decadal Oscillation (PDO) index (the leading mode of North Pacific SST variability), North Pacific Index (NPI), North Pacific Gyre Oscillation (NPGO), and Arctic Oscillation (AO). The time series of these indices from 2008 into spring/summer 2018 are plotted in Figure 15.

Status and trends: The North Pacific atmosphere-ocean climate system was mostly on the warm side during 2017–18. This was despite the second fall/winter in a row with a negative value for the NINO3.4 index in association with a weak/moderate La Niña event. The positive state of the PDO (indicating warmer than normal SST along the west coast of North America and cooler than normal in the central and western North Pacific) that began in early 2014 ended in 2017. This decline is consistent with the typical remote effects of ENSO, and in particular the transition from a strong El Niño in 2015–16 to the following two episodes of La Niña. The SST anomaly distribution during spring and summer of 2018 has a minimal projection on the characteristic pattern of the PDO. The NPI was strongly positive from fall 2017 into 2018 due to the relatively high SLP in the region of the Aleutian low. A positive sense for the NPI commonly accompanies La Niña, its magnitude from late 2017 into 2018 was greater than might be expected.

The NPGO became strongly negative in 2017, and stayed negative into 2018 (February is the latest month for which this index is available). This index has undergone an overall decline from positive values during the period of 2008 to 2012. The AO represents a measure of the strength of the polar vortex, with positive values signifying anomalously low pressure over the Arctic and high pressure over the Pacific and Atlantic Ocean at a latitude of roughly 45°N. It was in a near-neutral state during the last half of 2017 with a transition to a positive state in spring 2018 that has continued into summer. A consequence has been relatively low pressure in the Arctic during early summer.

Seasonal Projections from the National Multi-Model Ensemble (NMME)

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Description of indicator: Seasonal projections of SST from the National Multi-Model Ensemble (NMME) are shown in Figures 16. An ensemble approach incorporating different models is particularly appropriate for seasonal and longer-term simulations; the NMME represents the average of eight climate models. The uncertainties and errors in the predictions from any single climate model can be substantial. More detail on the NMME, and projections of other variables, are available at the following website: `http://www.cpc.ncep.noaa.gov/products/NMME/`.

Status and trends: First, the projections from a year ago are reviewed qualitatively. From an overall perspective, the SST forecasts were essentially correct with respect to their basin-scale patterns of negative and positive SST anomalies. The NMME forecasts included an under-prediction of the magnitudes of some of the more prominent anomalies. In particular, Alaskan waters generally ended up warmer than forecast,

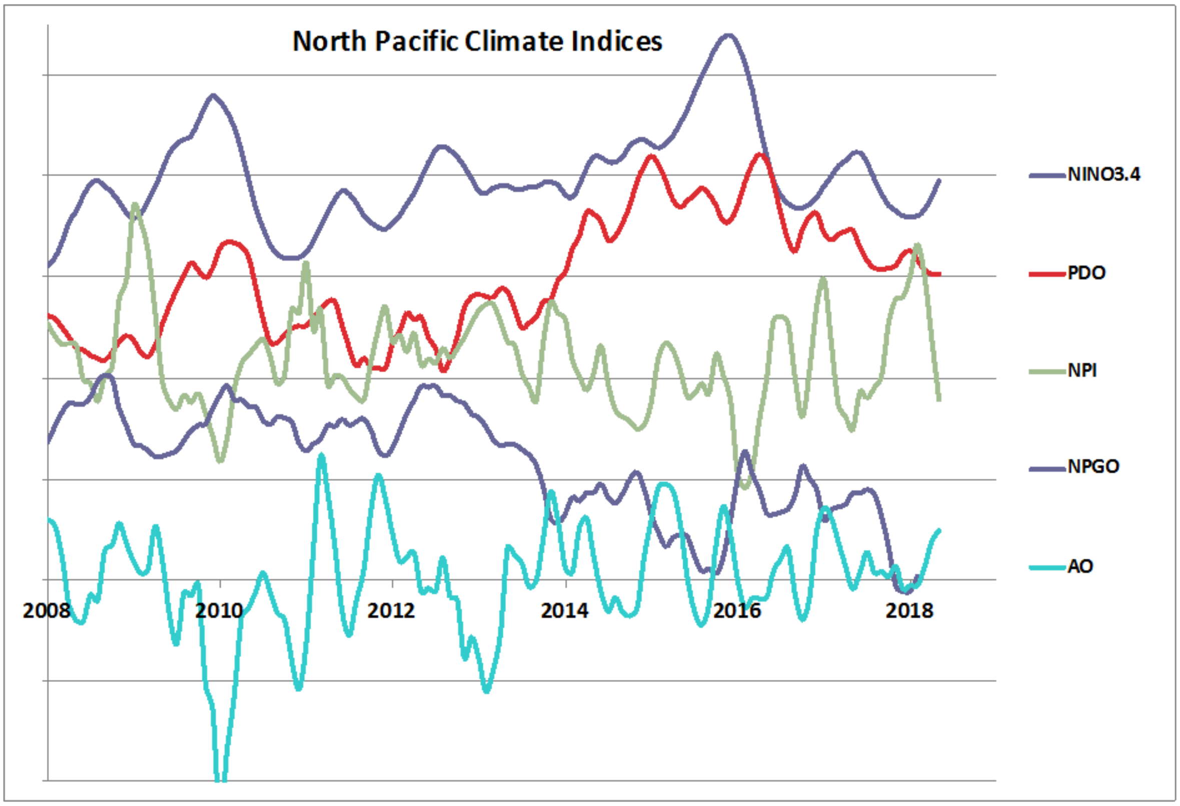


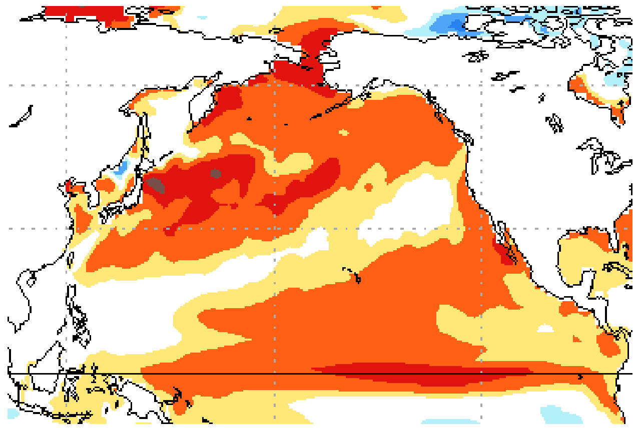
Figure 15: Time series of the NINO3.4 (blue), PDO (red), NPI (green), NPGO (purple), and AO (turquoise) indices for 2008–2018. Each time series represents monthly values that are normalized using a climatology based on the years of 1981–2010, and then smoothed with the application of three-month running means. The distance between the horizontal grid lines represents 2 standard deviations. More information on these indices is available from NOAA's Earth Systems Laboratory at `http://www.esrl.noaa.gov/psd/data/climateindices/`.

especially the Bering Sea shelf during late winter and early spring 2018 where there was much less sea ice than suggested by the model forecasts made during September 2017.

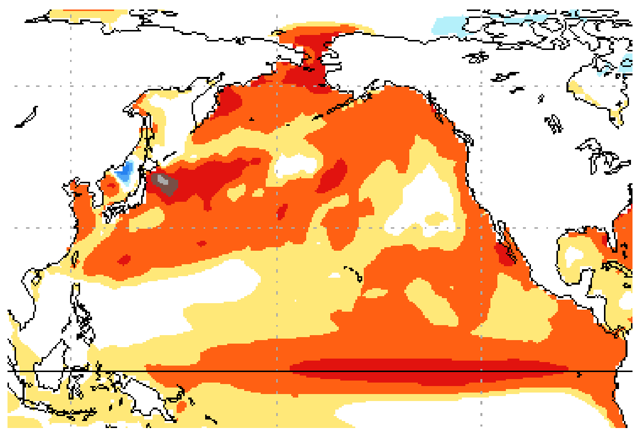
These NMME forecasts of three-month average SST anomalies indicate a continuation of warm conditions across virtually all of the North Pacific through the end of the year (Oct–Dec 2018) with a reduction in the longitudinal extent of cooler than normal temperatures offshore of the Pacific Northwest (Figure 16a). The magnitude of the positive anomalies is projected to be greatest (exceeding 1°C) north of the Kuroshio Extension in the western North Pacific and in the northern portion of the Bering Sea. Positive SST anomalies are projected in the central and eastern equatorial Pacific. The ensemble model average is strong enough to constitute El Niño of weak to moderate magnitude. As of early September 2018, the probabilistic forecast provided by NOAA's Climate Prediction Center (CPC) in collaboration with the International Research Institute for Climate and Society (IRI) for the upcoming fall through winter indicates about a 70% chance of

El Niño, and otherwise equatorial SSTs in the neutral category. The overall pattern of SST anomalies across the North Pacific is maintained through the 3-month periods of December 2018–February 2019 (Figure 16b) and February–April 2019 (Figure 16c). There is moderate but by no means a complete consensus among the models that the Aleutian low will be deeper than normal (negative SLP anomalies) during the latter portion of the winter of 2018–2019. This is a common remote response to El Niño, and tends to result in relatively warm late winter and early spring weather for Alaska that is liable to be enhanced by the effects of the warmth of the waters surrounding Alaska. For the period of February–April 2019, the models are projecting little noticeable decline in the magnitude of the equatorial Pacific temperature anomalies even though El Niño often weakens during the boreal spring. The positive SST anomalies along the west coast of North America that are indicated in Figure 16c commonly occur after El Niño winters.

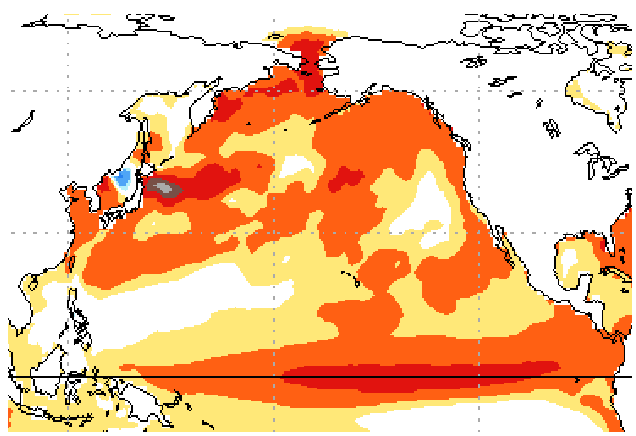
Implications: The PDO has also generally been positive during these kinds of periods in the past, but the predicted warmth in both the western and eastern portions of the mid-latitude North Pacific does not resemble the characteristic pattern of the PDO. An important implication is that the PDO is liable to be ill-suited for characterizing the state of the North Pacific in early 2019.



(a) Months OND



(b) Months DJF



(c) Months FMA

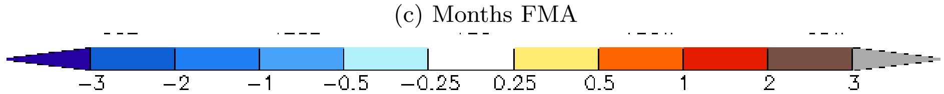


Figure 16: Predicted SST anomalies from the NMME model for OND (1 month lead), DJF (3 month lead), and JFM (4 month lead) for the 2017–2018 season.

Eddies in the Aleutian Islands

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Last updated: August 2018

Description of indicator: Eddies in the Alaskan Stream south of the Aleutian Islands have been shown to influence flow into the Bering Sea through the Aleutian Passes (Okkonen, 1996). By influencing flow through the passes, eddies could impact flow in the Aleutian North Slope Current and Bering Slope Current as well as influencing the transports of heat, salt and nutrients (Mordy et al., 2005; Stabeno et al., 2005) into the Bering Sea.

Since 1992, a suite of satellite altimeters has been monitoring sea surface height. Eddy kinetic energy (EKE) can be calculated from gridded altimetry data (Ducet et al., 2000). The Ssalto/Duacs altimeter products were produced and distributed by the Copernicus Marine and Environment Monitoring Service (CMEMS) (`http://www.marine.copernicus.eu`).

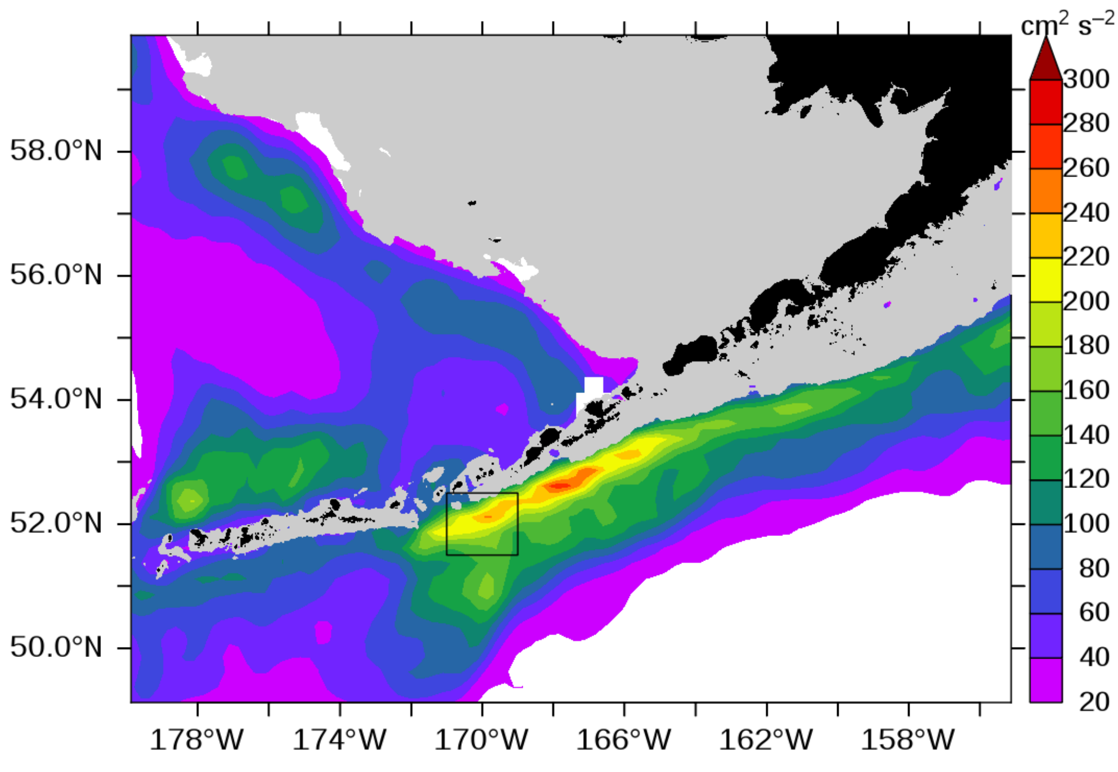

Figure 17: Eddy Kinetic Energy averaged over January 1993–December 2017 calculated from satellite altimetry. Square denotes region over which EKE was averaged for Figure 18.

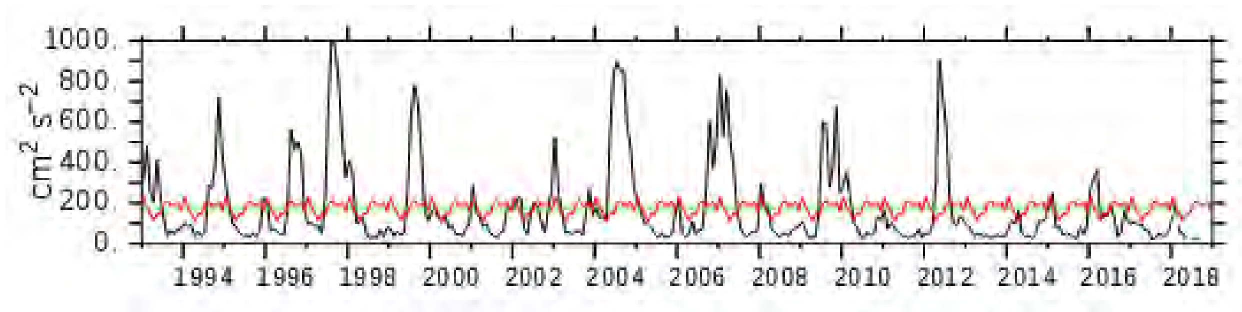

Figure 18: Eddy kinetic energy (cm^2 s^{-2}) averaged over region shown in Figure 17. Black (line with highest variability): monthly EKE (dashed part of line is from near-real-time altimetry product which is less accurate than the delayed altimetry product). Red: seasonal cycle. Green (straight line): mean over entire time series.

Status and trends: Eddy kinetic energy (EKE) calculated from gridded altimetry data is particularly high in the Alaskan Stream from Unimak Pass to Amukta Pass (Figure 17) indicating the occurrence of frequent, strong eddies in the region. The average EKE in the region 171°W-169°W, 51.5°-52.5°N (Figure 18) provides an index of eddy energy likely to influence the flow through Amukta Pass. Particularly strong eddies were observed south of Amukta Pass in 1997, 1999, 2004, 2006/2007, 2009/2010, and summer 2012. Eddy energy in the region has been low from the fall 2012 through 2018.

Factors causing trends: The causes of variability in EKE are currently unclear and a subject of ongoing research.

Implications: Numerical models have suggested that eddies passing near Amukta Pass may result in increased flow from the Pacific to the Bering Sea (Maslowski et al., 2008). These trends indicate that higher than average volume, heat, salt, and nutrient fluxes to the Bering Sea through Amukta Pass may have occurred in 1997/1998, 1999, 2004, 2006/2007, 2009/2010, and summer 2012. These fluxes likely have been smaller since fall 2012.

Satellite-derived Sea Surface Temperature Anomalies in the Aleutian Islands

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Last updated: August 2018

Description of indicator: Sea surface temperature (SST) is often used to explore relationships between commercial fisheries and environmental dynamics. During interpretation of fishery and ecological data, the question often arises, “Was it a cold year or a warm year?” Using satellite data, this ecosystem indicator provides a transparent and simple method by which to evaluate sea surface temperature anomalies across spatial scales that are not limited to the location of a single buoy or data collected during seasonal surveys.

A common limitation of SST records derived from satellites has been missing data as a result of cloud cover. Using the NASA multi-scale ultra-high resolution (MUR) SST dataset however, a combination of collection modalities creates a gap-free blend of data (`https://mur.jpl.nasa.gov/InformationText.php`). Data are available at the daily level for the North Pacific from mid-2002 to present and can be downloaded from the NOAA Coast Watch West Coast Node ERDDAP server (`https://coastwatch.pfeg.noaa.gov/erddap/`)

where they are searchable as "Multi-scale ultra-high resolution (MUR) SST Analysis fv04.1, Global, 0.01°, 2002–present, daily". More than 24 billion individual daily temperature records were downloaded (October 1, 2002–September 30, 2018) and the data were averaged daily by Alaska Department of Fish and Game (ADF&G) groundfish statistical areas (also called stat6 areas; `www.adfg.alaska.gov/index.cfm?adfg=fishingCommercialByFishery.statmaps`), yielding about 10 million temperature records (a daily record for each of the 1,736 statistical areas). More detailed methods are available online (`github.com/jordanwatson/ERDDAP`).

As an ecosystem indicator for the Aleutian Islands, daily temperatures were averaged by month for the Aleutian Islands (AI) ecosystem regions (from ADF&G statistical areas in the western AI [WAI], west of 177°W, central AI [CAI], 170 °–177°W, and east AI (EAI), 163°W–170°W [`https://alaskafisheries.noaa.gov/maps`]) and anomalies were calculated (Figure 19). Monthly anomalies were aggregated by winter (October–March) and summer (April–September). In Figure 19, winter 2002 refers to October–December 2002 and January–March 2003. Horizontal dashed lines in Figure 19 are provided as a reference at an anomaly of ±0.5. The full dataset (or aggregated versions) can be obtained by contacting the author of this contribution.

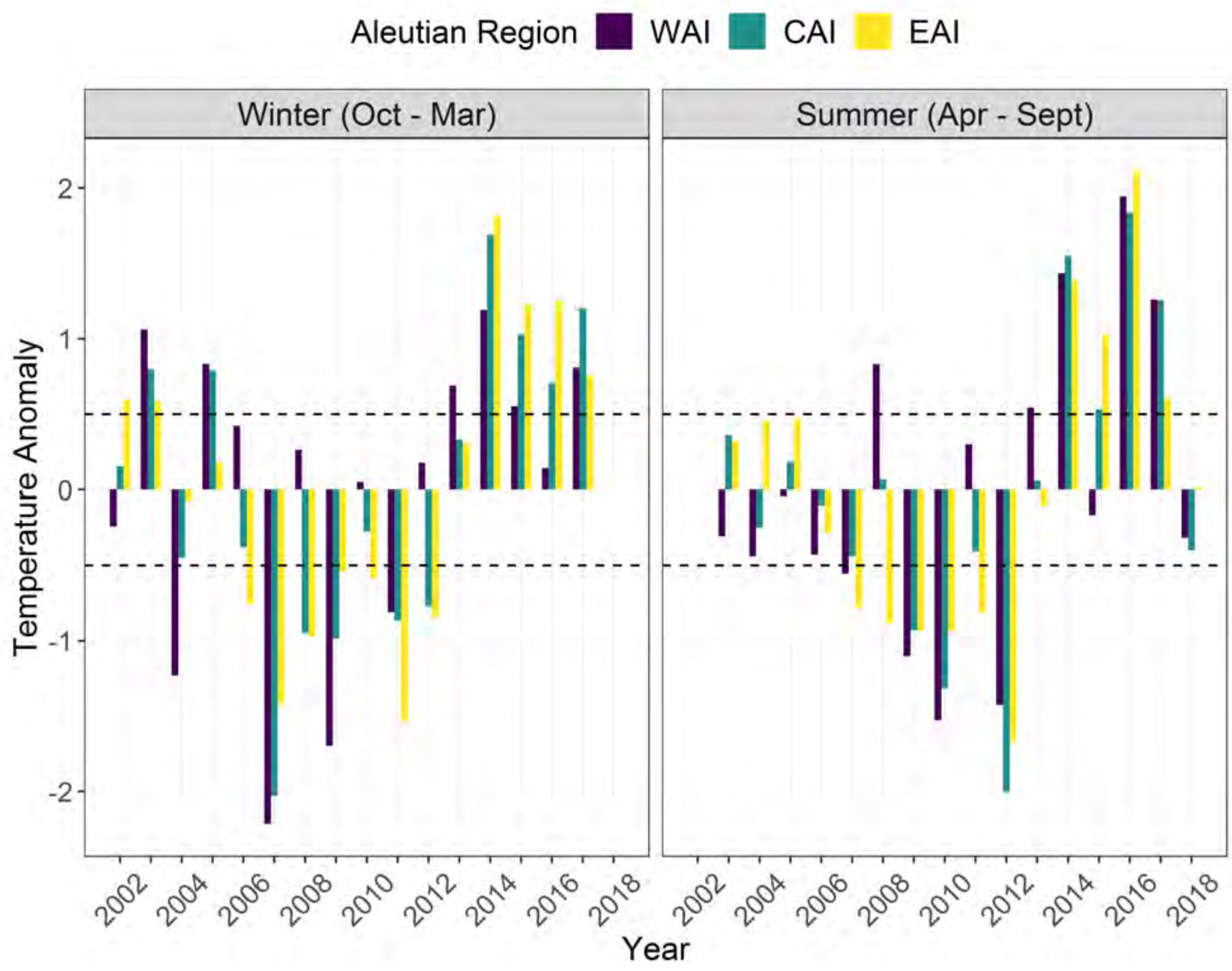

Figure 19: Seasonal sea surface temperature anomalies for the Aleutian Islands where WAI, CAI, and EAI are the western, central, and eastern Aleutian Islands, respectively. Data were unavailable for summer 2002 and winter 2018, so these portions of their respective figures are omitted.

Status and trends: There was a general consistency in temperature anomalies within each year for the central and eastern Aleutian Island areas, whereas the western Aleutian Island region was more likely to diverge from the other areas in the direction of temperature anomaly within a season (Figure 19). The first few years of the time series were mixed in terms of warm versus cold, before turning consistently cold during the winter of 2006. Summer and winter temperatures were anomalously warm starting in the summer and winter of 2014, and cooling down again during summer 2018.

Factors influencing observed trends: It may be important to note that the Aleutian Island ecosystem regions include waters both north and south of the Aleutian chain. Thus, temperature anomalies will be driven by the combined dynamics of both Bering Sea and Gulf of Alaska waters. The trends in warming during recent years are consistent with the remarkably warm periods throughout both the Bering Sea and Gulf of Alaska (Bond et al., 2015; Hu et al., 2017).

Implications: A large body of research has explored the effects of stanzas of warm water observed in the Bering Sea over the last two decades, and recent work in particular has attempted to understand what impacts the most recent warming may have on fishery ecosystems (e.g., Stabeno et al., 2017). While most of this work has focused on the eastern Bering Sea in particular, similar patterns of impacts on prey quality and recruitment of juvenile fish may occur in the Aleutian Islands.

The ecosystem indicator presented here provides an example of ways that satellite data can be explored at aggregated spatial and temporal scales. The temperature data set can be utilized across a range of fine (daily temperatures by state statistical area) to coarse (e.g., monthly temperatures by Aleutian Island ecosystem region) scales depending on the questions being asked by researchers or policy makers. For researchers that study fishery effects directly, the daily SST data described here are being linked to fish ticket data in AKFIN so that landings information will be explicitly associated with the temperature of the ADF&G statistical areas in which the fish were reported to have been caught.

Aleutian Islands Trawl Survey Water Temperature Analysis

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Last updated: October 2018

Description of indicator: Since 1994, water temperature data have routinely been collected during the Aleutian Islands Bottom Trawl Survey conducted by the Alaska Fisheries Science Center Resource Assessment and Conservation Engineering Division Groundfish Assessment Program (Von Szalay et al., 2017). There were three triennial AI bottom trawl surveys between 1994 and 2000; since 2000 the surveys have been conducted biennially (except in 2008 when there was no AI bottom trawl survey).

Microbathythermographs (MBTs) attached to the headrope of the net measure and record water temperature and depth during each trawl haul. In 2004, the SeaBird (SBE-39) MBT (Sea-Bird Electronics, Inc., Bellevue, WA) that is in use today replaced the Brancker XL200 data logger (Richard Brancker Research, Ltd., Kanata, Ontario, Canada) which had been in use since 1993. The analyses presented here utilize bathythermic data collected on AI bottom trawl surveys since 1994.

The bottom trawl survey has historically begun in late spring (late May to early June) and proceeds west from around Unimak Pass to Stalemate Bank over the course of the summer sampling in the Bering Sea and Pacific Ocean north and south of the archipelago (Von Szalay et al., 2017). In 2002 and 2006, our typical sampling progression was partially reversed with the later season survey sweeping from west to east. We anticipate that water temperatures will increase with advancing collection date and increasing day length as the survey progresses westward over the summer which could lead to spatially and temporally confounded data complicating inter-annual comparisons.

To account for the influence of changing day length on water temperatures over the course of the summer and to make inter-annual comparisons more meaningful, an attempt was made to remove the effect of collection date on water temperature by standardizing all bottom trawl collection dates to a median survey date. This was achieved using generalized additive modeling (GAM) to estimate the effects of collection date on temperature at depth across survey areas and years. The resulting model was used to predict temperature at depth at the historic median survey day for all survey trawl hauls of July 10. Residuals from this GAM were added to the predicted median day temperature-at-depth to produce estimates of thermal anomaly from the model prediction at each station in all survey years. To facilitate visualization, these temperature estimates were averaged over systematic depth bins in ½ degree longitude increments. Depth gradations were set finer in shallower depths and broader in deeper depths (e.g., 5 m bins between 0 and 100 m, 10 m bins between 100 and 200 m, and 100 m bins between 200 and 500 m) to capture the rapid changes anticipated in surface waters of temperature with depth. To further stretch the color ramp and enhance the visual separation of the near-surface temperature anomalies (between about 4 and 10°C and $<$ 100 m), predicted temperature anomalies $\geq$7.5°C and $\leq$3.5°C were fixed at 7.5 and 3.5°C (e.g., a 12.5°C temperature anomaly was recoded as 9.5°C for the graphic representation).

Status and trends: The warmest anomalies across the AI typically occurred near the surface ($<$ 50 m) and their depth of penetration beyond the surface varied between years (Figure 20). During the warmest years in the record (2014 and 2016), the warmer anomalies penetrated to 100 m or deeper. There were also some temporally persistent and spatially consistent features in these anomaly plots. Warm, near-surface temperature anomalies were commonly found around the Island of Four Mountains, between Seguam Pass (173^{0}W) and Amchitka Pass (179^{0}W), and west of Buldir Pass (175^{0}E) and cooler temperatures were consistently observed at depths $\geq$100 m near Seguam Island (172^0 30'W) which is a particularly striking feature during colder years (e.g., 2000, 2012). Warmer years were dominated not only by warmer surface anomalies, but by deeper penetration of warmer waters across the breadth of the archipelago. The last three survey years in the AI have generally been warmer than previous years with the exception of 1997 which was comparable with the thermal anomalies observed in 2014 and 2016. The 2018 AI profile suggests a return to slightly cooler conditions relative to 2016, but is still amongst the warmer years from our record with warm anomalies penetrating deeper and distributed more extensively across the Aleutian archipelago than in 2014. The marked differences amongst survey years and the warm and cold year patterns help to illustrate the highly variable and dynamic oceanographic environment found in the Aleutian archipelago.

Factors influencing observed trends: These observations, and the thermal anomalies modeled from them, represent a brief spatial and temporal snapshot of water temperatures collected during bottom trawl surveys in the AI. Each temperature bin represents data collected over a relatively short time as the vessels moved through an area. Thus, it is difficult to draw general conclusions since short term events such as storms, tidal exchange, or freshwater runoff greatly affect local water temperatures.

More recent and larger scale phenomena may have longer-lasting implications on water temperatures in the region. The thermal signal caused by the "Ridiculously Resilient Ridge" of atmospheric high pressure that helped to establish the persistent warm water "Blob" in the Northeast Pacific during 2014 and 2015 (Bond et al., 2015; Di Lorenzo and Mantua, 2016), and which likely intensified the El Niño Southern Oscillation (ENSO) event of 2015–2016 (Levine and McPhaden, 2016), probably influenced the temperatures observed on our 2016 survey. Daily plots of sea surface temperature anomalies (SST) show warmer surface waters extending from east to west during the summer of 2016 (`http://www.ospo.noaa.gov/Products/ocean/sst/anomaly/index.html`). Due to these and other sources of variation not accounted for in the temperature model presented here, caution should be exercised when interpreting these results.

Implications: The strength and persistence of various oceanographic features in the AI are anticipated to influence ecological processes there. The depth and horizontal dispersion of the mixed layer affect primary production in this region (Mordy et al., 2005). Water temperatures influence ontogenesis of Atka mackerel eggs and larvae (Lauth et al., 2007) and have been shown to impact pollock abundance in the eastern Bering Sea (Stevenson and Lauth, 2012). Work on habitat-based delineation of essential fish habitat (EFH) in the AI and eastern Bering Sea have demonstrated that water temperature can be an important determinant of EFH for many groundfish species (Laman et al., 2017*a*,*b*; Turner et al., 2017). Eddies are also believed to

play a major role in the transport of both heat and nutrients into the Bering Sea through the Aleutian passes (Maslowski et al., 2008). Phenomena such as these must influence both AI and Bering Sea ecosystems and fish populations. By considering inter-annual differences in water temperatures and their implications, we can better utilize our survey data to understand the state of fish populations in the AI.

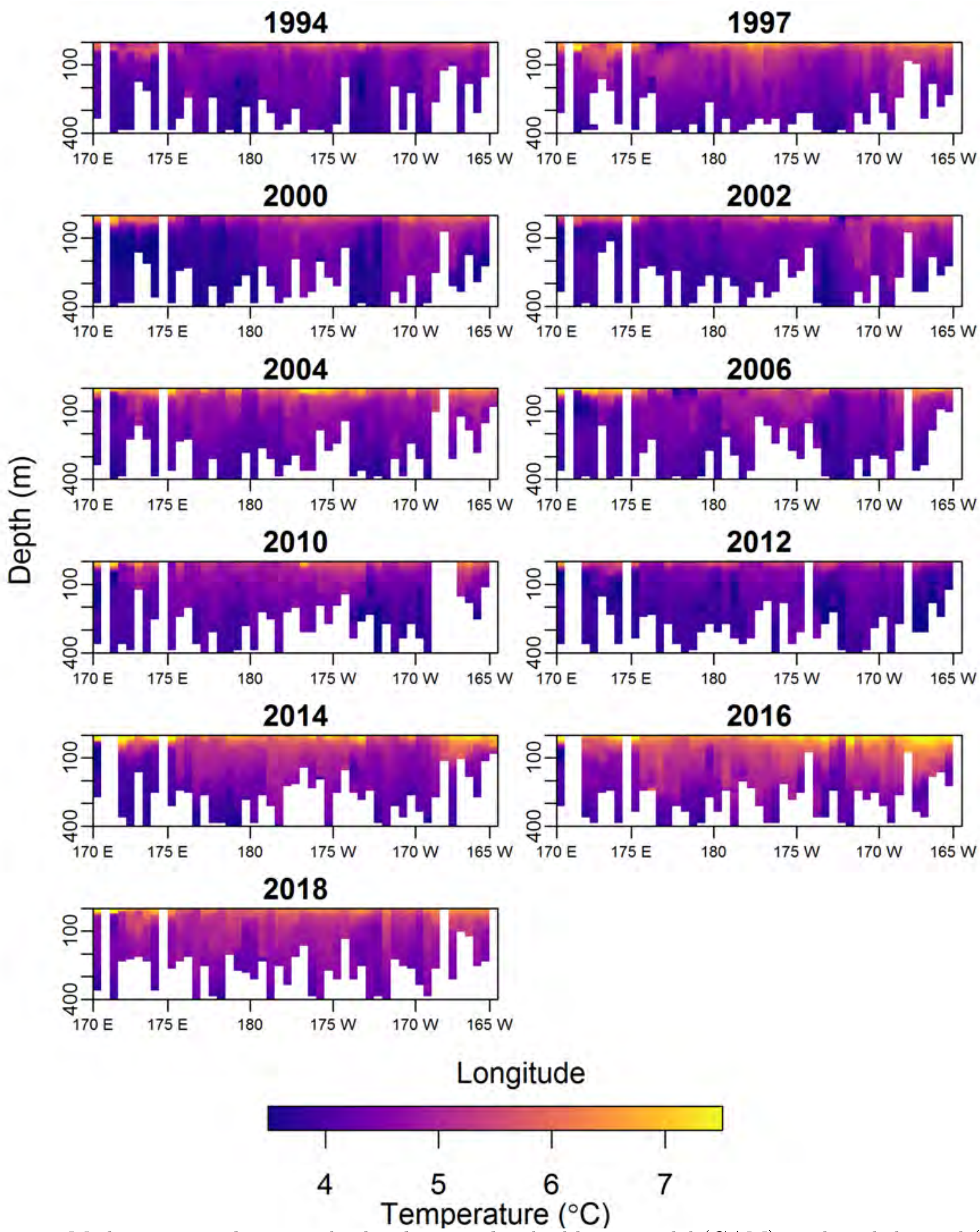

Figure 20: Median-survey-date-standardized, generalized additive model (GAM) predicted thermal (°C) anomaly profiles from water temperature measurements collected on Aleutian Islands bottom trawl surveys (1994–2018); to visually enhance near-surface temperature changes, values ≤3.5°C or ≥7.5°C were fixed at 3.5 or 7.5°C and the y-axis (depth) was truncated at 400 m though maximum collection depth was ca. 500 m.

Habitat

Structural Epifauna in the Aleutian Islands

Contributed by Wayne Palsson and Chris Rooper, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA
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Last updated: October 2018

Description of indicator: Groups considered to be structural epifauna, formerly known as Habitat Areas of Particular Concern (HAPC) biota, include seapens/seawhips, corals, anemones, and sponges. The biennial survey in the Aleutian Islands (AI) does not sample the density of HAPC fauna well, but does seem to capture spatial trends in presence or absence (Rooper et al., 2016, 2018). However, survey effort in rough or rocky areas where these groups are likely to be more abundant and survey effort is quite limited. The gears used by the Japanese vessels in the surveys prior to 1991 were quite different from the survey gear used aboard U.S. vessels in subsequent surveys and likely resulted in different catch rates for many of these groups. For each species group, the largest catch over the time series was arbitrarily scaled to a value of 100 and all other values were similarly scaled. The standard error (±1) was weighted proportionally to the CPUE to get a relative standard error. Note that CPUE is presented in four areas that differ from the ecoregions that are used elsewhere in this report (Figure 26).

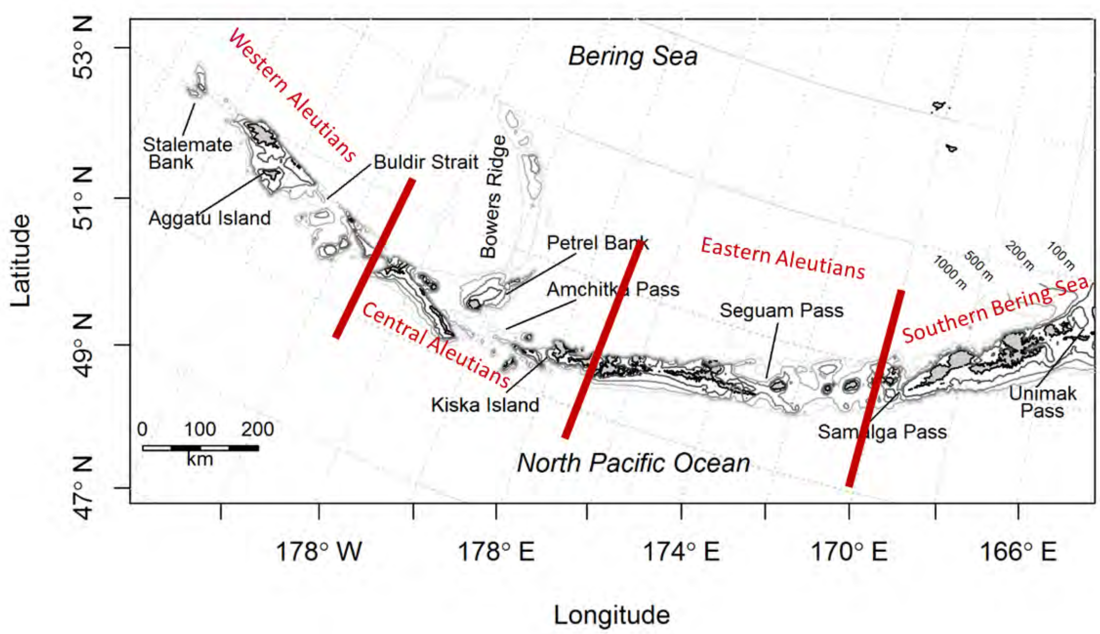

Figure 21: NMFS summer bottom trawl survey strata in the Aleutian Islands. Red lines demarcate Aleutian Islands INPFC Areas. The Central and Eastern Aleutians INPFC areas together correspond to the Central Aleutians ecoregion in this report. Similarly, the Southern Bering Sea INPFC area corresponds to the Eastern Aleutian ecoregion in this report.

Sponges include unidentified Porifera, calcareous sponges, hexactinellid sponges and demosponges, which are the dominant group. Gorgonians include families of upright branching coral (Primnoidae, Plexauridae, Isididae, etc.). Hydrocorals include stylasterid corals and stony corals. Soft corals are uncommon in the Aleutian Islands bottom trawl survey, but are represented by species such as *Gersemia*. Sea anemones include all sea anemones captured in the bottom trawl surveys and pennatulaceans include sea pens and sea

whips.

Status and trends: A few general patterns are clearly discernible (Figure 22). Sponges are caught in most tows (>80%) in the AI west of the southern Bering Sea. Interestingly, the frequency of occurrence of sponges in the southern Bering Sea is relatively high, but sponge abundance is much lower than other areas. The sponge estimates for the 1983 and 1986 surveys are much lower than other years, probably due to the use of different gear, including large tire gear that limited the catch of most sponges and possibly recording inconsistencies. In recent years, the abundance of sponges in the western and central AI and the frequency of occurrence have been declining but with the 2018 results may be stabilizing.

Gorgonian corals occur in about 20-40% of bottom trawl survey tows. Abundance of coral in all areas has declined since about 1991-1993 surveys and is at generally low levels in all areas, but the frequency of occurrence has remained steady. Hydrocorals are commonly captured, except in the southern Bering Sea. They typically occur in about 20-40% of tows in other areas. Similar to sponges, hydrocoral frequency of occurrence and abundance has decreased in the western and central Aleutian Islands over recent surveys (from a peak in the 2000 survey). The 2018 results indicate recent stability at low levels.

Soft corals occur in relatively few tows, except in the eastern Aleutian Islands where they occur in about 20% of tows. Their abundance time series is dominated by a couple of years (1986 in the western Aleutians and 1991 in the central Aleutians).

Sea anemones are also common in survey catches (∼20-40% of tows) but abundance trends are not clear for most areas. In the Southern Bering Sea abundance and frequency of occurrence have been increasing during recent surveys until 2018 when relative abundance declined.

Sea pens are much more likely to be encountered in the southern Bering Sea and eastern AI than in areas further west. Abundance estimates are low across the survey area and large apparent increases in abundance, such as that seen in the eastern AI in 1997, are typically based on a single large catch.

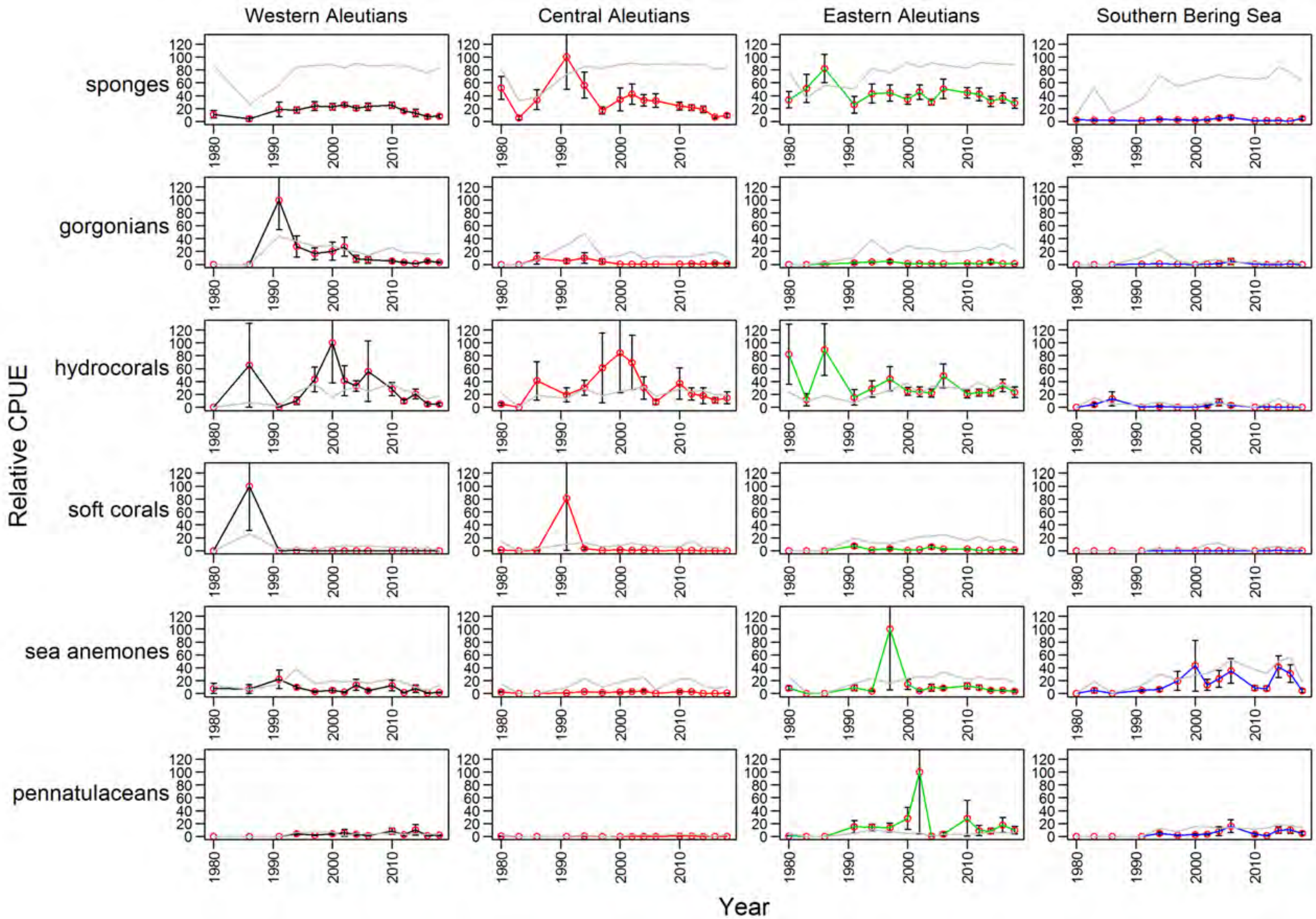

Figure 22: Mean CPUE of structural epifauna groups by area from RACE bottom trawl surveys in the Aleutian Islands from 1980 through 2018. Error bars represent standard errors. The gray lines represent the percentage of non-zero catches.

Factors influencing observed trends: The two major threats to populations of benthic invertebrates in the Aleutian Islands have been identified as fishing impacts and impacts of climate change. Both of these processes are occurring in the Aleutian Islands. Much of the benthic habitat in the Aleutians (∼50% of the shelf and slope to depths of 500 m) has been protected from mobile fishing gear since 2006, however, no studies have been conducted to determine potential recovery or expansion of populations due to the closures. As indicated by the 2018 bottom trawl survey temperature time series (p. 52), temperatures for the last three biennial surveys have been warmer than historical records. Non-motile organisms are sensitive to these changes in the benthic environment as well.

Implications: The Aleutian Islands bottom trawl survey is not particularly good at measuring the abundance trends fore these groups of HAPC species. However, the bottom trawl surveys are reasonably adept at capturing presence or absence trends as indicated by recent distribution model validation studies for the species groups. The recent declines in sponge, gorgonians and hydrocorals in the western and central Aleutian Islands should continue to be monitored.

Primary Production

There are no updates to primary production indicators in this year's report. See the contribution archive for previous indicator submissions at: http://access.afsc.noaa.gov/reem/ecoweb/index.php

Zooplankton

Continuous Plankton Recorder Data from the Aleutian Islands and southern Bering Sea through 2017

Contributed by Sonia Batten, Marine Biological Association (CPR Survey), c/o 4737 Vista View Cr, Nanaimo, BC, V9V 1N8, Canada
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Last updated: August 2018

Description of indicator: Continuous Plankton Recorders (CPRs) have been deployed in the North Pacific routinely since 2000. Two transects are sampled seasonally, both originating in the Strait of Juan de Fuca. One is sampled monthly (~Apr-Sept) and terminates in Cook Inlet; the second is sampled 3 times per year and follows a great circle route across the Pacific, terminating in Japan. Several indicators are now routinely derived from the CPR data and updated annually. In this report we update three indices for three regions (Figure 23): large diatoms (the CPR only retains large, hard-shelled phytoplankton so while a large proportion of the community is not sampled, the data are internally consistent and may reveal trends), mesozooplankton biomass (estimated from taxon-specific weights and abundance data) and mean Copepod Community Size (Richardson et al., 2006) as an indicator of community composition. Anomaly time series of each index have been calculated as follows: a monthly mean value (geometric mean) is first calculated. Each sampled month is then compared to the mean of that month and an anomaly calculated (Log_{10}). The mean anomaly of all sampled months in each year is calculated to give an annual anomaly.

The Aleutian Island region, including the southern Bering Sea is sampled at most 3 times per year by the east-west transect. Note that in 2017 the region was only sampled in May owing to variability in the ship's transect which went south of the Bering Sea in the summer. New this year, the top three taxa by abundance and biomass in 2017 are presented to allow comparison across Alaskan CPR sampling regions 2. Biomass is a taxon specific value from literature, not actually measured. Some taxa are a group of many species, some are individual life history stages of a single species. Aggregating by season can mask phenological differences. For example, the copepod *Neocalanus plumchrus* is common in spring but nearly absent in late summer/fall. This project is funded in part by the Gulf Watch Alaska long-term monitoring program funded by the *Exxon Valdez* Oil Spill Trustee Council.

Status and trends: Figure 24 shows that the diatom abundance and mesozooplankton biomass anomalies for May 2017 continued to be slightly positive, as they have been in more recent years, while the mean copepod community size anomaly was strongly negative still (it has been negative in each season sampled since summer 2014), indicating a community biased towards smaller species than typical for May.

Factors influencing observed trends: Recent analysis of summer CPR data in this region has revealed alternating (and opposing) patterns of high and low abundance of diatoms and large copepods between 2000 and 2012, believed to be the result of a trophic cascade caused by maturing pink salmon present in the region (Batten et al., 2018). Although the upper panel (diatoms) in Figure 24 contains data from spring and autumn as well as summer the alternating pattern is clear until 2012. The zooplankton data in Figure 2 consist of more taxa than just large copepods but it is likely that there is some top-down influence of the Pink Salmon also present in these data. In 2013 the east Kamchatka Pink Salmon run was much lower than expected, and in 2014 it was much higher. CPR data were not collected in this region in the summers

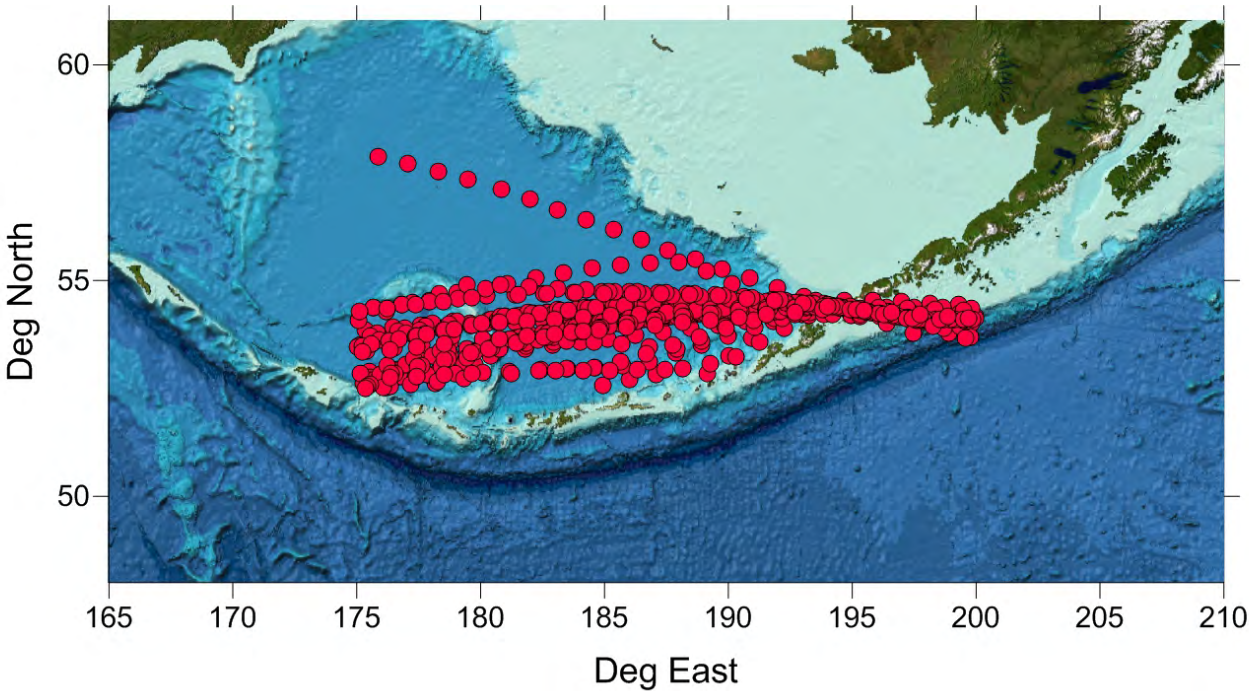

Figure 23: Location of the data in this report. Dots indicate actual sample positions and may overlay each other.

of 2015–2017 so we are not certain if their influence on the plankton continues, nor how to tease out the simultaneous influence of ocean climate. However, the copepod community size anomaly has been negative in each season sampled since summer 2014, which suggests a real increase in the relative abundance of smaller species, likely because of warmer than normal conditions.

Implications: This region appears to be subjected to top down influence by pink salmon as well as bottom up forcing by ocean climate, which is particularly challenging to interpret. Changes in community composition (e.g. abundance and composition of large diatoms, prey size as indexed by mean copepod community size) may reflect changes in the nutritional quality of the organism to their predators. Changes in abundance or biomass, together with size, influences availability of prey to predators. For example, while mesozooplankton biomass anomalies were positive during the last 3 years, the reduced average size of the copepod community suggests that the biomass was packaged into numerous, but small, prey items. This may require more work by predators to obtain their nutritional needs.

Table 2: The top three taxa by abundance and biomass across Alaska CPR regions in 2017:

	Taxa by abundance	Mean # sample	Taxa by Biomass	mg per sample
Southern Bering Sea/Aleutians	*Foraminifera*	214.7	*Neocalanus plumchrus* V	44.2
	Neocalanus plumchrus I_IV	102.7	*Neocalanus flemingeri* V	8.7
	Oithona spp.	91.0	*Eucalanus bungii*	7.4
Alaskan Shelf	*Pseudocalanus spp.*	687.4	*Neocalanus plumchrus* V	23.1
	Limacina helicina	153.7	*Pseudocalanus spp.*	13.4
	Neocalanus plumchrus V	47.4	*Neocalanus cristatus* V_VI	13.0
Oceanic NE Pacific	*Pseudocalanus spp.*	84.9	*Neocalanus cristatus* V_VI	18.3
	Tintinnida Total	83.8	*Neocalanus plumchrus* V	5.0
	Foraminifera	83.3	*Limacina helicina*	2.9

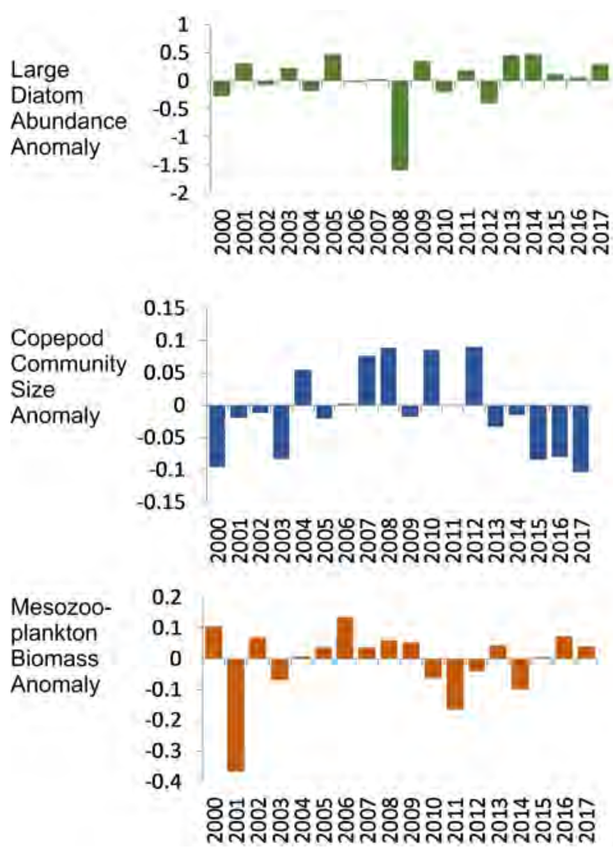

Figure 24: Annual anomalies of three indices of lower trophic levels (see text for description and derivation) for each region shown in Figure 23.

Jellyfish

Jellyfish in the Bottom Trawl Survey

Contributed by Wayne Palsson and Chris Rooper, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA
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Last updated: October 2018

Description of indicator: RACE bottom trawl surveys in the Aleutian Islands (AI) are designed primarily to assess populations of commercially important fish and invertebrates. However many other species are identified, weighed and counted during the course of these surveys and these data may provide a measure of relative abundance for some of these species. Jellyfish are probably not sampled well by the gear due to their fragility and potential for catch in the mid-water during net deployment or retrieval. Therefore jellyfish encountered in small numbers which may or may not reflect their true abundance in the AI. The fishing gear used aboard the Japanese vessels that participated in all AI surveys prior to 1990 was very different from the gear used by all vessels since. This gear difference almost certainly affected the catch rates for jellyfish. For jellyfish, the catches for each year were scaled to the largest catch over the time series (which was arbitrarily scaled to a value of 100). The standard error (± 1) was weighted proportionally to the CPUE to get a relative standard error. The percentage of positive catches in the survey bottom trawl hauls was also calculated. Note that CPUE is presented in four areas that differ from the ecoregions that are used elsewhere in this report (see Figure 26).

Status and trends: Jellyfish mean catch per unit effort (CPUE) is typically higher in the western and eastern AI than in other areas (Figure 25). The frequency of occurrence in trawl catches is generally from 20-60% across all areas, but has been variable. The 2006 AI survey experienced peak biomasses in all areas, whereas the 1992 survey had high abundance in the western AI only. Jellyfish catches and frequency of occurrence in the AI bottom trawl survey has been steadily increasing from 2012 to 2016 surveys in all areas, but decreased in 2018 in all areas.

Factors influencing observed trends: Unknown

Implications: The 2018 decline in CPUE and frequency of occurrence of jellyfish is in contrast to the steady increase in occurrence and abundance between 2012 and 2016. The increase during these three surveys coincided with warming temperatures found during the AI survey, but despite continuing warm temperatures in 2018, the relative abundance of jellyfish declined.

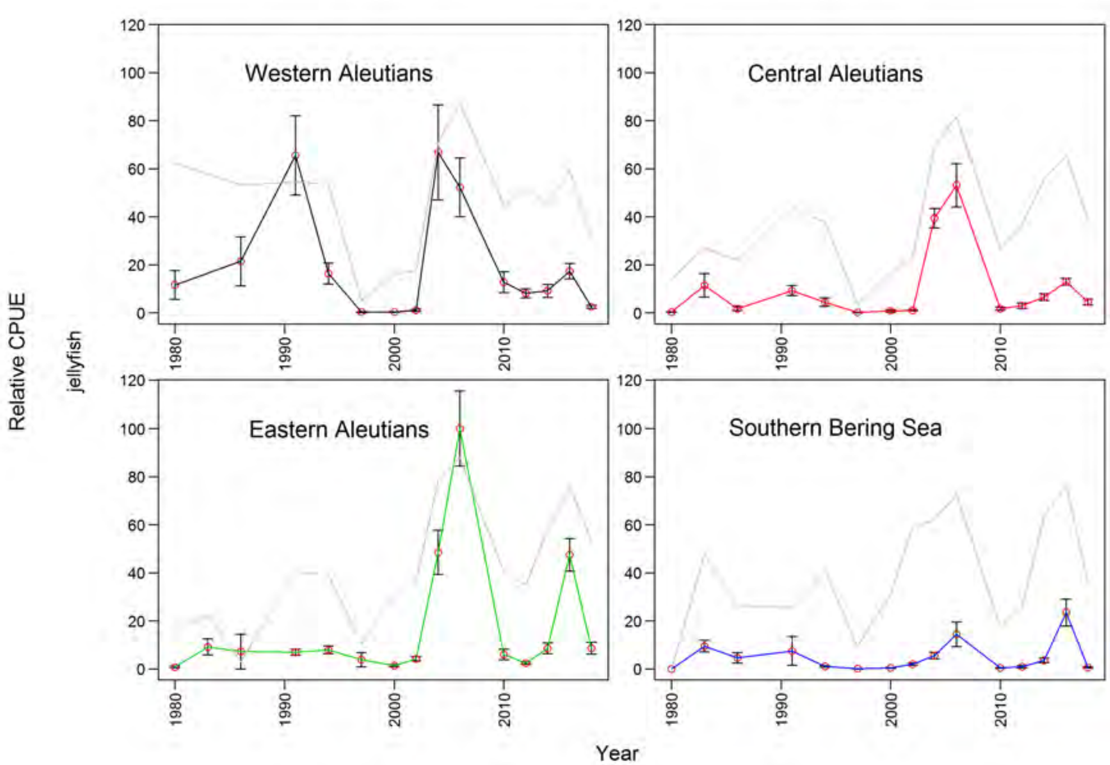

Figure 25: Relative mean CPUE of jellyfish species by INPFC area from RACE bottom trawl surveys in the Aleutian Islands from 1980 through 2018. Error bars represent standard errors. The gray lines represent the percentage of non-zero catches. The Central and Eastern Aleutians INPFC areas together correspond to the Central Aleutians ecoregion in this report. Similarly, the Southern Bering Sea INPFC area corresponds to the Eastern Aleutian ecoregion in this report.

Ichthyplankton

There are no ichthyoplankton indicators in this year's report. See the contribution archive for previous indicator submissions at: `http://access.afsc.noaa.gov/reem/ecoweb/index.php`

Forage Fish

There are no individual contributions with forage fish indicators in this year's report, other than the pelagic foragers guild and the puffin indicators in the Report Card. See the contribution archive for previous indicator submissions at: `http://access.afsc.noaa.gov/reem/ecoweb/index.php`

Groundfish

Aleutian Islands Groundfish Condition

Contributed by Jennifer Boldt[1], Chris Rooper[1], and Jerry Hoff[2]
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Last updated: October 2018

Description of indicator: Length-weight residuals are an indicator of somatic growth (Brodeur et al., 2004) and, therefore, a measure of fish condition. Fish condition is an indicator of how heavy a fish is per unit body length, and may be an indicator of ecosystem productivity. Positive length-weight residuals indicate fish are in better condition (i.e., heavier per unit length); whereas, negative residuals indicate fish are in poorer condition (i.e., lighter per unit length). Fish condition may affect fish growth and subsequent survival (Paul et al., 1997; Boldt and Haldorson, 2004).

The AFSC Aleutian Islands bottom trawl survey data was utilized to acquire lengths and weights of individual fish for walleye pollock, Pacific cod, arrowtooth flounder, southern rock sole, Atka mackerel, northern rockfish, and Pacific ocean perch. Only standard survey stations were included in analyses. Data were combined by INPFC area; Southern Bering sea, Eastern Aleutian Islands, Central Aleutian Islands, and Western Aleutian Islands (Figure 26). Length-weight relationships for each of the seven species were estimated with a linear regression of log-transformed values over all years where data was available (during 1984–2018). Additionally, length-weight relationships for age 1+ walleye pollock (length from 100–250 mm) were also calculated independent from the adult life history stage. Predicted log-transformed weights were calculated and subtracted from measured log-transformed weights to calculate residuals for each fish. Outliers were removed using a Bonferroni outlier test (with a cutoff test statistic of 0.7 for removal). Length-weight residuals were averaged for the entire AI and for the 3 INPFC areas sampled in the standard summer survey. Temporal and spatial patterns in residuals were examined.

Status and trends:: Length-weight residuals varied over time for all species with a few notable patterns (Figure 27). Residuals for most species where there was data were negative from 2000 to 2006. Residuals were positive for all species but southern rock sole in 2010. In 2012–2016 length-weight residuals were negative across most species, and the trendline has been negative since 2010. For northern rockfish, Pacific cod and Pacific ocean perch there has been a declining trend in residuals over the years covered by the survey and condition in the last four surveys has been particularly negative.

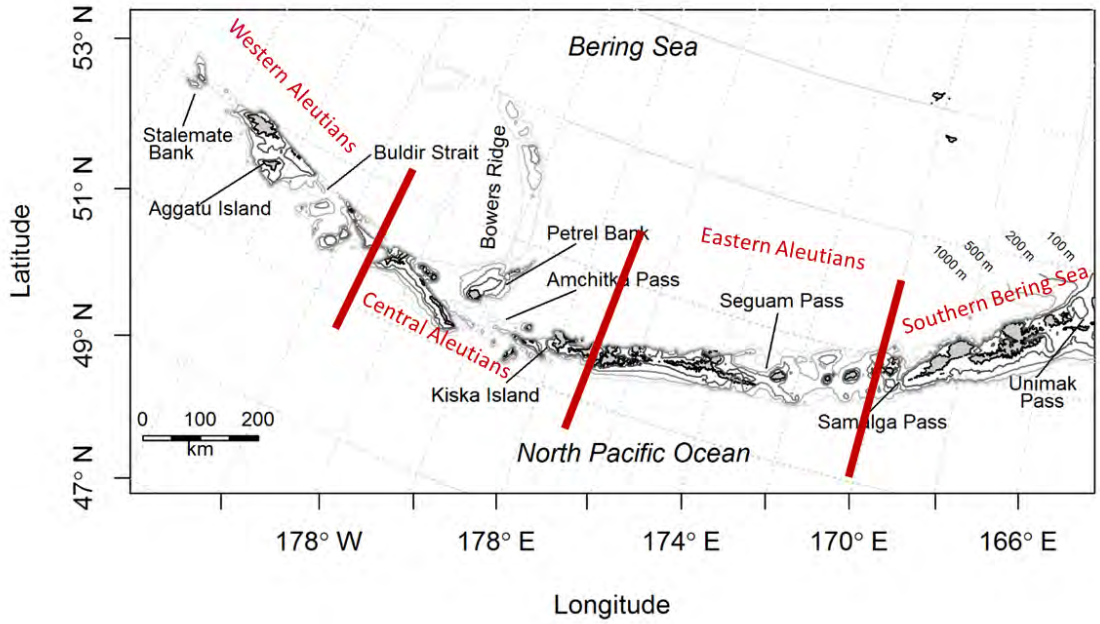

Figure 26: NMFS summer bottom trawl survey strata in the Aleutian Islands. Red lines demarcate Aleutian Islands INPFC Areas. The Central and Eastern Aleutians INPFC areas together correspond to the Central Aleutians ecoregion in this report. Similarly, the Southern Bering Sea INPFC area corresponds to the Eastern Aleutian ecoregion in this report.

Spatial trends in residuals were also apparent for some species (Figure 28). Most species were generally in better condition in the southern Bering Sea (with the exception of Pacific cod). Species generally exhibited the worst condition in the Western Aleutians (with the exception of Pacific cod) Even in years where length weight residuals were positive overall (such as the early years in the northern rockfish time series), length weight residuals were lower (although still positive) in the western Aleutian Islands relative to other areas.

Factors influencing observed trends: One potential factor causing the observed temporal variability in length-weight residuals may be population size. The species that appear to exhibit declining trends over the time series, have generally been increasing in abundance throughout the Aleutians (northern rockfish, Pacific Ocean perch and Pacific cod). In the western Aleutians, this may be especially magnified, due to the overall high level of population abundance in the area.

Other factors that could affect length-weight residuals include temperature, survey sampling timing and fish migration. The date of the first length-weight data collected is generally in the beginning of June and the bottom trawl survey is conducted sequentially throughout the summer months from east to west. Therefore, it is impossible to separate the in-season time trend from the spatial trend in this data.

Implications: A fish's condition may have implications for its survival. For example, in Prince William Sound, the condition of herring prior to the winter may in part determine their survival (Paul and Paul 1999). The condition of Aleutian Island groundfish, may therefore partially contribute to their survival and recruitment. In the future, as years are added to the time series, the relationship between length-weight residuals and subsequent survival can be examined further. It is likely, however, that the relationship is more complex than a simple correlation. Also important to consider is the fact that condition of all sizes of fish were examined and used to predict survival. Perhaps it would be better to examine the condition of juvenile fish, not yet recruited to the fishery, or the condition of adult fish and correlations with survival.

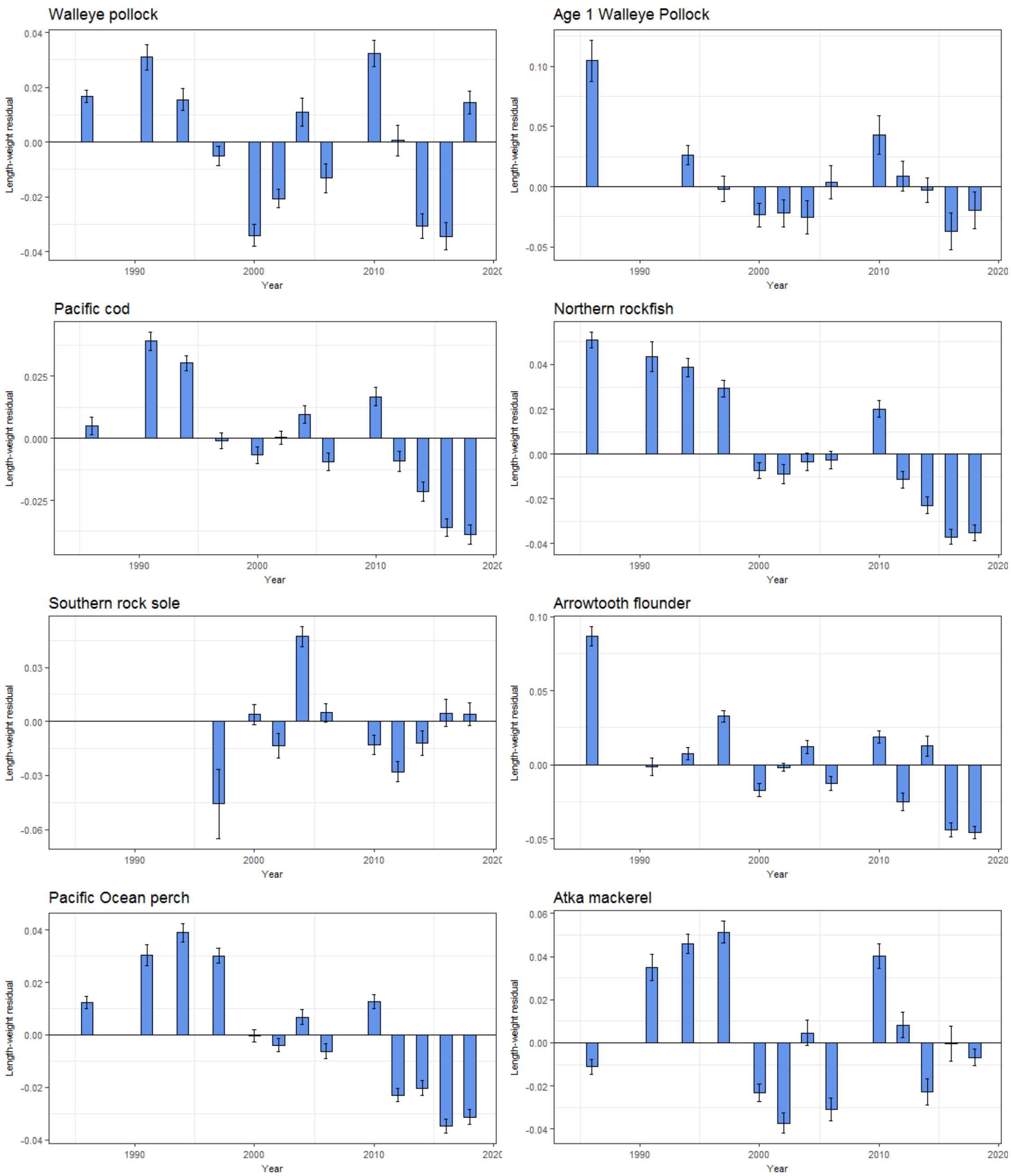

Figure 27: Length-weight residuals for seven Aleutian Islands groundfish sampled in the NMFS standard summer bottom trawl survey, 1984-2018. The Central and Eastern Aleutians INPFC areas together correspond to the Central Aleutians ecoregion in this report. Similarly, the Southern Bering Sea INPFC area corresponds to the Eastern Aleutian ecoregion in this report.

Distribution of Rockfish Species in the Aleutian Islands

Contributed by Wayne Palsson and Chris Rooper, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA
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Last updated: October 2018

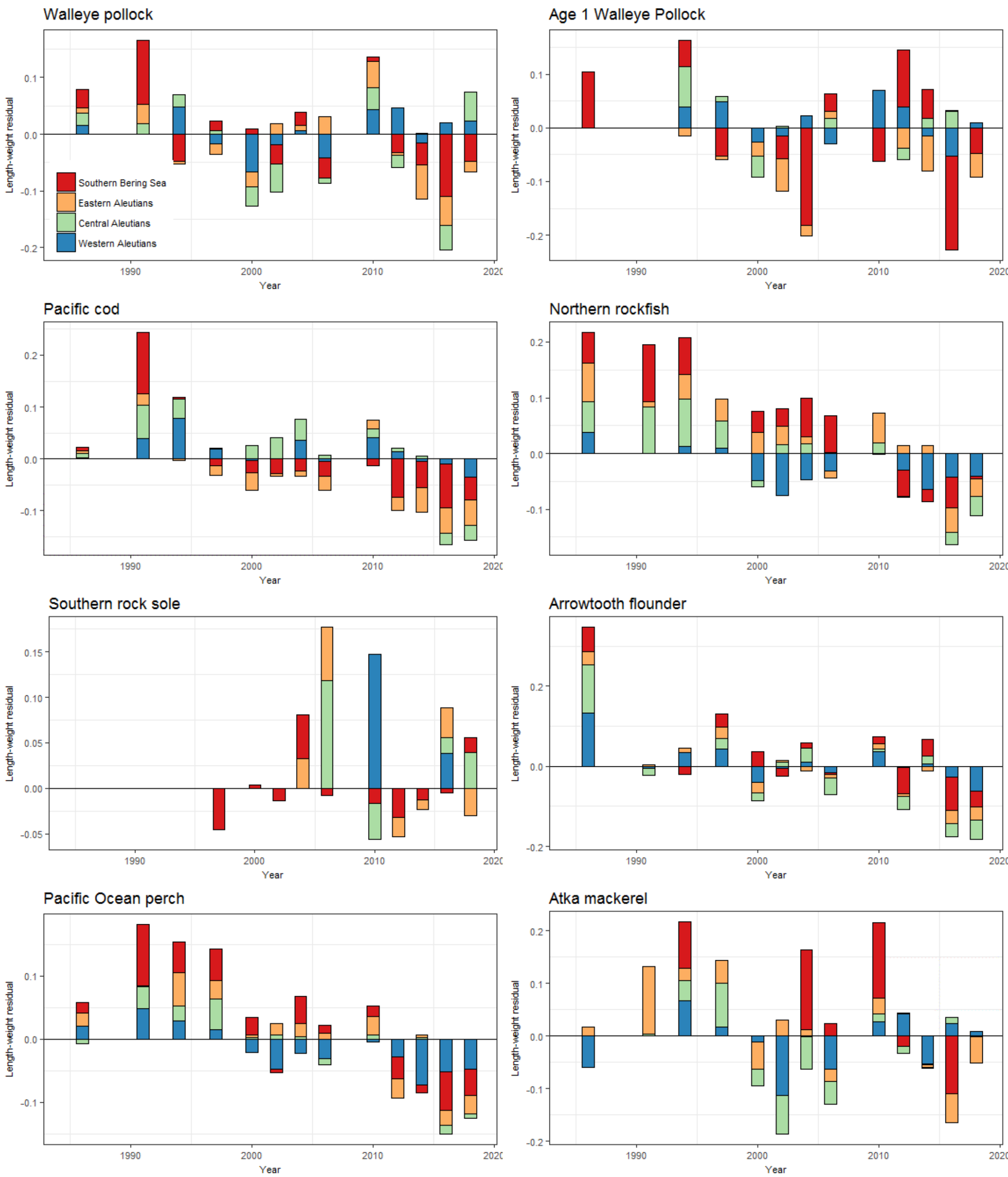

Figure 28: Length-weight residuals for seven Aleutian Islands groundfish sampled in the NMFS standard summer bottom trawl survey, 1984-20186, by INPFC area. The Central and Eastern Aleutians INPFC areas together correspond to the Central Aleutians ecoregion in this report. Similarly, the Southern Bering Sea INPFC area corresponds to the Eastern Aleutian ecoregion in this report.

Description of indicator: In a previous analysis of rockfish from 14 bottom trawl surveys in the Gulf of Alaska and Aleutian Islands (Rooper, 2008), five species assemblages were defined based on similarities in their distributions along geographical position, depth, and temperature gradients. The 180 m and 275 m depth contours were major divisions between assemblages inhabiting the shelf, shelf break, and lower

continental slope. Another noticeable division was between species centered in southeastern Alaska and those found in the Aleutian Islands.

In this time-series, the mean-weighted distributions of six rockfish (*Sebastes* spp.) species along the three environmental gradients (depth, temperature, and position) were calculated for the Gulf of Alaska and Aleutian Islands. A weighted mean value for each environmental variable was computed for each survey as:

$$Mean = \frac{\sum (f_i x_i)}{\sum f_i},$$

where f_i is the CPUE of each rockfish species group in tow i and x_i is the value of the environmental variable at tow i. The weighted standard error (SE) was then computed as:

$$SE = \frac{\sqrt{\frac{(\sum (f_i x_i^2)) - ((\sum f_i) * mean^2)}{(\sum f_i) - 1}}}{\sqrt{n}},$$

where n is the number of tows with positive catches. Details of the calculations and analyses can be found in Rooper (2008). These indices monitor the distributions of major components of the rockfish fisheries along these environmental gradients to detect changes or trends in rockfish distribution.

Status and trends: There are four statistically significant depth-related trends over the time series that have continued over the last several surveys, as the distribution of adult rougheye rockfish, adult Pacific Ocean perch, shortraker rockfish, and northern rockfish have been shallower in the most recent surveys of the AI (Figure 29). It appears that shallow-distributed dusky rockfish and deepwater shortspine thornyhead are maintaining their same depth interval over time. Northern rockfish show a significant increasing trend in distance over the time series, indicating that their mean distribution is trending westward. There were no significant trends in mean-weighted temperature distributions for any species and all species were found within about 1°C.

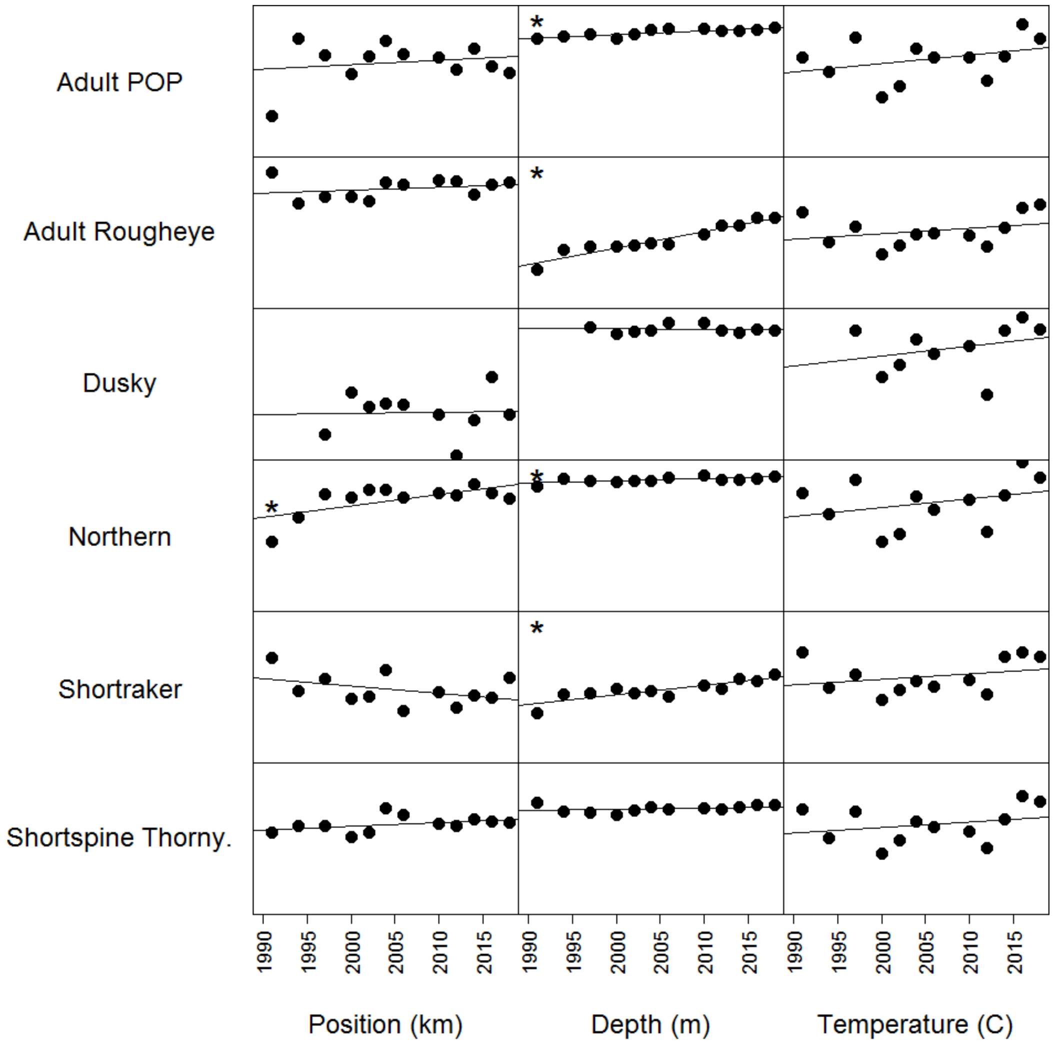

Figure 29: Plots of mean weighted (by catch per unit effort) distributions of six rockfish species-groups along three environmental variables in the Aleutian Islands. Mean weighted distributions of rockfish species-groups are shown for A) position, B) depth, and C) temperature. Position is the distance from Hinchinbrook Island, Alaska, with positive values west of this point.

Factors causing observed trends: The observed changes in depth and spatial distributions for adult rougheye rockfish, shortraker rockfish, northern rockfish and adult Pacific Ocean perch in the AI are probably related to changes (increases) in overall abundance. Although it is interesting to note that in the cases of adult rougheye rockfish, adult Pacific Ocean perch, northern rockfish, and shortraker rockfish their depth range has become shallower while the temperatures occupied by the species have not changed significantly in recent surveys (with the exception of possibly the 2016 survey).

Implications: The trends in the mean-weighted distributions of rockfish should continue to be monitored, with special attention to potential causes of the shift in depth and position distributions of rockfish, especially as they relate to changing temperatures. During the last two surveys in 2016 and 2018, all five rockfish groups were found at the highest mean-weighted temperature in the time series, and the trend for all species has been upward since the 2012 survey.

Benthic Communities and Non-target Fish Species

Miscellaneous Species in the Aleutian Islands

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Last updated: October 2018

Description of indicator: RACE bottom trawl surveys in the Aleutian Islands (AI) are designed primarily to assess populations of commercially important fish and invertebrates. However many other species are identified, weighed and counted during the course of these surveys and these data may provide a measure of relative abundance for some of these species. Many of these species are not sampled well by the gear or occur in areas that are not well sampled by the survey (hard, rough areas, mid-water etc.) and are therefore encountered in small numbers which may or may not reflect their true abundance in the AI. The fishing gear used aboard the Japanese vessels that participated in all AI surveys prior to 1991 was very different from the gear used by all vessels since. This gear difference almost certainly affected the catch rates for some of these species groups. Apparent abundance trends for a few of these groups are shown in Figure 30. For each species group, the largest catch over the time series was arbitrarily scaled to a value of 100 and all other values were similarly scaled. The standard error (± 1) was weighted proportionally to the CPUE to get a relative standard error. Note that CPUE is presented in four areas that differ from the ecoregions that are used elsewhere in this report (see Figure 26).

Status and trends: Echinoderms are frequently captured in all areas of the AI surveys occurring in 80-90% of all bottom trawl hauls. Echinoderm mean catch per unit effort (CPUE) is typically higher in the central and eastern AI than in other areas, although frequency of occurrence in trawl catches is consistently high across all areas. The lowest echinoderm CPUE has usually been in the southern Bering Sea, but has been increasing for the last three surveys. Eelpout CPUEs have generally been highest in the central and eastern AI. There has been a decline in eelpout biomass in the western AI over the last four surveys and in the central AI in 2018. Eelpouts generally occur in <10% of survey hauls across all areas. Poachers occur in a relatively large number of tows across the AI survey area (about 30-40% consistently), but mean CPUE trends are unclear and abundance appears low. A new shrimp time series has been calculated since 2016. The shrimp time series shows generally increasing trends in frequency of occurrence across all areas except the western AI since ∼1990. However, the CPUE is dominated by a single peak in 2006 in the western AI. Shrimp CPUE in 2018 was slightly lower in all regions except the western AI.

Factors influencing observed trends: Unknown

Implications: AI survey results provide limited information about abundance or abundance trends for these species due to problems in catchability. Therefore, the indices presented are likely of limited value to fisheries management. These species are not typically commercially important, but the trends in shrimp especially should be monitored as these are an important prey base for benthic commercial species.

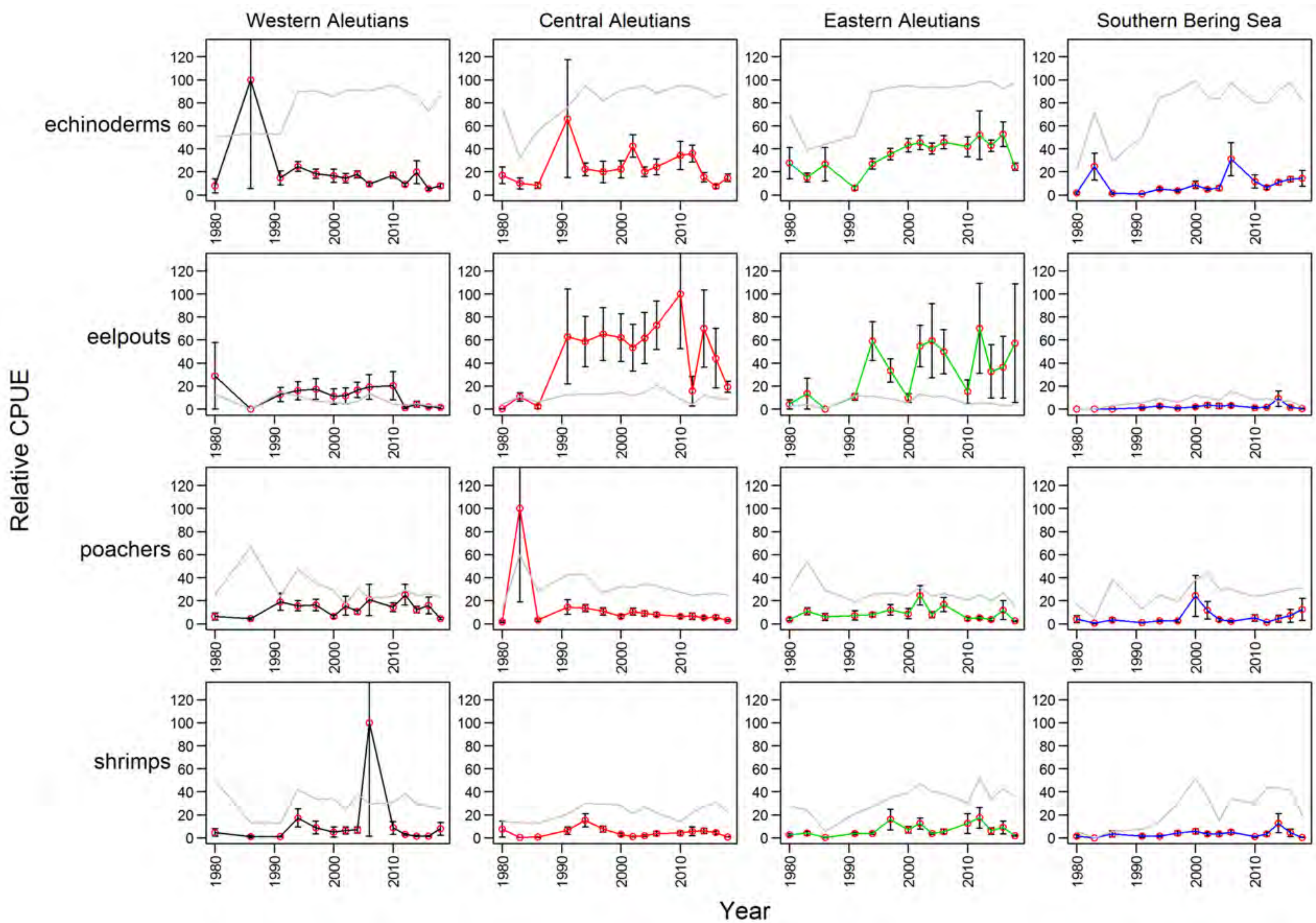

Figure 30: Relative mean CPUE of miscellaneous species by area from RACE bottom trawl surveys in the Aleutian Islands from 1980 through 2018. Error bars represent standard errors. The gray lines represent the percentage of non-zero catches. The Central and Eastern Aleutians correspond to the Central AI ecoregion. The Southern Bering Sea corresponds to the Eastern AI ecoregion.

Seabirds

Seabird Monitoring Summary from Alaska Maritime National Wildlife Refuge

Contributed by Heather Renner and Nora Rojek, Alaska Maritime National Wildlife Refuge, Homer, AK
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Last updated: October 2018

Description of indicator: The Alaska Maritime National Wildlife Refuge has monitored seabirds at colonies around Alaska in most years since the early- to mid-1970s. Time series of annual breeding success and phenology (and other parameters) are available from over a dozen species at eight Refuge sites in the Gulf of Alaska, Aleutian Islands, and Bering and Chukchi Seas (Figure 31). Monitored colonies in the Aleutian Islands include Buldir (western Aleutians) and Aiktak (eastern Aleutians). Reproductive success is defined as the proportion of nest sites with eggs (or just eggs for murres that do not build nests) that fledged a chick.

Status and trends: Seabird reproductive success differed between the western Aleutians and eastern Aleutians in 2018 (Figure 32). At Buldir, fish-eating seabird species, which include tufted puffins and common and thick-billed murres, had low to zero productivity. Black-legged kittiwakes, storm-petrels and auklets (which consume a mix of fish and invertebrates) showed average to above average fledging rates. Timing of breeding was extremely late for most species at Buldir. At Aiktak, murres had low to zero productivity, but tufted puffins had high productivity that was more than 1 standard deviation (SD) above the long term mean. Timing of breeding was near average for all species but storm-petrels, which were late.

Factors influencing observed trends: In general, seabirds in the Aleutians did not experience widespread failures like the Gulf of Alaska did during the marine heat wave of the past few years. However many seabirds did poorly in 2018 at Buldir and had mixed success at Aiktak, while planktivorous seabirds have remained generally successful. This suggests that zooplankton availability was sufficient at both sites, but that forage fish prey were insufficient to support chick-rearing at Buldir.

Implications: Reproductive activity of central-place foraging seabirds can reflect ecosystem conditions at multiple spatial and temporal scales. Tufted puffins completely failed at Buldir only one other time, in 2011. In general, tufted puffins can adapt their foraging to what is available, so their failure suggests a potentially broad lack of prey (that includes forage fish and squid). Field crew did observe some puffins carrying prey to chicks, but given that all breeding was late there may have been a mismatch in prey availability and typical breeding. The differences in patterns of reproductive activity between Buldir and Aiktak likely reflect differences in ecosystem conditions between the western and eastern Aleutian Islands.

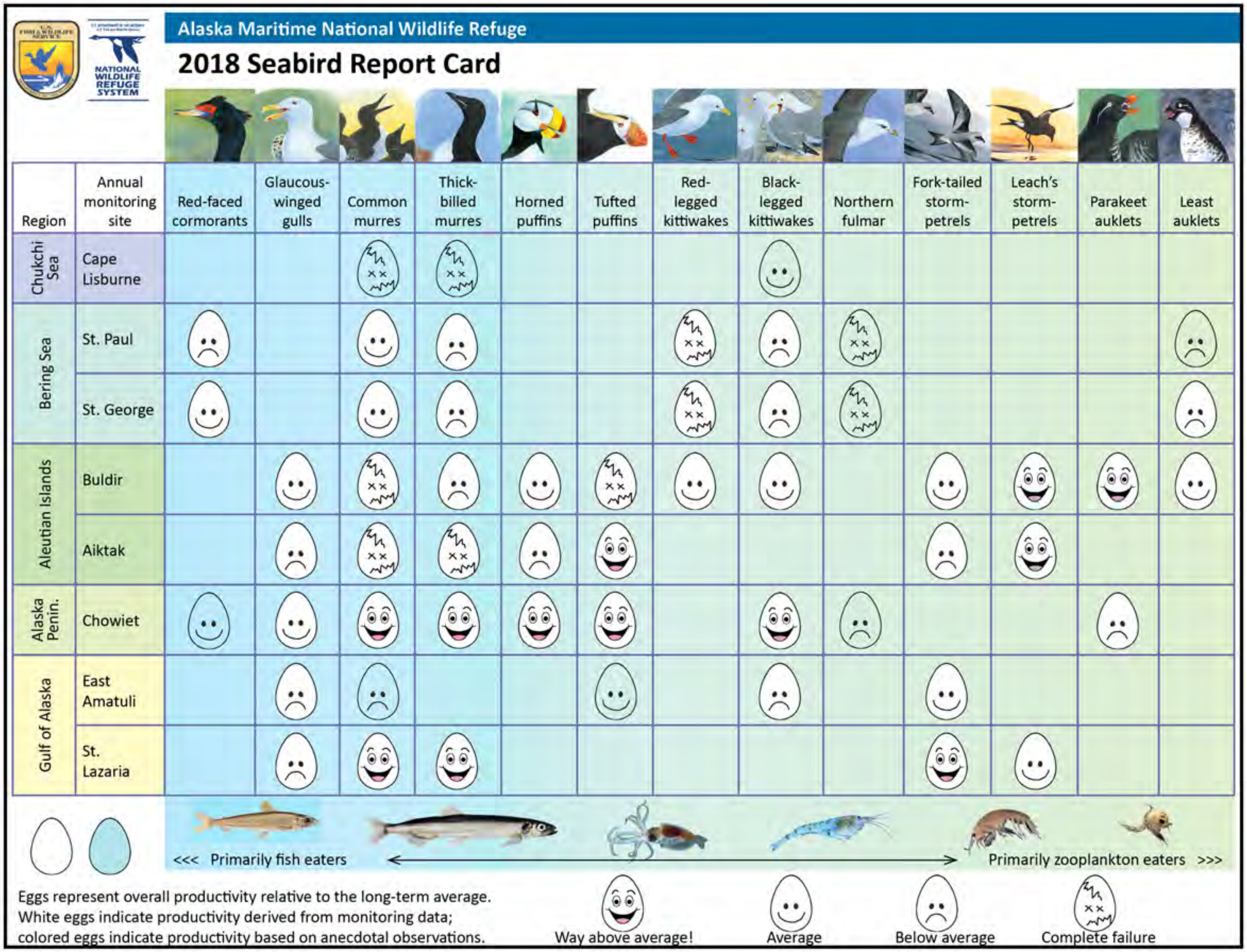

Figure 31: Summary of reproductive success in 2018 at long-term monitored sites on the Alaska Maritime National Wildlife Refuge. Figure created by AMNWR

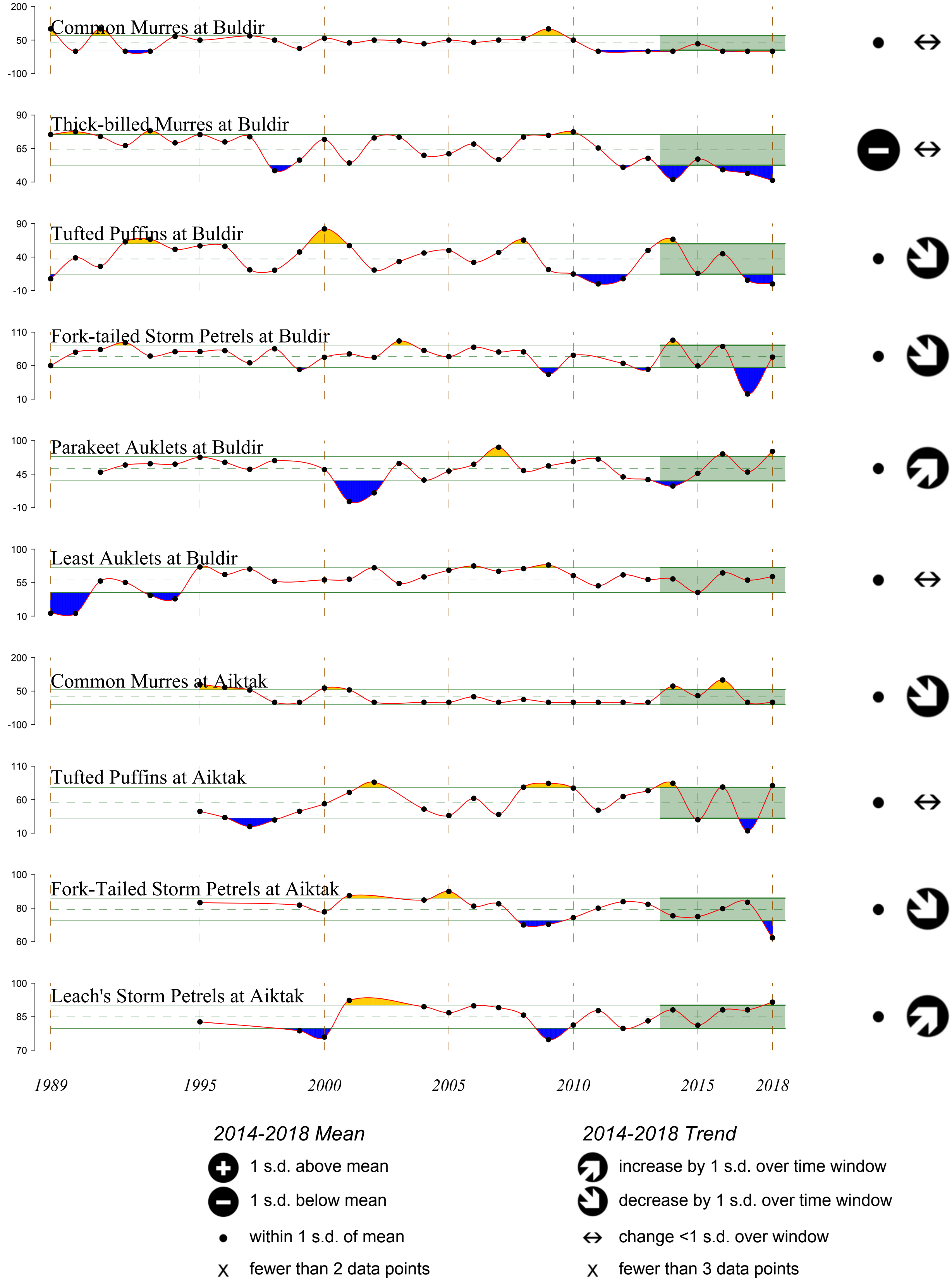

Figure 32: Summary of reproductive success of some seabird species at Chowiet (WGOA) and St Lazaria (EGOA)

Marine Mammals

The Marine Mammal Protection Act requires stock assessment reports to be reviewed annually for stocks designated as strategic, annually for stocks where there are significant new information available, and at least once every 3 years for all other stocks. Each stock assessment includes, when available, a description of the stock's geographic range, a minimum population estimate, current population trends, current and maximum net productivity rates, optimum sustainable population levels and allowable removal levels, and estimates of annual human-caused mortality and serious injury through interactions with commercial fisheries and subsistence hunters. The most recent (2014) Alaska Marine Mammal stock assessment was released in August 2015 and can be downloaded at `http://www.nmfs.noaa.gov/pr/sars/region.htm`.

There are no updates to marine mammal indicators in this year's report, with the exception of those in the Report Card. See the contribution archive for previous indicator submissions at: `http://access.afsc.noaa.gov/reem/ecoweb/index.php`

Ecosystem or Community Indicators

Stability of Groundfish Biomass in the Aleutian Islands

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Last updated: October 2018

Description of indicator: The stability of the groundfish community total biomass is measured with the inverse biomass coefficient of variation (1 divided by the coefficient of variation of total groundfish biomass (1/CV[B])). This indicator provides a measure of the stability of the ecosystem and its resistance to perturbations. The variability of total community biomass is thought to be sensitive fishing and is expected to increase with increasing fishing pressure (Blanchard and Boucher 2001). This metric is calculated following the methods presented in Shin et al. (2010). The CV is calculated as the mean total groundfish biomass over the previous 10 years divided by the standard deviation over the same time span. The biomass index for groundfish species was calculated from the catch of the NMFS/AFSC biennial summer bottom-trawl survey of the Aleutian Islands. The Aleutian Islands survey time series began in 1980 and was conducted on a triennial basis until 2000 when it switched to a biennial schedule. The 1989 survey did not occur and the AI was not surveyed again until 1991, leaving a 5 year gap. Also, the 2008 survey did not occur leaving a 4 year gap. Additionally, the 1980 data were not available at the time this indicator was prepared so the time series begins in 1983. Since 10 years of data are required to calculate this metric, the indicator values start in 2010, the tenth time the Aleutian Islands were surveyed over the time series examined (1983–2018). This metric is presented as an inverse, so as the CV increases the value of this indicator decreases, and if the CV decreases the value of this indicator increases.

Status and trends: The stability of groundfish biomass in the Aleutian Islands has been relatively constant over the time period examined (Figure 33). There has been a gradual decrease in this indicator from a high of 4.6 in 2010 to a low of 3.5 in 2018. However, the slope of a trendline was not significant ($p > 0.05$).

Factors influencing observed trends: Fishing is expected to influence this metric as fisheries can selectively target and remove larger, long-lived species effecting population age structure (Berkeley et al. 2004, Hsieh et al. 2006). Larger, longer-lived species can become less abundant and be replaced by smaller shorter-lived species (Pauly et al. 1998). Larger, longer-lived individuals help populations to endure prolonged periods of unfavorable environmental conditions and can take advantage of favorable conditions when they return (Berkeley et al. 2004). A truncated age-structure could lead to higher population variability

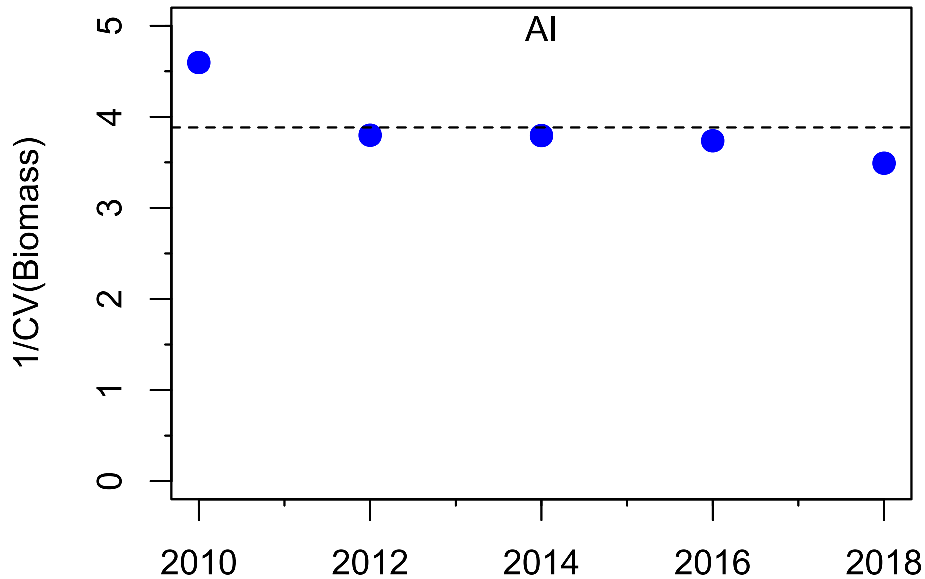

Figure 33: The stability of groundfish in the Aleutian Islands represented with the metric, one divided by the coefficient of variation of total groundfish biomass (1/CV[B]). Ten years of data are required to calculate this metric, so this time series begins in 2010 after the tenth occurrence of the NMFS/AFSC summer bottom-trawl survey over the time period examined (1983-2018). The dashed line represents the mean of the time series (2010–2018).

(CV) due to increased sensitivity to environmental dynamics (Hsieh et al. 2006). Interannual variation in this metric could also be influenced by interannual variation in species abundance in the trawl survey catch, and patchy spatial distribution for some species. This metric, as calculated here with trawl-survey data, reflects the stability of the groundfish community that is represented in the catch of the GOA summer bottom-trawl survey. In general, as total biomass decreases species spatial distribution may contract or have increasingly isolated patches, both of which may lead to increased CV (Shin et al. 2010).

Walleye pollock and Atka mackerel are two of the biomass dominant species in the catch of the Aleutian Islands bottom trawl survey. The first two years of the trawl survey included in this metric (1983 and 1986) were years dominated by walleye pollock. In subsequent years Atka mackerel had a higher biomass index than walleye pollock. The biomass index for Atka mackerel is generally more variable than the index for walleye pollock. This has resulted in the gradually decreasing values of this indicator over the time period examined.

Implications: The biomass of the groundfish community in the western GOA appears to be stable over the time period examined. Although there are only 5 data points for this metric, there is no indication of a clear trend in the stability of the groundfish community biomass.

Mean Length of the Fish Community in the Aleutian Islands

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Last updated: October 2018

Description of indicator: The mean length of the groundfish community tracks fluctuations in the size of groundfish over time. This size-based indicator is thought to be sensitive to the effects of commercial fisheries because larger predatory fish are often targeted by fisheries and their selective removal would reduce mean size (Shin et al. 2005). Fish lengths are routinely recorded during the biennial NMFS bottom trawl survey of the Aleutians Islands. The survey time series began in 1980 and was conducted on a triennial basis until 2000 when it switched to a biennial schedule. The 1989 survey did not occur and the AI was not surveyed again until 1991, leaving a 5 year gap. Also, the 2008 survey did not occur leaving a 4 year gap. The 1980 data was not available at the time this indicator was prepared, so it begins with 1983.

Species-specific mean lengths are calculated for groundfish species from the length measurements collected during the trawl survey. The mean length for the groundfish community is calculated with the species-specific mean lengths, weighted by biomass indices (Shin et al. 2010) calculated from the bottom-trawl survey. This indicator specifically applies to the portion of the demersal groundfish community efficiently sampled with the trawling gear used by NMFS during the summer bottom-trawl survey of the AI and have their lengths regularly sampled (for complete survey details see von Szalay and Raring 2018). This includes species of skates, flatfishes, and roundfishes (e.g., cods, sculpins, eelpouts). Species that are predominately found in the pelagic environment (e.g., capelin, pelagic smelts), over untrawlable habitat (e.g., rockfishes), or are otherwise infrequently encountered (e.g., sharks, grenadiers, myctophids) or not efficiently caught by the bottom-trawling gear are excluded from this indicator.

Status and trends: The mean length of the Aleutian Islands groundfish community in 2018 is 41.8 cm. This is up one cm from 2017 and is the highest value over the time series (Figure fig.ailen). This indicator has shown some year to year variation but has generally stayed close to the long term mean. The interannual variation is a reflection of the variation in the abundance of species sampled for lengths. The slope of a trendline was not significant (α=0.05).

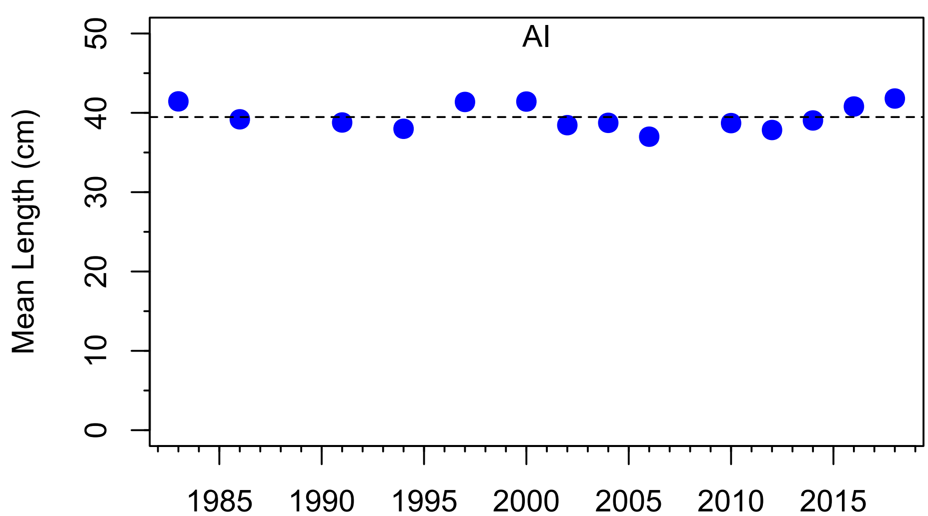

Figure 34: Mean length of the groundfish community sampled during the NMFS/AFSC summer bottom-trawl survey of the Aleutian Islands (1983–2018). The groundfish community mean length is weighted by the relative biomass of the sampled species. The dashed line represents the time series mean (1983–2018).

Factors influencing observed trends: This indicator is specific to the fishes that are routinely caught and sampled during the NMFS summer bottom-trawl survey. The estimated mean length can be biased if specific species-size classes are sampled more or less than others, and is sensitive to spatial variation in the size distribution of species. Changes in fisheries management or fishing effort could also affect the

mean length of the groundfish community. Modifications to fishing gear, fishing effort, and targeted species could affect the mean length of the groundfish community if different size classes and species are subject to changing levels of fishing mortality. The mean length of groundfish could also be influenced by fluctuations in recruitment, where a large cohort of small forage species could reduce mean length of the community. Environmental factors could also influence fish growth and mean length by effecting the availability and quality of food, or by direct temperature effects on growth rate.

Implications: The mean length of the groundfish community in the Aleutian Islands has been stable over the bottom-trawl time series (1983–2018). There is no evidence at this time of an obvious trend in mean size or indication that an external pressure such as climate or fishing is affecting this indicator.

Mean Lifespan of the Fish Community in the Aleutian Islands

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Last updated: October 2018

Description of indicator: The mean lifespan of the community is defined by Shin et al. (2010) as, "a proxy for the mean turnover rate of species and communities" and is intended to reflect "ecosystem stability and resistance to perturbations." The indicator for mean lifespan of the groundfish community is modeled after the method for mean lifespan presented in (Shin et al. 2010). Lifespan estimates of groundfish species regularly encountered during the NMFS/AFSC biennial summer bottom-trawl survey of the Aleutian Islands were retrieved from the AFSC Life History Database (`https://access.afsc.noaa.gov/reem/LHWeb/Index.php`). The Aleutian Islands survey time series began in 1980 and was conducted on a triennial basis until 2000 when it switched to a biennial schedule. The 1989 survey did not occur and the AI was not surveyed again until 1991, leaving a 5 year gap. Also, the 2008 survey did not occur leaving a 4 year gap. The 1980 data was not available at the time this indicator was prepared, so it begins with 1983.

Status and trends: The mean lifespan of the Aleutian Islands demersal fish community in 2018 is 22.3 which is up from 19.6 in 2016 and above the long term mean of 20.9 over the years 1983–2018 (Figure 35). This exhibits some interannual variation but is generally stable. The slope of a trendline was not significantly different from zero.

Factors influencing observed trends: Fishing can affect the mean lifespan of the groundfish community by preferentially targeting larger, older fishes, leading to decreased abundance of longer-lived species and increased abundance of shorter-lived species (Pauly et al. 1998). Interannual variation in mean lifespan can be influenced by the spatial distribution of species and the differential selectivity of species to the trawling gear used in the survey. Strong recruitment events or periods of week recruitment could also influence the mean community lifespan by altering the relative abundance of age classes and species. High values in the early part of the time series (1983 and 1986) and in 2018 correspond to years with relatively high biomass indices for walleye pollock (lifespan = 31). Years with lower values (1994, 2012–2016) correspond to years with relatively high biomass indices for Atka mackerel (lifespan = 17).

Implications: The groundfish mean lifespan has been generally stable over the time series of the summer bottom trawl survey. There is no indication at this time of an increasing or decreasing trend in mean lifespan. Species that are short-lived are generally smaller and more sensitive to environmental variation than larger, longer-lived species (Winemiller 2005). Longer-lived species help to dampen the effects of environmental variability, allowing populations to persist through periods of unfavorable conditions and to take advantage when favorable conditions return (Berkeley et al. 2004, Hsieh et al. 2006).

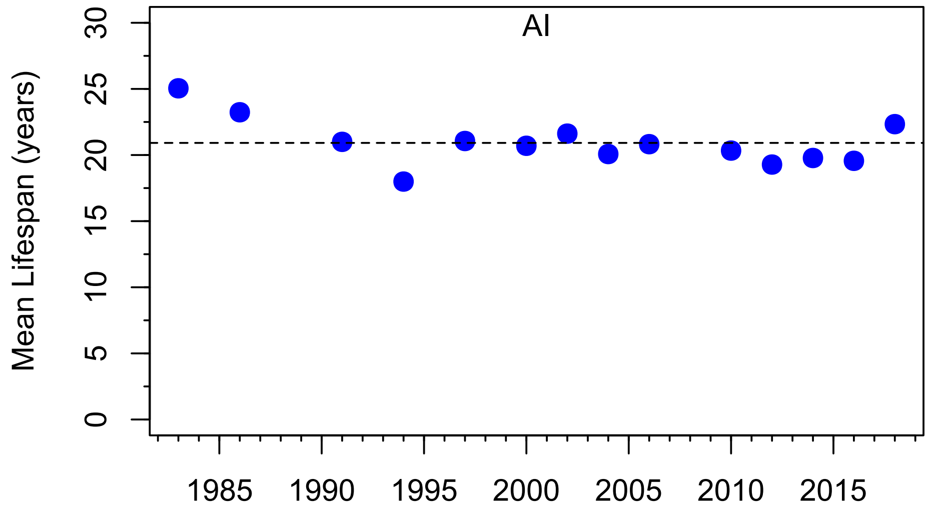

Figure 35: The mean lifespan of the western Gulf of Alaska demersal fish community (blue line), weighted by relative biomass calculated from the NMFS/AFSC summer bottom-trawl survey. The dashed line represents the mean of the time series (1984–2017) and the solid line is a trendline with slope = 0.169.

Disease Ecology Indicators

There are no disease ecology indicators in this year's report. See the contribution archive for previous indicator submissions at: `http://access.afsc.noaa.gov/reem/ecoweb/index.php`

Fishing and Human Dimensions Indicators

Indicators presented in this section are intended to provide a summary of the status of several ecosystem-scale indicators related to fishing and human economic and social well-being. These indicators are organized around objective categories derived from U.S. legislation and current management practices:

- Maintaining diversity
- Maintaining and restoring fish habitats
- Sustainability (for consumptive and non-consumptive uses)
- Seafood production
- Profits
- Recreation
- Employment
- Socio-cultural

The indicators presented are meant to represent trends in different aspects of the general management objective, but some indicators are better proxies than others. For example, seafood production is a fairly good proxy for the production of seafood to regional, national, and international markets but ex-vessel and wholesale value are imperfect proxies for harvesting and processing sector profits. This suite of indicators will continue to be revised and updated to provide a more holistic representation of human/environment interactions and dependencies.

Maintaining Diversity: Discards and Non-Target Catch

Time Trends in Groundfish Discards

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Last updated: September 2018

Description of indicator: Estimates of groundfish discards for 1993-2002 are sourced from NMFS Alaska Regions blend data, while estimates for 2003 and later come from the Alaska Regions Catch Accounting System. These sources, which are based on observer data in combination with industry landing and production reports, provide the best available estimates of groundfish discards. Discard rates as shown in the figure below are calculated as the weight of groundfish discards divided by the total (i.e., retained and discarded) catch weight for the relevant area-gear-target sector. Where rates are described below for species or species groups, they represent the total discarded weight of the species/species group divided by the total catch weight of the species/species group for the relevant area-gear-target sector. These estimates include only catch of FMP-managed groundfish species within the FMP groundfish fisheries: not included are groundfish discards in the halibut fishery and discards of non-groundfish species, such as forage fish and species managed under prohibited species catch (PSC) limits.

Status and trends: Since 1993 discards and discard rates of groundfish in federally-managed Alaskan groundfish fisheries have generally declined across the trawl pollock, non-pollock trawl, and fixed gear (hook-and-line and pot) sectors in the Aleutian Islands (AI). Over the most recent 5-year period (2013–2017), the annual discard biomass and discard rate in the AI fixed gear sector have averaged 1215 mT and 7%, respectively, compared to averages of 2438 mT and 11% over the 1993–2017 period. Discard biomass in the trawl pollock sector was highest during 1995 to 1997, averaging 2330 mT annually, before falling in 1998 to 215 mT and averaging 293 mT annually from 1998 to 2017. The non-pollock trawl sector shows the steepest declines in discard biomass and rates. Discards in this sector peaked at 32500mT in 1996 (21% discard rate), and annual discard biomass and rates averaged 15300 mT and 1% from 1997 to 2007 and 4500 mT and 4% from 2008 to 2017. The 2016 and 2017 discard biomass (2220 mT, 2335 mT) and discard rates (2 for both years) reflect the lowest levels over the entire 1993-2017 period. To date in 2018, discard levels across all sectors appear to be consistent with levels during the previous 5-year period.

Factors influencing observed trends: Discards of groundfish may occur for economic or regulatory reasons. Economic discards include discards of lower value and unmarketable fish in order to maximize harvest or production value. Regulatory discards are those required by regulation, such as discards of species where harvest has reached the allowable catch limit and which may no longer be retained. Mechanisms used in North Pacific groundfish fisheries for reducing discards include:

- Limited access privilege programs (LAPPs), which allocate catch quotas and may reduce economic discards by removing the race for fish
- In-season closure of fisheries once target or bycatch species quotas are reached
- Minimum retention and utilization standards for certain fisheries
- Maximum retainable amounts (MRAs) specifying the amounts of non-target species that harvesters may retain relative to other groundfish species that remain open to directed fishing. MRAs reduce regulatory discards by allowing for limited retention of species harvested incidentally in directed fisheries.

In the Aleutian Islands fixed gear (hook-and-line and pot) sector, discards of flatfish accounted for the majority of discards by weight through the 1990s. Catch and discards of flatfish in the longline sablefish

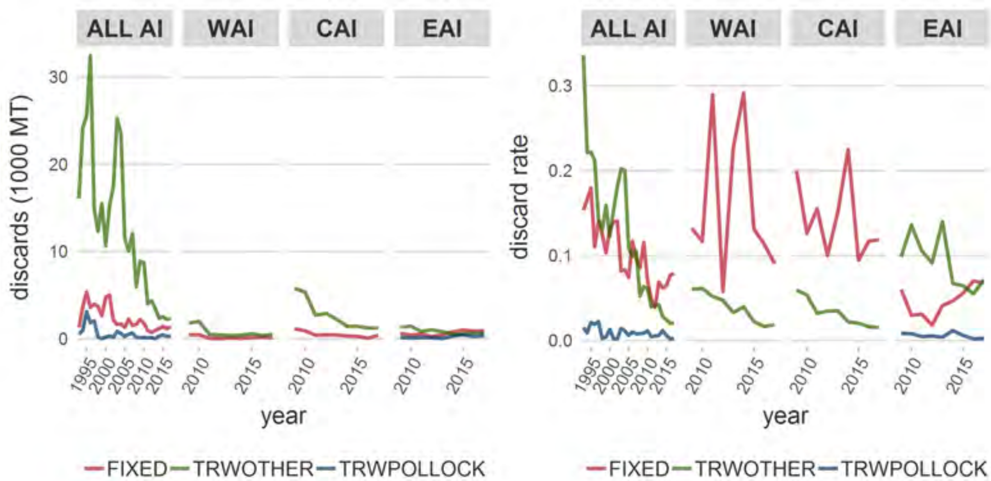

Figure 36: Total biomass and percent of total catch biomass of FMP groundfish discarded in the fixed gear, pollock trawl, and non-pollock trawl sectors, 1993–2017, for the AI and central, eastern, and western AI subregions (data by subregion available only for 2009 and forward). Discard rates are calculated as total discard weight of FMP groundfish divided by total retained and discarded weight of FMP groundfish for the sector (includes only catch counted against federal TACs).

fishery peaked in 1994 and generally declined following implementation of the Pacific Halibut and Sablefish Individual Fishing Quota (IFQ) program in 1995, possibly as a result of the slower pace of the fishery under the program. In the longline cod fishery, flatfish catch and discards grew steadily from 1993, peaking in 2001 at 3250 mT of discards. Since 2002, total discard biomass of flatfish in the fixed gear sector has remained comparatively low due both to reductions in flatfish discard rates and generally lower catch levels across all managed groundfish in the AI longline cod fishery. Discards of species historically managed together as the other groundfish assemblage (skate, sculpin, shark, squid, and octopus) are tracked in the catch accounting data going back to 2003 and have accounted for the largest share of discards in this sector since then. Discard rates for sculpin are typically 100%; there has been limited retention of skate and octopus due to the existence of markets for these species.

Full retention requirements for pollock and Pacific cod were implemented in 1998 for federally-permitted vessels fishing for groundfish, leading to declines in discards of these species across all sectors in the Aleutian Islands. The trawl pollock fishery was closed between 1998 and 2004 for Steller Sea lion recovery and has had minimal to no participants since reopening in 2005.

In the non-pollock trawl sector, Atka mackerel and rockfish have historically accounted for the largest amounts of catch and discards by weight. Amendments 79 and 80 to the BSAI Groundfish FMP established a Groundfish Retention Standard Program and a cooperative-based limited access privilege program (LAPP) for the non-AFA BSAI trawl catcher processor fleet, which targets Atka mackerel and Pacific ocean perch in the Aleutian Islands. Both amendments were intended in part to address the high rates of discard in this fleet. Across the entire non-pollock trawl sector, discard rates for rockfish and flatfish in particular have seen a marked decline since the associated measures went into effect in 2008. Discard rates in this sector for groundfish species groups other than those in the other groundfish assemblage have been at or below 10% for the last several years.

Implications: Minimizing fishery discards is recognized as an ecological, economic, and moral imperative in various multilateral initiatives and in National Standard 9 of the Magnuson-Stevens Fishery Conservation and Management Act (Alverson et al. 1994, FAO 1995, NMFS 2011). Fishery bycatch adds to the total human impact on biomass without providing a benefit to the Nation and as such are seen as "contrary to responsible stewardship and sustainable utilization of marine resources" (Kelleher 2005). Bycatch may constrain the

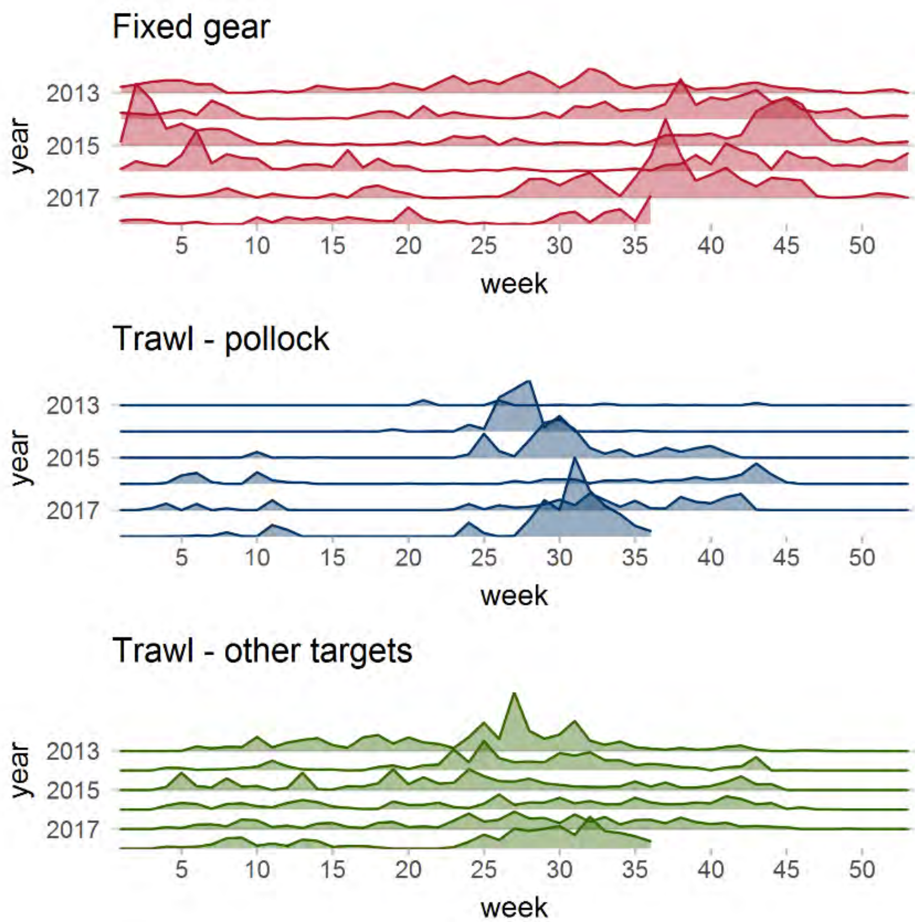

Figure 37: Total biomass of FMP groundfish discarded in the AI by sector and week of the fishing season, 2013–2018 (data for 2018 is shown through week 36). Plotted heights are not comparable across fisheries.

utilization of target species and increases the uncertainty around total fishing-related mortality, making it more difficult to assess stocks, define overfishing levels, and monitor fisheries for overfishing (Alverson et al. 1994, NMFS 2011, Clucas 1997). Although ecosystem effects of discards are not fully understood, discards of whole fish and offal have the potential to alter energy flow within ecosystems and have been observed to result in changes to habitat (e.g., oxygen depletion in the benthic environment) and community structure (e.g., increases in scavenger populations) (Queirolo et al. 1995; Alverson et al. 1994; Catchpole, Frid, and Gray 2006; Zador and Fitzgerald 2008). Monitoring discards and discard rates provides a means of assessing the efficacy of measures intended to reduce discards and increase groundfish retention and utilization.

Time Trends in Non-Target Species Catch

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Last updated: August 2018

Description of indicator: We monitor the catch of non-target species in groundfish fisheries in the Aleutian Islands (AI) ecosystem. The catch could not be summarized at the ecoregion level due to confidentiality issues and is instead presented at the LME level (i.e., AI). In previous years we included the catch of "other" species, "non-specified" species, and forage fish in this contribution. However, stock assessments have now been developed or are under development for all groups in the "other species" category (sculpins, unidentified sharks, salmon sharks, dogfish, sleeper sharks, skates, octopus, squid), some of the species in the "non-specified" group (giant grenadier, other grenadiers), and forage fish (e.g., capelin, eulachon, Pacific sand lance, etc.), therefore we no longer include trends for these species/groups here (see AFSC stock assessment website at `http://www.afsc.noaa.gov/refm/stocks/assessments.htm`). Invertebrate species associated with habitat areas of particular concern, previously known as HAPC biota (seapens/whips, sponges, anemones, corals, and tunicates) are now referred to as structural epifauna. Starting with the 2013 Ecosystem Considerations Report, the three categories of non-target species we continue to track here are:

1. Scyphozoan jellyfish
2. Structural epifauna (seapens/whips, sponges, anemones, corals, tunicates)
3. Assorted invertebrates (bivalves, brittle stars, hermit crabs, miscellaneous crabs, sea stars, marine worms, snails, sea urchins, sand dollars, sea cucumbers, and other miscellaneous invertebrates).

Total catch of non-target species is estimated from observer species composition samples taken at sea during fishing operations, scaled up to reflect the total catch by both observed and unobserved hauls and vessels operating in all FMP areas. Catch since 2003 has been estimated using the Alaska Region's Catch Accounting System. This sampling and estimation process does result in uncertainty in catches, which is greater when observer coverage is lower and for species encountered rarely in the catch.

Status and trends: The catch of Scyphozoan jellyfish in the AI gradually decreased from 2011–2015, then increased in 2016 and increased again to a peak value in 2017 (Figure 38). Scyphozoan jellyfish are primarily caught in the pollock fishery. The catch of structural epifauna in the AI has been variable from 2011–2017, with a peak catch in 2015. The catch of structural epifauna in 2016 was half of the catch in 2015. The catch of structural epifauna in 2017 is the third highest over this time period. Sponge comprise the majority of the structural epifauna catch, followed by corals and bryozoans. These species are primarily caught in the Atka mackerel and rockfish fisheries. The catch of assorted invertebrates in the AI increased from 2011 to 2013 then dropped sharply in 2014. The catch has remained relatively constant from 2015 to 2017. Sea stars dominate the assorted invertebrate catch in each year. Sea stars are caught primarily in the Pacific cod and halibut fisheries.

Factors influencing observed trends: The catch of non-target species may change if fisheries change, if ecosystems change, or both. Because non-target species catch is unregulated and unintended, if there have been no large-scale changes in fishery management in a particular ecosystem, then large-scale signals in the non-target catch may indicate ecosystem changes. Alternatively, changes in allowable catch for target species, external market forces, fishing effort, or fishing gear restrictions can affect the catch of non-target species.

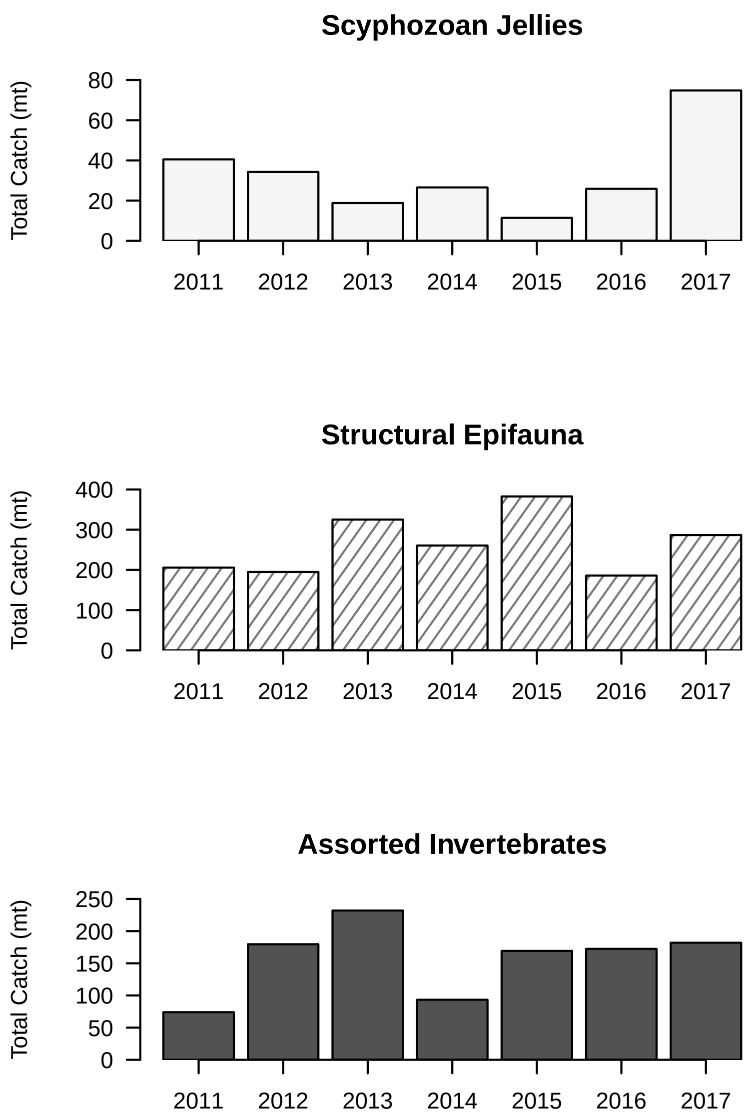

Figure 38: Total catch of non-target species (tons) in AI groundfish fisheries (2011–2017). Please note the different y-axis scales between regions and species groups.

Catch trends may be driven by changes in biomass or changes in distribution (overlap with the fishery) or both. Fluctuations in the abundance of jellyfish in the EBS are influenced by a suite of biophysical factors affecting the survival, reproduction, and growth of jellies including temperature, sea ice phenology, wind-mixing, ocean currents, and prey abundance (Purcell, 2005; Brodeur et al., 2008).

Implications: The catch of structural epifauna species and assorted invertebrates is very low compared with the catch of target species. The recent increase in the catch of scyphozoan jellies may reflect interannual variation in jellyfish biomass or changes in the overlap with fisheries. Abundant jellyfish may have a negative impact on fishes as they compete with planktivorous fishes for prey resources (Purcell and Sturdevant, 2001), and additionally, jellyfish may prey upon the early life history stages (eggs and larvae) of fishes (Purcell and Arai, 2001; Robinson et al., 2014).

Seabird Bycatch Estimates for Groundfish Fisheries in the Aleutian Islands, 2007-2017

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Last updated: August 2018

Description of indicator: This report provides estimates of the numbers of seabirds caught as bycatch in commercial groundfish fisheries operating in federal waters of the U.S. Exclusive Economic Zone surrounding the Aleutian Islands for the years 2007 through 2017. Estimates of seabird bycatch from earlier years using different methods are not included here. Fishing gear types represented are demersal longline, pot, pelagic trawl, and non-pelagic trawl. These numbers do not apply to gillnet, seine, or troll fisheries. Data collection on the Pacific halibut longline fishery began in 2013 with the restructured observer program, although some small amounts of halibut fishery information were collected in previous years when an operator had both halibut and sablefish individual fishing quota (those previous years of halibut data, from 2007–2012, are not included in the data presented in this report).

Estimates are based on two sources of information, (1) data provided by NMFS-certified fishery observers deployed to vessels and floating or shoreside processing plants (AFSC, 2011), and (2) industry reports of catch and production. The NMFS Alaska Regional Office Catch Accounting System (CAS) produces the estimates (Cahalan et al., 2014, 2010). The main purpose of the CAS is to provide near real-time delivery of accurate groundfish and prohibited species catch and bycatch information for inseason management decisions. It is also used for the provision of estimates of non-target species (such as invertebrates) and seabird bycatch in the groundfish fisheries. The CAS produces estimates based on these two current data sets, which may change over time. Changes in the data from one reporting year to another are due to errors that were discovered through additional data quality checks, use of data for analysis, or issues with the data that come to light. Examples of the possible changes in the underlying data include: changes in species identification; deletion of data sets where data collection protocols were not properly followed; and changes in the landing or at-sea production reports where data entry errors were found.

Status and trends: The numbers of seabirds estimated to be caught incidentally in the Aleutian Islands fisheries in 2017 increased from that in 2016, and exceeded the 2007–2016 average of 475 by 174% (Table 3; Figure 39). Notably, 2017 experienced the highest number of birds estimated to be caught incidentally in the Aleutian Islands fisheries in this time series, 2007–2017. This increase was largely due to an increase in shearwater bycatch. In 2017, the number of shearwaters increased by 721% compared to that of the 2007–2016 average of 129 and by 474% compared to 2016. Besides shearwaters, northern fulmars were the most common species group caught incidentally. No short-tailed albatross or black-footed albatross were caught, and a relatively low number of Laysan albatross were caught incidentally. The estimated numbers of birds caught incidentally in the Aleutian Islands was less than that in the Gulf of Alaska and Bering Sea, as has been the case in all years in this time series, with the exception of two years where Gulf of Alaska bycatch totals were lower (2010 and 2015; Figure 39). Although the number of albatross caught incidentally is highest in the Gulf of Alaska, the number of albatross caught in the Aleutian Islands is greater than that in the eastern Bering Sea, as has been the case in all but three years in this time series (2007, 2011, and 2017; Figure 40).

Factors influencing observed trends: There are many factors that may influence annual variation in bycatch rates, including seabird distribution, population trends, prey supply, and fisheries activities. For example, a marked decline in overall numbers of birds caught after 2002 reflected the increased use of seabird mitigation devices. A large portion of the freezer longline fleet adopted these measures in 2002, followed by regulation requiring them for the rest of the fleet beginning in February 2004. Since 2002, seabird bycatch estimates have varied annually but have not returned to the level seen prior to the use of seabird mitigation

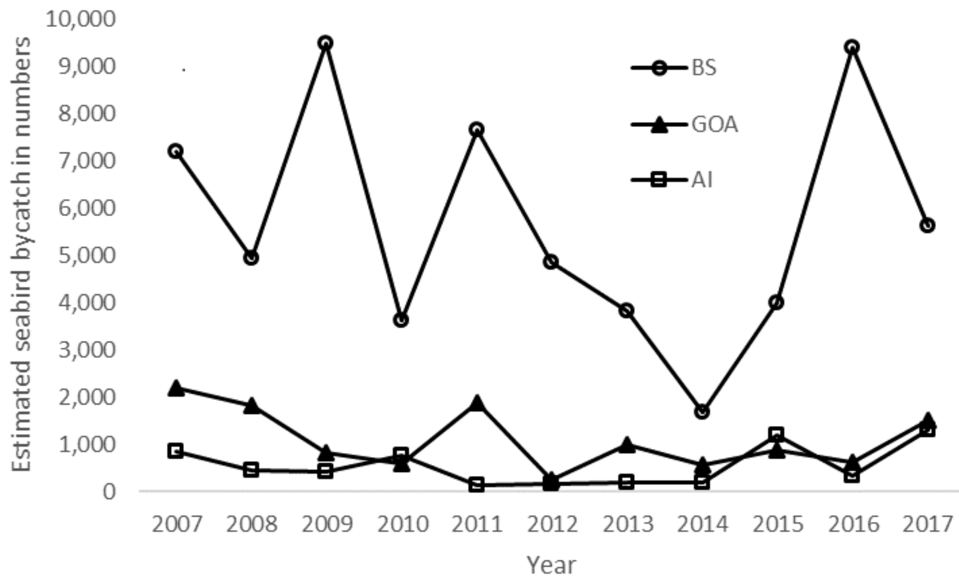

Figure 39: Total estimated seabird bycatch in eastern Bering Sea (EBS), Aleutian Islands (AI), and Gulf of Alaska (GOA) groundfish fisheries, all gear types combined, 2007 to 2017.

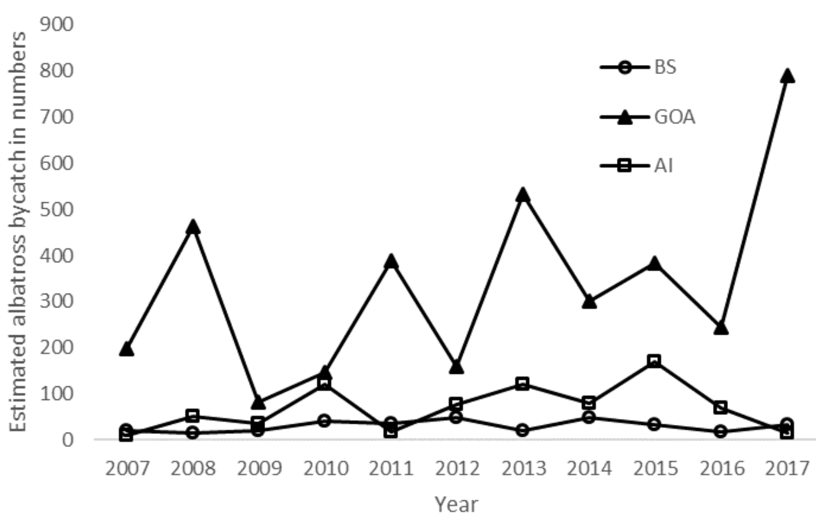

Figure 40: Total estimated albatross bycatch in eastern Bering Sea (EBS), Aleutian Islands (AI), and Gulf of Alaska (GOA) groundfish fisheries, all gear types combined, 2007 to 2017.

devices. Since 2004, work has continued on developing new and refining existing mitigation gear (Dietrich and Melvin, 2008).

The longline fleet has traditionally been responsible for about 90% of the overall seabird bycatch in Alaska, as determined from the data sources noted above. However, standard observer sampling methods on trawl vessels do not account for additional mortalities from net entanglements, cable strikes, and other sources. Thus, the trawl estimates may be downward biased. For example, the 2010 estimate of trawl-related seabird mortality is 823, while the additional observed mortalities (not included in this estimate and not expanded to the fleet) were 112 (S. Fitzgerald, pers. comm.). Observers now record the additional mortalities they see on trawl vessels and the AFSC Seabird Program has contracted an analyst to work on how these additional numbers can be folded into an overall estimate. The challenge to further reduce seabird bycatch is great

Table 3: Estimated seabird bycatch in the Aleutian Islands groundfish fisheries for all gear types, 2007 through 2017. Note that these numbers represent extrapolations from observed bycatch, not direct observations. See text for estimation methods.

Species Group	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Unidentified Albatrosses	0	0	0	0	0	0	0	22	0	0	0
Short-tailed Albatross	0	0	0	0	0	0	0	0	0	0	0
Laysan Albatross	11	51	35	122	12	76	108	50	150	69	14
Black-footed Albatross	0	0	0	0	5	0	12	7	19	0	0
Northern Fulmar	77	308	306	368	50	15	34	56	974	72	221
Shearwaters	734	39	49	88	42	60	0	68	23	184	1,056
Storm Petrels	0	44	0	0	0	0	0	0	0	0	0
Gulls	38	19	36	175	22	12	23	0	37	4	0
Kittiwakes	0	0	0	0	0	0	0	0	0	0	0
Murres	0	0	0	0	0	0	0	0	0	0	0
Puffins	0	0	0	0	0	0	0	0	0	0	0
Auklets	0	0	0	0	0	0	0	2	0	0	2
Other Birds	0	0	0	0	0	0	0	0	0	0	0
Unidentified Birds	5	1	7	17	0	3	8	0	0	0	10
Grand Total	865	462	433	770	131	166	185	205	1,203	329	1,303

given the rare nature of the event. For example, (Dietrich and Fitzgerald, 2010) found in an analysis of 35,270 longline sets from 2004 to 2007 that the most predominant species, northern fulmar, only occurred in 2.5% of all sets. Albatross, a focal species for conservation efforts, occurred in less than 0.1% of sets. However, given the vast size of the fishery, the total estimated bycatch can add up to hundreds of albatross or thousands of fulmars (Eich et al., 2017).

Implications: The increase in the number of estimated seabirds caught incidentally in the Aleutian Islands in 2017 relative to the year before was primarily due to a dramatic increase in shearwater bycatch. Estimated seabird bycatch also increased from 2016 to 2017 in the Gulf of Alaska, but that was primarily attributed to increased numbers of black-footed albatross and northern fulmar. Estimated seabird bycatch decreased from 2016 to 2017 in the eastern Bering Sea, but 2016 had an unusually large number of shearwaters caught incidentally; the 2017 seabird bycatch estimates were closer to what is normally seen in that region. These differences indicate localized changes in the three different regions regarding seabird distribution, fishing effort, and/or seabird prey supply, all of which could impact bycatch.

The effects of the "Warm Blob", that resulted in an extreme marine heat wave from 2014–2016, appeared to be moderating and dissipating in 2017 (Zador and Yasumiishi, 2017). The warm temperatures caused variability in prey availability for seabirds. Over the last few years, seabird die-offs appear to have increased, presumably linked to the extreme marine heat wave from 2014–2016. Numerous seabirds have been reported dead, in poor body condition, or in reproductive failure (Zador and Yasumiishi, 2017; Siddon et al., 2017; K. Kuletz, pers comm.). These seabirds include northern fulmars, murres, storm petrels, short-tailed shearwaters, black-legged kittiwakes, auklets, gulls, and horned puffins. Examined birds ultimately died of starvation or drowning, but underlying factors contributing to the die-off have yet to be determined (K. Kuletz, pers comm.).

It is difficult to determine how seabird bycatch numbers and trends are linked to changes in ecosystem components because seabird mitigation gear is used in the longline fleet. There does appear to be a link between poor ocean conditions and the peak bycatch years, on a species-group basis. Fishermen have noted in some years that the birds appear starved and attack baited longline gear more aggressively. From year to year, broad changes in total seabird bycatch for all regions combined, up to 5,746 birds per year, occurred

between 2007 and 2017. This probably indicates changes in food availability rather than distinct changes in how well the fleet employs mitigation gear. A focused investigation of this aspect of seabird bycatch is needed and could inform management of poor ocean conditions if seabird bycatch rates (reported in real time) were substantially higher than normal.

Maintaining and Restoring Fish Habitats

Areas Closed to Bottom Trawling in the BSAI and GOA

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Last updated: October 2018

Description of indicator: Many trawl closures have been implemented to protect benthic habitat or reduce bycatch of prohibited species (i.e., salmon, crab, herring, and halibut) (Figure 41, Table 4). Some of the trawl closures are in effect year-round while others are seasonal. In general, year-round trawl closures have been implemented to protect vulnerable benthic habitat. Seasonal closures are used to reduce bycatch by closing areas where and when bycatch rates had historically been high.

Status and trends: Additional measures to protect the declining western stocks of the Steller sea lion began in 1991 with some simple restrictions based on rookery and haulout locations; in 2000 and 2001 more specific fishery restrictions were implemented. In 2001, over 90,000 nm^2 of the Exclusive Economic Zone (EEZ) of Alaska was closed to trawling year-round. Additionally, 40,000 nm^2 were closed on a seasonal basis. State waters (0-3 nmi) are also closed to bottom trawling in most areas. A motion passed the North Pacific Management Council in February 2009 which closed all waters north of the Bering Strait to commercial fishing as part of the development of an Arctic Fishery management plan. This additional closure adds 148,300 nm^2 to the area closed to bottom trawling year round.

In 2010, the Council adopted area closures for Tanner crab east and northeast Kodiak Island. Federal waters in Marmot Bay are closed year round to vessels fishing with nonpelagic trawl gear. In two other designated areas, Chiniak Gully and ADF&G statistical area 525702, vessels with nonpelagic trawl gear can only fish if they have 100% observer coverage. To fish in any of the three areas, vessels fishing with pot gear must have minimum 30% observer coverage.

Implications: With the Arctic FMP closure included, almost 65% of the U.S. EEZ of Alaska is closed to bottom trawling. For additional background on fishery closures in the U.S. EEZ off Alaska, see Witherell and Woodby (2005).

Steller Sea Lion closure maps are available here:

`http://www.fakr.noaa.gov/sustainablefisheries/sslpm/atka_pollock.pdf`

`http://www.fakr.noaa.gov/sustainablefisheries/sslpm/pcod_nontrawl.pdf`

`http://www.fakr.noaa.gov/sustainablefisheries/sslpm/cod_trawl.pdf`

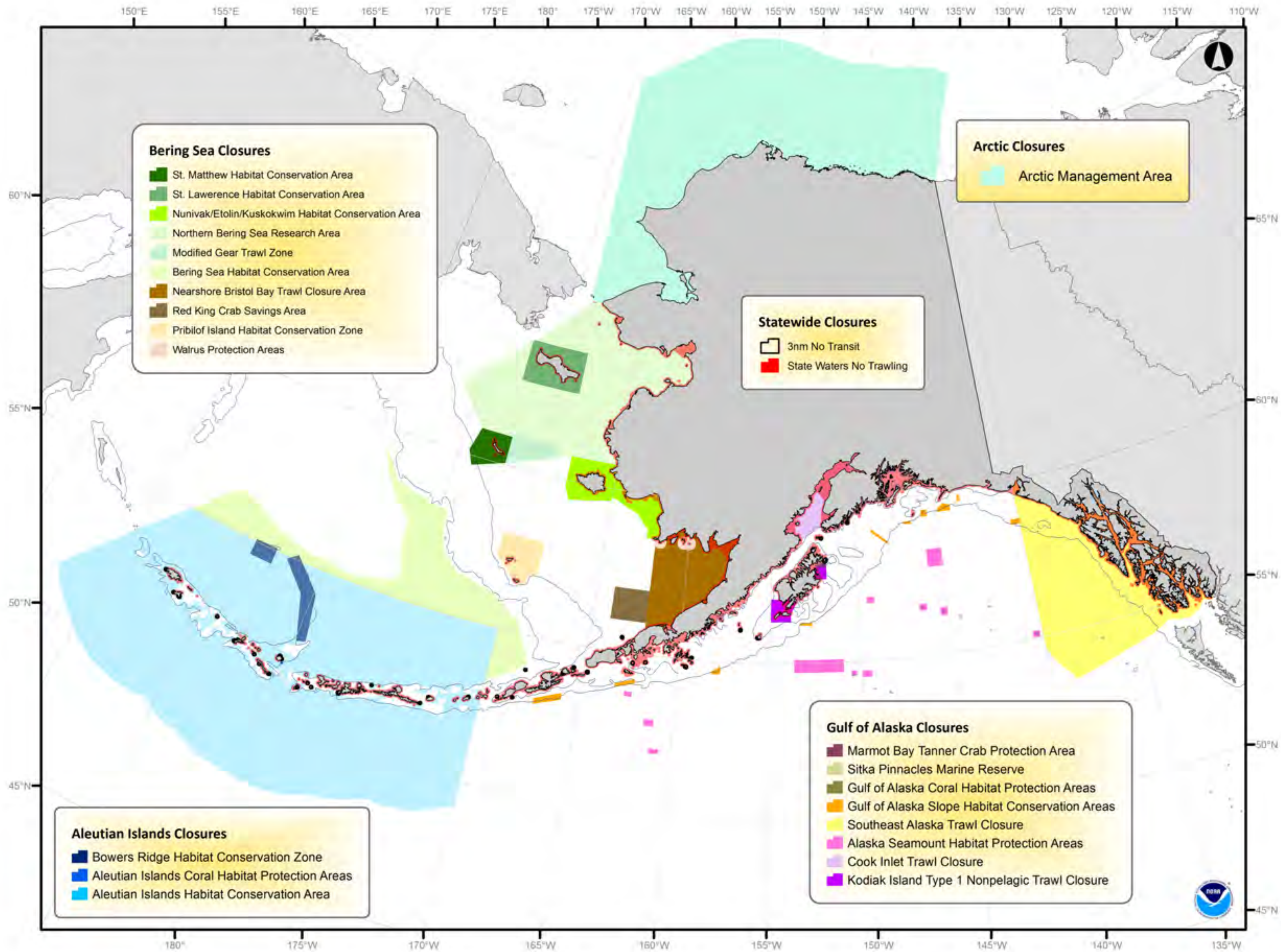

Figure 41: Year-round groundfish closures in the U.S. Exclusive Economic Zone (EEZ) off Alaska, excluding most SSL closures.

Area Disturbed by Trawl Fishing Gear in Alaska

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Last updated: October 2018

Description of indicator: Fishing gear can impact habitat used by a fish species for the processes of spawning, breeding, feeding, or growth to maturity. This indicator uses output from the Fishing Effects (FE) model to estimate the area of geological and biological features disturbed across Alaska's Large Marine Ecosystems, utilizing spatially-explicit VMS data. The time series for this indicator is available since 2003, when widespread VMS data became available.

Status and trends: The percent of area disturbed due to commercial fishing interactions (pelagic and non-pelagic trawl, longline, and pot) decreased steadily from 2008 to the present in the Bering Sea, with slightly decreasing or steady trends in the Gulf of Alaska and Aleutian Islands (Figures 42 and 43).

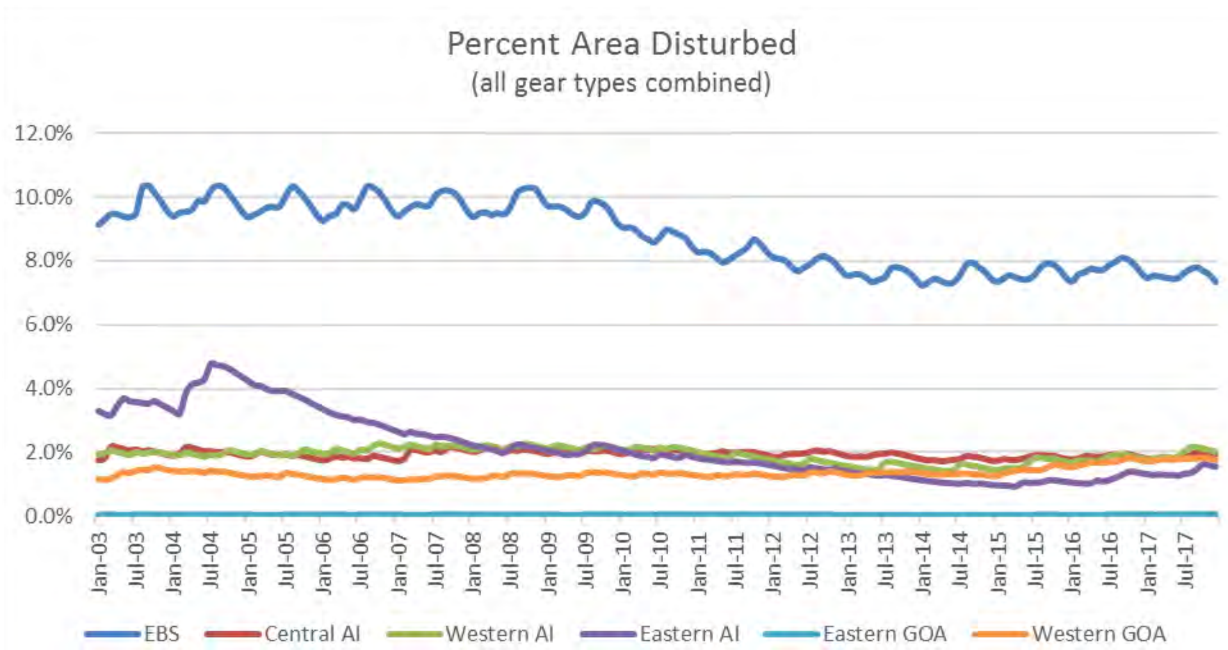

Figure 42: Percent habitat reduction, all gear types combined, from 2003 through 2017.

Factors influencing observed trends: Trends in seafloor area disturbed can be affected by numerous variables, such as fish abundance and distribution, management actions (e.g., closed areas), changes in the structure of the fisheries due to rationalization, increased technology (e.g., increased ability to find fish), markets for fish products, and changes in vessel horsepower and fishing gear. Intensive fishing in an area can result in a change in species diversity by attracting opportunistic fish species which feed on animals that have been disturbed by fishing activity, or by reducing the suitability of habitat used by some species. It is possible that increased effort in fisheries that interact with both living and non-living bottom substrates could result in increased

habitat loss/degradation due to fishing gear effects. The footprint of habitat damage varies with gear (type, weight, towing speed, depth of penetration), the physical and biological characteristics of the areas fished, recovery rates of living substrates in the areas fished, and management changes that result in spatial redistribution of fishing effort.

Between 2003 and 2008, variability in area disturbed was driven largely by the seasonality of fishing in the Bering Sea. In 2008, Amendment 80 was implemented, which allocated BSAI Yellowfin sole, Flathead sole, Rock sole, Atka mackerel, and Aleutian Islands Pacific ocean perch to the head and gut trawl catcher processor sector, and allowed qualified vessels to form cooperatives. The formation of cooperatives reduced overall effort in the fleet while maintaining catch levels. In 2010, trawl sweep gear modifications were implemented on non-pelagic trawls in the Bering Sea, resulting in less gear contacting the seafloor and less habitat impact. Trawl sweep modifications were implemented in the Gulf of Alaska in 2014.

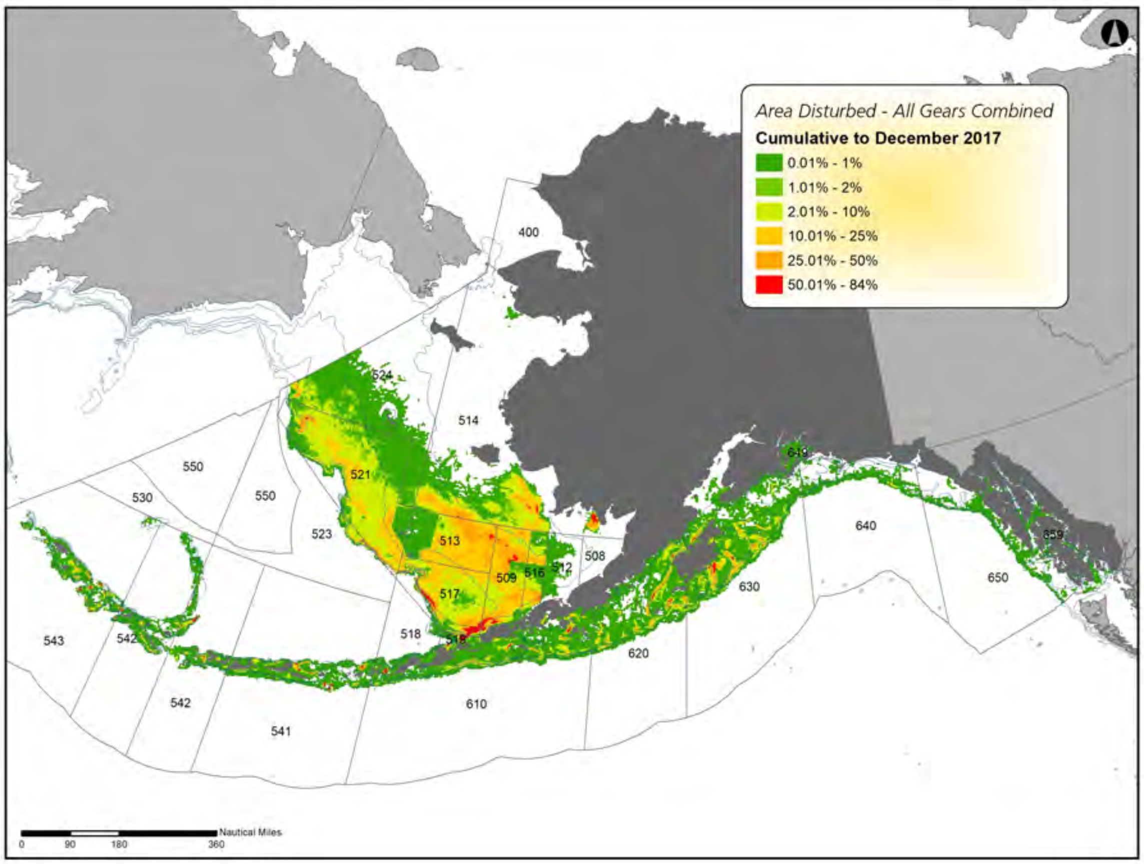

Figure 43: Map of percentage area disturbed per grid cell for all gear types. Effects are cumulative, and consider impacts and recovery of features from 2003 to 2017.

Implications: The effects of changes in fishing effort on habitat are largely unknown, although our ability to quantify those effects has increased greatly with the development of a Fishing Effects model as a part of the 2015 EFH Review (`ftp://ftp.library.noaa.gov/noaa_documents.lib/NMFS/TM_NMFS_AFKR/TM_NMFS_FAKR_15.pdf`). The 2005 EFH FEIS, 2010 EFH Review, and 2015

EFH Review concluded that fisheries do have long term effects on habitat, and these impacts were determined to be minimal and not detrimental to fish populations or their habitats. These previous EFH analyses indicated the need for improved fishing effects model parameters. With the FE model, our ability to analyze fishing effects on habitat has grown exponentially. Vessel Monitoring System data provides a much more detailed treatment of fishing intensity, allowing better assessments of the effects of overlapping effort and distribution of effort between and within grid cells. The development of literature-derived fishing effects database has increased our ability to estimate gear-specific susceptibility and recovery parameters. The distribution of habitat types, derived from increased sediment data availability, has improved. The combination of these parameters has greatly enhanced our ability to estimate fishing impacts.

New methods and criteria were developed to evaluate whether the effects of fishing on EFH are more than minimal and not temporary on managed fish stocks in Alaska. Criteria were developed by and reviewed by the Council and its advisory committees in 2016, and stock assessment authors in 2017. In April 2017, based on the analysis with the FE model, the Council concurred with the Plan Team consensus that the effects of fishing on EFH do not currently meet the threshold of more than minimal and not temporary, and mitigation action is not needed at this time.

Although the impacts of fishing across the domain are very low, it is possible that localized impacts may be occurring. The issue of local impacts is an area of active research.

Table 4: Time series of groundfish trawl closure areas in the BSAI and GOA, 1995-2017. LLP= License Limitation Program; HCA = Habitat Conservation Area; HCZ = Habitat Conservation Zone.

Area	Year	Location	Season	Area size	Notes
BSAI	1995	Area 512	year-round	8,000 nm^2	closure in place since 1987
		Area 516	3/15-6/15	4,000 nm^2	closure in place since 1987
		Chum Salmon Savings Area	8/1-8/31	5,000 nm^2	re-closed at 42,000 chum salmon
		Chinook Salmon Savings Area	trigger	9,000 nm^2	closed at 48,000 Chinook salmon
		Herring Savings Area	trigger	30,000 nm^2	trigger closure
		Zone 1	trigger	30,000 nm^2	trigger closure
		Zone 2	trigger	50,000 nm^2	trigger closure
		Pribilofs HCA	year-round	7,000 nm^2	
		Red King Crab Savings Area	year-round	4,000 nm^2	pelagic trawling allowed
		Walrus Islands	5/1-9/30	900 nm^2	12 mile no-fishing zones
		SSL Rookeries	seasonal ext.	5,100 nm^2	20 mile extensions at 8 rookeries
	1996	Nearshore Bristol Bay Trawl Closure	year-round	19,000 nm^2	expanded area 512 closure
		C. opilio bycatch limitation zone	trigger	90,000 nm^2	trigger closure
	2000	Steller Sea Lion protections			
		Pollock haulout trawl exclusion zones for EBS, AI * areas include GOA	* No trawl all year	11,900 nm^2	
			No trawl (Jan-June)*	14,800 nm^2	
			No Trawl Atka Mackerel restrictions	29,000 nm^2	
	2006	Essential Fish Habitat			
		AI Habitat Conservation Area	No bottom trawl all year	279,114 nm^2	
		AI Coral Habitat Protection Areas	No bottom contact gear all year	110 nm^2	
		Bowers Ridge Habitat Conservation Zone	No mobile bottom tending fishing gear	5,286 nm^2	
	2008	Northern Bering Sea Research Area	No bottom trawl all year	66,000 nm^2	
		Bering Sea HCA	No bottom trawl all year	47,100 nm^2	
		St. Matthews HCA	No bottom trawl all year	4,000 nm^2	
		St. Lawrence HCA	No bottom trawl all year	7,000 nm^2	
		Nunivak/Kuskokwim Closure Area	No bottom trawl all year	9,700 nm^2	
Arctic	2009	Arctic Closure Area	No Commercial Fishing	148,393 nm^2	
GOA	1995	Kodiak King Crab Protection Zone Type 1	year-round	1,000 nm^2	red king crab closures, 1987
		Kodiak King Crab Protection Zone Type 2	2/15-6/15	500 nm^2	red king crab closures, 1987
		SSL Rookeries	year-round	3,000 nm^2	10 mile no-trawl zones
	1998	Southeast Trawl Closure	year-round	52,600 nm^2	adopted as part of the LLP
		Sitka Pinnacles Marine reserve	year-round	3.1 nm^2	
	2000	Pollock haulout trawl exclusion zones for GOA* areas include EBS, AI	No trawl all year	11,900 nm^2*	
			No trawl (Jan-June)	14,800 nm^2	
	2006	Essential Fish Habitat			
		GOA Slope Habitat Conservation Area	No bottom trawl all year	2,100 nm^2	
		GOA Coral Habitat Protection Measures	No bottom tending gear all year	13.5 nm^2	
		Alaska Seamount Habitat Protection Measures	No bottom tending gear all year	5,329 nm^2	
	2010	Marmot Bay Tanner Crab Protection Area	No bottom trawl all year	112 nm^2	

Sustainability (for consumptive and non-consumptive uses)

Fish Stock Sustainability Index and Status of Groundfish, Crab, Salmon, and Scallop Stocks

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Last updated: July 2018

Description of indicator: The Fish Stock Sustainability Index (FSSI) is a performance measure for the sustainability of fish stocks selected for their importance to commercial and recreational fisheries (`http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries`). The FSSI will increase as overfishing is ended and stocks rebuild to the level that provides maximum sustainable yield. The FSSI is calculated by awarding points for each fish stock based on the following rules:

1. Stock has known status determinations:
   (a) overfishing level is defined = 0.5
   (b) overfished biomass level is defined = 0.5
2. Fishing mortality rate is below the "overfishing" level defined for the stock = 1.0
3. Biomass is above the "overfished" level defined for the stock = 1.0
4. Biomass is at or above 80% of the biomass that produces maximum sustainable yield (B_{MSY}) = 1.0 (this point is in addition to the point awarded for being above the "overfished" level)

The maximum score for each stock is 4.

In the Alaska Region, there are 36 FSSI stocks and an overall FSSI of 144 would be achieved if every stock scored the maximum value, 4. Over time, the number of stocks included in the FSSI has changed as stocks have been added and removed from Fishery Management Plans (FMPs). Prior to 2015 there were 35 FSSI stocks and maximum possible score of 140. To keep FSSI scores for Alaska comparable across years we report the FSSI as a percentage of the maximum possible score (i.e., 100%).

Additionally, there are 29 non-FSSI stocks, two ecosystem component species complexes, and Pacific halibut which are managed under an international agreement. None of the non-FSSI stocks are known to be subject to overfishing, be overfished, or to be approaching an overfished condition. For more information on non-FSSI stocks see the Status of U.S. Fisheries webpage.

Within the BSAI region there are 22 FSSI stocks. The assessment for sablefish is based on aggregated data from the GOA and BSAI regions. In FSSI contributions prior to 2017, the sablefish FSSI score was included among BSAI species. Starting with last year's contribution sablefish was removed from the BSAI FSSI contribution and placed in the GOA FSSI contribution (see the Gulf of Alaska Ecosystem Considerations Report). With few exceptions, groundfish species (or species

Table 5: Summary of status for the 22 FSSI stocks in the BSAI, updated through June 2018.

BSAI FSSI (22 stocks)	Yes	No	*Unknown*	*Undefined*	N/A
Overfishing	0	22	0	0	0
Overfished	1	21	0	0	0
Approaching Overfished Condition	0	21	0	0	1

complex) in the BSAI are managed as single stocks and not separately for the Bering Sea and Aleutian Islands. As such, the FSSI scores are reported for the BSAI as a whole. At this time it is not practical to report FSSI separately for the Bering Sea or Aleutian Islands.

Status and trends: As of June 30, 2018, no BSAI groundfish stock or stock complex is subjected to overfishing, is considered to be overfished, or to be approaching an overfished condition (Table 5). Among BSAI crab stocks, the Pribilof Islands blue king crab stock is considered to be overfished but is not subject to overfishing. This stock is in year 4 of a rebuilding plan.

The current overall Alaska FSSI is 135 out of a possible 144, or 93.75%, based on updates through June 2018 and is the highest score observed over the time period examined (Figure 44). FSSI increased 2.5 points from last year's score and is the net result of increased scores for two king crab stocks in the EBS and a lower score for snow crab in the EBS. The overall Alaska FSSI has generally trended upwards from 80% in 2006 to 93.75% in 2018.

The BSAI groundfish FSSI score is 56 out of a maximum possible 56, and BSAI king and tanner crabs are 28 out of a possible 32. The overall Bering Sea/Aleutian Islands score is 84 out of a maximum possible score of 88 (Table 6). Since 2006 the BSAI overall FSSI has increased from 74% up to 95.45% in 2018 (Figure 45).

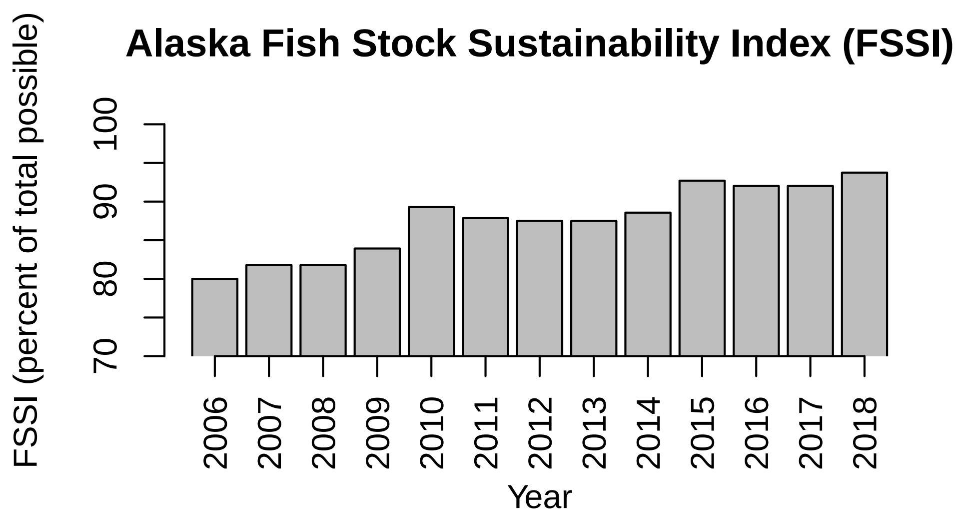

Figure 44: The trend in overall Alaska FSSI, as a percentage of the maximum possible FSSI from 2006 through 2018. The maximum possible FSSI is 140 for 2006 to 2014, and from 2015 on it is 144. All scores are reported through the second quarter (June) of each year, and are retrieved from the Status of U.S. Fisheries website: `http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries`.

Factors influencing observed trends: The overall trend in Alaska FSSI has been positive over the duration examined here (2006-2018). The increase in overall score in 2018 is the net result of increased scores for two king crab stocks in the EBS and a decreased score for EBS snow crab. All other FSSI scores for individual stocks of crabs and groundfish are unchanged. In the EBS, the Pribilofs Islands blue king crab stock gained a point by no longer being subject to overfishing. The primary driver of decline for this stock is thought to be changes in environmental conditions that negatively affect reproduction. Two and a half points were gained for the Aleutian Islands golden king crab stock by defining the overfished state (0.5), determining the stock biomass was above the overfished level (1.0), and by having biomass greater than 80% of B_{MSY} (1.0). A point was lost for the snow crab biomass falling below 80% of B_{MSY} (-1.0). The net result of these changes is an overall increase of 2.5 points from last year. The only other stock in the EBS with an FSSI less than 4 is Saint Matthews Island blue king crab which loses a point for having biomass less than 80% of B_{MSY}.

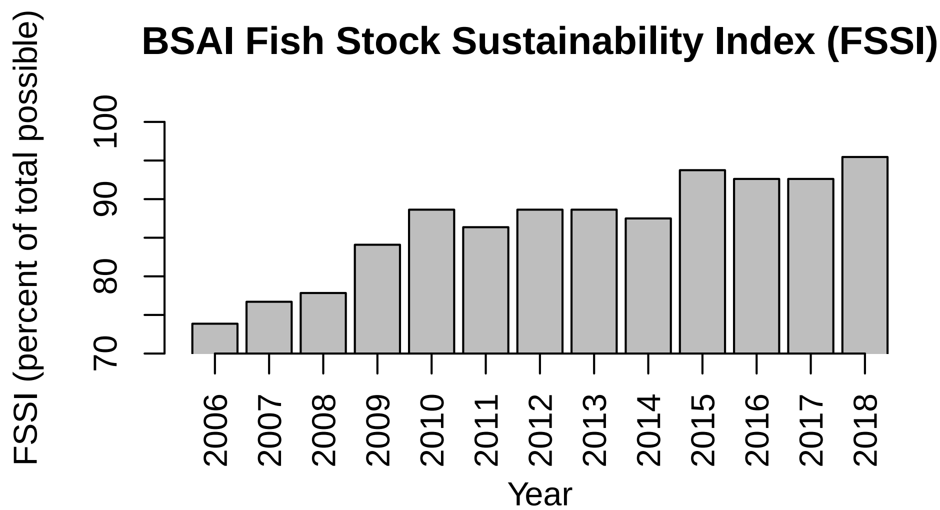

Figure 45: The trend in FSSI from 2006 through 2018 for the BSAI region as a percentage of the maximum possible FSSI. All scores are reported through the second quarter (June) of each year, and are retrieved from the Status of U.S. Fisheries website: `http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries`.

Implications: The majority of Alaska groundfish fisheries appear to be sustainably managed. No stocks in the BSAI are subject to overfishing and only a single crab stock is considered to be overfished (Pribilof Islands blue king crab). No other stocks or stock complexes in the BSAI are known to be approaching an overfished condition.

Table 6: BSAI FSSI stocks under NPFMC jurisdiction updated through June 2018 adapted from the Status of U.S. Fisheries website: http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries. See Box A for endnotes and definition of stocks and stock complexes.

Stock	Overfishing	Overfished	Approaching	Action	Progress	B/B_{MSY}	FSSI Score
Blue king crab - Pribilof Islands[a]	No	Yes	N/A	Continue rebuilding	Year 4 of plan	0.09	2
Blue king crab - Saint Matthews Island	No	No	No	N/A	N/A	0.57	3
Golden king crab - Aleutian Islands	No	No	No	N/A	N/A	1.18	4
Red king crab - Bristol Bay	No	No	No	N/A	N/A	0.93	4
Red king crab - Norton Sound	No	No	No	N/A	N/A	1.29	4
Red king crab - Pribilof Islands	No	No	No	N/A	N/A	1.64	4
Snow crab - Bering Sea	No	No	No	N/A	N/A	0.60	3
Southern Tanner crab - Bering Sea	No	No	No	N/A	N/A	2	4
BSAI Alaska plaice	No	No	No	N/A	N/A	2.03	4
BSAI Atka mackerel	No	No	No	N/A	N/A	1.41	4
BSAI Arrowtooth Flounder	No	No	No	N/A	N/A	2.67	4
BSAI Blackspotted and Rougheye Rockfish[b]	No	No	No	N/A	N/A	0.90	4
BSAI Flathead Sole Complex[c]	No	No	No	N/A	N/A	2.07	4
BSAI Rock Sole Complex[d]	No	No	No	N/A	N/A	1.66	4
BSAI Skate Complex[e]	No	No	No	N/A	N/A	1.99	4
BSAI Greenland halibut	No	No	No	N/A	N/A	1.15	4
BSAI Northern rockfish	No	No	No	N/A	N/A	1.92	4
BS Pacific cod	No	No	No	N/A	N/A	1.56	4
BSAI Pacific Ocean perch	No	No	No	N/A	N/A	1.72	4
Walleye pollock - Aleutian Islands	No	No	No	N/A	N/A	1.02	4
Walleye pollock - Eastern Bering Sea	No	No	No	N/A	N/A	1.88	4
BSAI Yellowfin sole	No	No	No	N/A	N/A	1.83	4

Box A. Endnotes and stock complex definitions for FSSI stocks listed in Table xx, adapted from the Status of U.S. Fisheries website: `http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries/`

(a) A new rebuilding plan for this stock was implemented January 1, 2015 but does not specify a target rebuilding date because it is not known when the stock is expected to rebuild. There is no directed fishing for the blue king crab-Pribilof Islands and the majority of blue king crab habitat is closed to bottom trawling, and beginning in 2015 there is a prohibition on directed cod pot fishing in the Pribilof Islands Habitat Conservation Zone (PIHCZ). For this stock to rebuild, the stock would likely require multiple years of above average recruitment and/or a change in environmental conditions to increase larval productivity around the Pribilof Islands.

(b) BSAI Blackspotted and Rougheye Rockfish consists of Blackspotted Rockfish and Rougheye Rockfish. An assessment of the combined species provides the overfished determination, and the OFL is based on the combined-species assessment.

(c) Flathead Sole Complex consists of Flathead Sole and Bering Flounder. Flathead Sole accounts for the overwhelming majority of the biomass and is regarded as the indicator species for the complex. The overfished determination is based on the combined abundance estimates for the two species; the overfishing determination is based on the OFL, which is computed from the combined abundance estimates for the two species.

(d) Rock Sole Complex consists of Northern Rock Sole and Southern Rock Sole (NOTE: These are two distinct species, not two separate stocks of the same species). Northern Rock Sole accounts for the overwhelming majority of the biomass and is regarded as the indicator species for the complex. The overfished determination is based on the combined abundance estimates for the two species; the overfishing determination is based on the OFL, which is computed from the combined abundance estimates for the two species.

(e) The Skate Complex consists of Alaska Skate, Aleutian Skate, Bering Skate, Big Skate, Butterfly Skate, Commander Skate, Deepsea Skate, Mud Skate, Okhotsk Skate, Roughshoulder Skate, Roughtail Skate, Whiteblotched Skate, and Whitebrow Skate. Alaska Skate is assessed and is the indicator species for this complex.

Seafood Production

Economic Indicators in the Aleutian Islands Ecosystem—Landings

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Last updated: September 2018

Description of indicator: Landings are a baseline metric for characterizing commercial economic production in the Aleutian Islands (AI). Landings are the retained catch of fish and are plotted here by functional group. While many species comprise a functional group, it is the handful of species that fishermen target that dominate the economic metrics in each group. The primary target species in the apex predators functional group is Pacific cod, though there are some landings of non-halibut flatfish such as arrowtooth flounder. The primary target species in the pelagic foragers functional group are Atka mackerel, Pacific ocean perch, and northern rockfish. Catch in the benthic foragers functional group is split between flatfish, such as rock sole and flathead sole, and benthic rockfish, such as thornyhead and shortraker. The primary species caught in the motile epifauna functional group is king crab. Landings are plotted in log scale because of significant differences in the relative scale of landings across functional group.

Status and trends: Landings in the AI are primarily from two functional groups: pelagic foragers and apex predators (Figure 46). Atka mackerel comprise roughly two thirds of the pelagic foragers. Atka mackerel landings have been fairly stable except for 2012–2015 when the Total Allowable Catch (TAC) was reduced to support populations of Steller sea lions. Pacific ocean perch, and northern rockfish make up most of the rest of the pelagic forager catch, and landings of these species have shown an increasing trend over time. Within the apex predator functional group, Pacific cod catch constitutes 70% of the total on average, but this share ranges for 50%–90% depending on both the volume of Pacific cod catch as well as the volume of flatfish catch. Pacific cod catches between 2011–2017 are roughly half the level that they were in 2003–2010. Catches of apex predator flatfish increased significantly in 2009–2014, in part as a result of diverted effort from reduced Atka mackerel fishing opportunities. Relative to the preceding three functional groups, benthic forager and motile epifauna are caught in significantly smaller quantities. Landings of both of these functional groups has remained fairly stable.

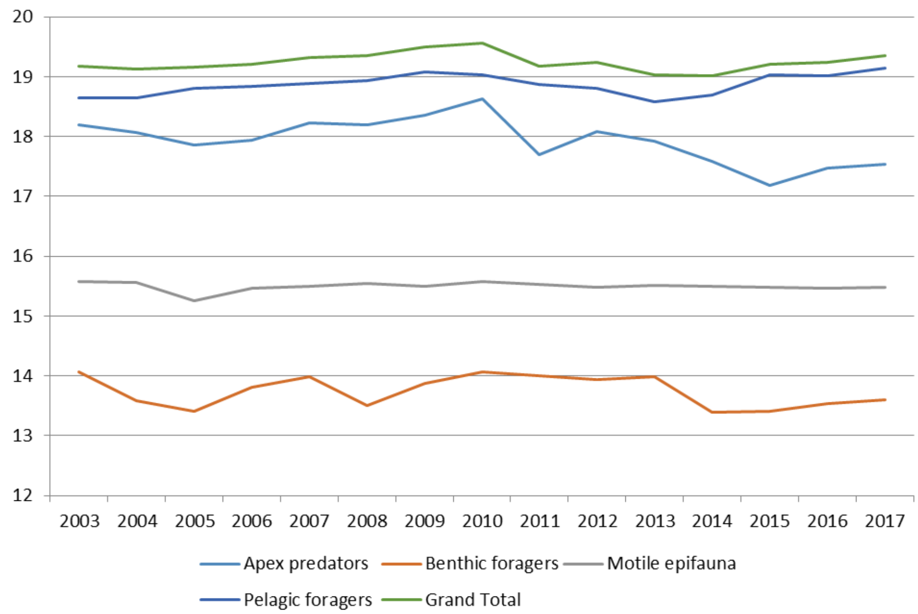

Figure 46: Aleutian Islands fishery landings by functional group (pounds in log scale).

Factors influencing observed trends: Pacific cod in the AI has been assessed separately from the eastern Bering Sea (BS) since 2013, which lowered the TAC from previous historical levels. Flatfish remain jointly assessed for the BS and the AI. The allocation between Pacific cod and flatfish comprise part of the pelagic forager, apex predators, and benthic foragers' functional groups in the BS/AI that are capped at 2 million metric tons. The sum of the Allowable Biological Catches (ABC) for the species in the functional groups are typically above the cap, and TACs are reduced from the ABC by the North Pacific Fishery Management Council to meet the cap requirement. This cap system influences interpretation of trends in landings relative to their underlying stocks as changes in landings may not be the direct result of changes in biomass; even when they are, the changes in biomass may reflect the dynamics of the Bering Sea more than those in the AI. In 2008 Amendment 80 to the BSAI groundfish FMP was implemented rationalizing the major flatfish fisheries which resulted in significant reductions in bycatch.

Implications: Landings depict one aspect of the raw stresses from harvesting imposed on the AI ecosystems functional group through fishing. This information can be useful in identifying areas where harvesting may be impacting different functional groups in times where the functional groups within the ecosystem might be constrained. In the AI ecosystem, pelagic foragers make up the largest share of the catch, followed closely by apex predators, with motile epifauna and benthic foragers constituting a much smaller amount of landings in the ecosystem. Monitoring the trends in landings stratified by ecosystem functional group provides insight on the fishing related stresses on ecosystems. The ultimate impact that these stresses have on the ecosystem cannot be discerned from these metrics alone and must be viewed within the context of what the ecosystem can provide.

Salmon and Halibut Subsistence Trends in the Aleutian Islands

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Last updated: August 2018

Description of indicator: Subsistence uses of wild resources are defined as "noncommercial, customary and traditional uses" for a variety purposes, including nutritional, trade, and cultural purposes (ADF&G 2018). Rural Alaskans harvest an average of 155 pounds of fish per person per year (Fall et al., 2017). Salmon and halibut were chosen as representative focal species for tracking subsistence trends. Harvest data were compiled from the Alaska Department of Fish and Game (ADF&G) Division of Subsistence for years 1990–2016 (ADF&G 2018). ADF&G reports that 1994 was the initial year data from all subsistence fisheries was available and comparable to current collections. Subsistence data is largely collected from household surveys in select communities. Halibut harvest for the Eastern Aleutians (EAI) is based on IPHC Area 4A and for the Central Aleutians (CAI) is based on IPHC Area 4B. Subsistence data is largely collected from household surveys in select communities. Only data for the EAI and CAI are presented here.

Status and trends: Although all five species of Pacific salmon are resident in the AI, targeted species and number harvested varies greatly among communities. ADF&G records report an increase in household permits in the EAI. When considered as a whole, salmon harvests appear to follow a cyclical pattern of increasing, followed by a few years of decreasing harvest (Figure 47). However, if sockeye salmon are removed from the analysis, there is a general pattern of declining harvests with the exception of 2015. The average harvest since 1990 is 5,973 salmon annually, with the most recent total salmon subsistence harvest in 2016 estimated at 6,430 fish. Of the total harvest, sockeye salmon has been removed at an increasingly greater percentage (from 50% to 86%) of the total salmon catch, with 2011 and 2016 being the highest years for sockeye. In contrast, Chinook salmon remains under 1% of total harvest, while coho salmon fluctuates from year to year. Chum salmon harvest has decreased slightly from 3.5% to under 1% in recent years. Pink salmon harvest has decreased consistently, but remained <1% of total catch. According to a random survey of Unalaska households in 2001, 4% of all salmon subsistence were removed from commercial catches, 62% were harvested with non-commercial nets, and 34% were taken with rod and reel (ADF&G 2018).

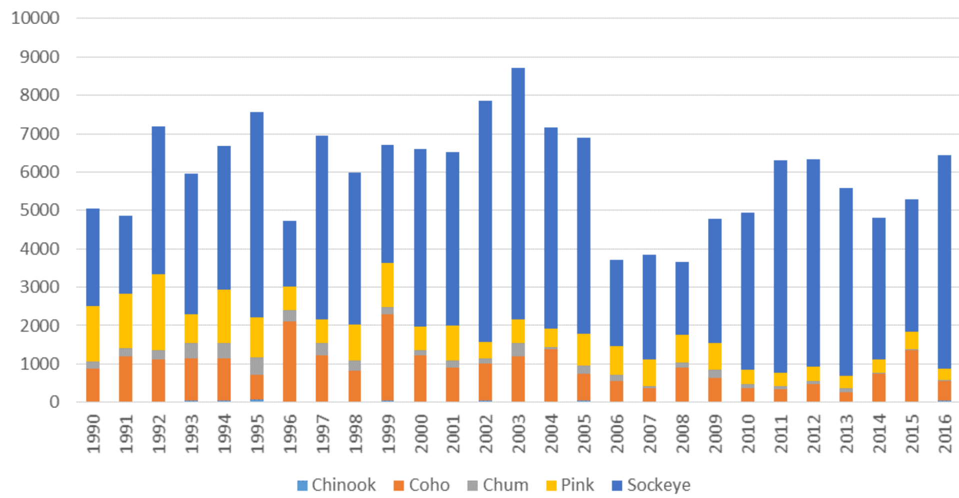

Figure 47: Subsistence salmon harvests between 1990–2016 in the Eastern Aleutians

ADF&G records report a decrease in salmon permits in the CAI. In 2016 only one (1) individual held a subsistence salmon permit compared to 61 in 1990. In the CAI, sockeye salmon is harvested almost exclusively, and harvest rates are largely variable (Figure 48). The historical average since 1990 is 241 salmon, with the most recent total salmon subsistence harvest in 2016 estimated at 0 fish. There are no data for 1994.

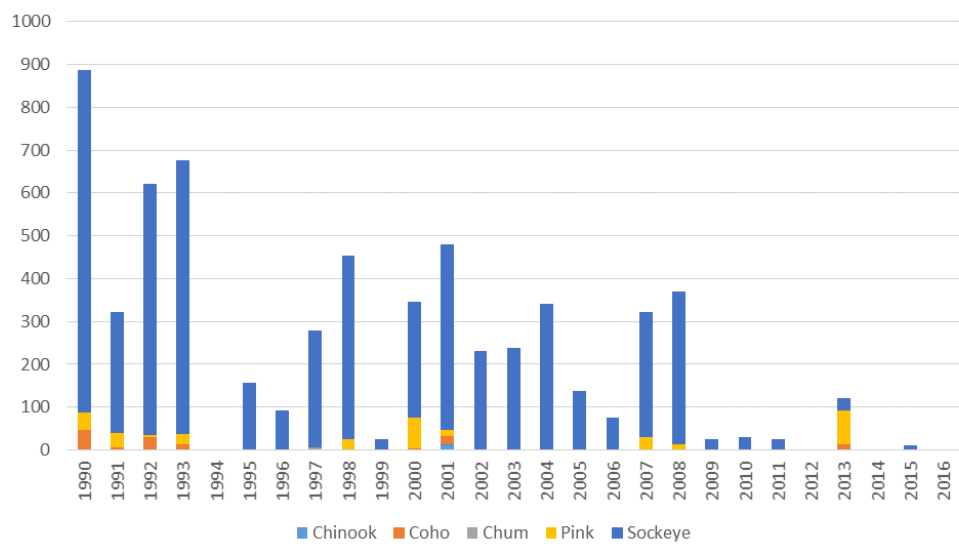

Figure 48: Subsistence salmon harvests between 1990–2016 in the Central Aleutians.

Based on ADF&G data, statewide subsistence halibut harvest (in pounds) declined substantially between 2004 and 2012, with a slight uptick in 2014–2016. There were approximately 8,847 subsistence permits issued in the whole of Alaska, harvesting an estimated 36,467 halibut in 2016. The International Pacific Halibut Commission (IPHC) reduced the suggested coastwide catch for 2018 at 28.03 million pounds. Subsistence halibut harvests represent less than two million pounds, with most coming from British Columbia and the eastern Gulf of Alaska. In 2016 the total halibut

harvest in the EAI represented 1% of that in Alaska, following the same decreasing trend from 2004–2016 as that observed statewide (Figure 49). The number of Subsistence Halibut Registration Certificate (SHARC) permits issued has stayed relatively stable. No subsistence harvest of halibut was reported in the CAI in 2016. The amount of halibut subsistence harvest substantially declined from 2004–2014, with the exception of 2008 (Figure 50). The number of SHARC permits issued has declined from 19 in 2003 to 3 in 2016.

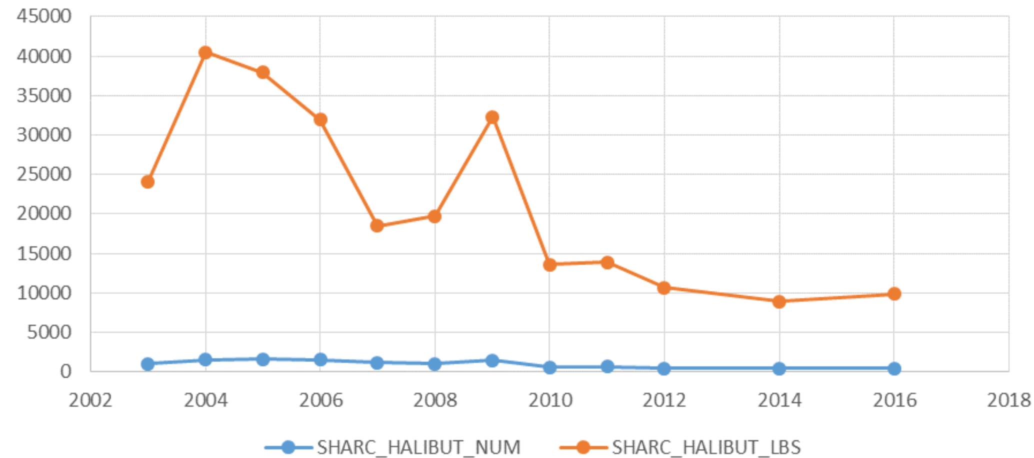

Figure 49: Estimated Subsistence harvest of halibut in the Eastern Aleutians ecoregion, 2003–2012, 2014, and 2016 (lbs. net weight).

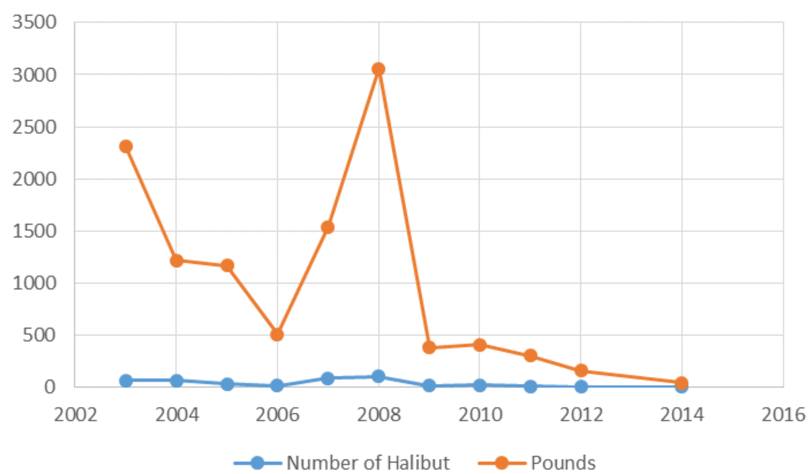

Figure 50: Estimated Subsistence harvest of halibut in the Central Aleutians ecoregion, 2003–2012, 2014, and 2016 (lbs. net weight).

Factors influencing observed trends: Salmon harvests are closely monitored and documented regularly. In the EAI the species composition of total salmon harvest has shifted toward more sockeye salmon. Interviews suggest a general preference for sockeye, which may contribute to the increasing trend, as could the decrease in availability of other species. In the CAI, decreases in salmon harvest may suggest a decrease in availability of targeted species, a reduction in reliance on subsistence fisheries, or reflect a decreasing number of subsistence harvesters.

The reasons for the decline in subsistence halibut harvest are complex and in large part related to participation in the survey and methodology (Fall and Lemons, 2015). Due to budgetary constraints, data collection efforts were reduced in size and scope, which is consistent with the decrease in reported harvests, suggesting that some of the decrease in halibut harvest is a result of a lower participation in the survey. In certain regulatory areas, there is a downturn in renewal of halibut permits (SHARCs) after the initial rise in participation following the start of the SHARC program in 2003 (Fall and Lemons, 2015). Nonrenewal of SHARCs, low survey participation rates, and the lack of follow-up field work indicates halibut harvest was under-estimated. In addition, survey methodology differed in some regions. Similarly, the decrease in response rate could suggest survey fatigue. In 2014, an effort was made to follow up with non-participants in some regions to complete the survey, increasing the reported harvest estimates.

Implications: Food security among subsistence users is a growing concern. Changing environmental conditions are affecting fish movement, health, and abundance, directly affecting the people relying on subsistence fisheries to survive. Subsistence fishing and hunting represent a major source of food security and cultural identity for many Alaskans. Rural households rely on subsistence resources to supplement food during the winter when other sources of food may be unavailable or prohibitively expensive (Loring and Gerlach, 2009). Equally important, subsistence practices represent a way of life which supports community bonds of sharing and inter reliance, and reinforces community connections to land and a shared heritage (Holen, 2014; Picou et al., 1992). More research is needed to determine reasons for downward trends.

Profits

Economic Indicators in the Aleutian Islands Ecosystem—Value and Unit Value

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Last updated: September 2018

Description of indicator: Three metrics are used to characterize the economic value derived from catches of commercial species in the Aleutian Islands (AI): 1) ex-vessel value, 2) first-wholesale value, and 3) real first-wholesale to total catch unit value. The ex-vessel value and first-wholesale values are aggregated by functional group. While many species comprise a functional group, those few targeted by fishermen dominate the economic metrics in each group. The primary target of apex predators is Pacific cod, and to a lesser extent arrowtooth flounder. The main target in the pelagic foragers are Atka mackerel, Pacific ocean perch, and northern rockfish. Catch in the benthic foragers is split between flatfish such as rock sole and flathead sole, and benthic rockfish such as thornyhead and shortraker. The main species in the motile epifauna is king crab.

Ex-vessel value is the un-processed value of the retained catch (landings) and it can informally be thought of as the revenue that fishermen receive from the catch. First-wholesale value is the revenue from the catch after primary processing by a processor or revenue by sales of processed fish. It is a

more comprehensive measure of value to the fishing industry as it includes ex-vessel value as well as the value-added revenue from processing which goes to the processing sector. Real first-wholesale value to total catch unit value is the ratio of value to biomass extracted as a result of commercial fish harvesting. The measure of biomass extracted in this index includes retained catch, discards, and prohibited species catch. This metric answers the question: "how much revenue is the fishing industry receiving per-unit biomass extracted from the ecosystem?"

Status and trends: Ex-vessel value and landings trends are closely related because ex-vessel value is the revenue from landings. Pelagic foragers have had the highest ex-vessel value since 2010 due to both higher landings and prices for Atka mackerel and rockfish (Figure 107). In contrast, landings of apex predators have dropped since 2010 because of decreasing landings of Pacific cod. Halibut has significantly smaller catches than Pacific cod, but because halibut is a high priced species, it accounts for roughly 30–40% of the ex-vessel revenue from the apex predator functional group. Halibut catches have also been declining since 2010. Ex-vessel revenues in the motile epifauna functional group have remained fairly stable since 2010 with stable catch volumes and prices of king crab. Ex-vessel revenues in the benthic forager group dropped in 2014 as lower-priced flatfish catch has been increasing while the higher-priced rockfish catch has been decreasing. Revenues from benthic foragers has decreased as rockfish have a higher price than flatfish.

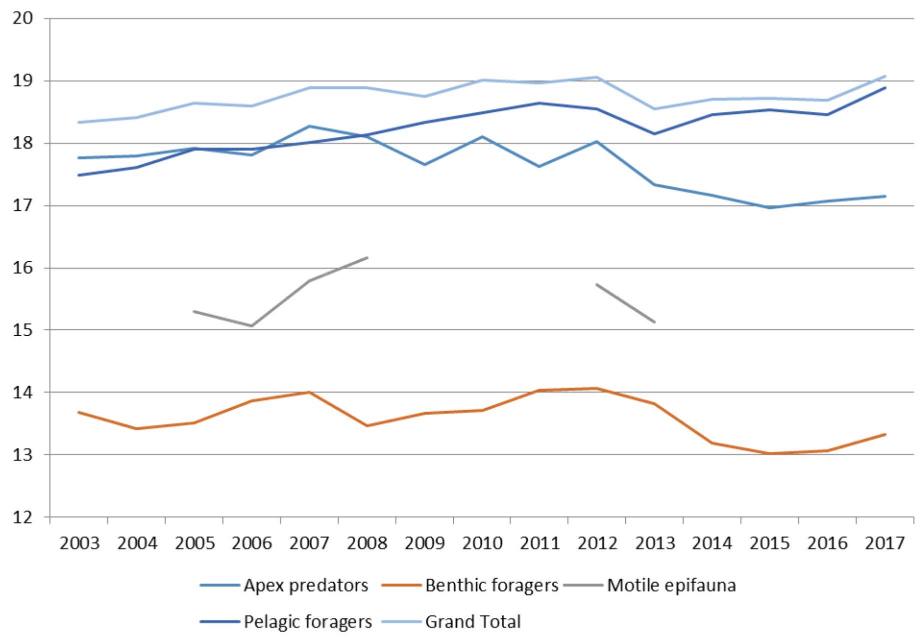

Figure 51: Aleutian Islands fishery landings by functional group (pounds in log scale).

First-wholesale revenue by functional group in the AI show similar qualitative results to the ex-vessel indices (Figure 52). First wholesale value in the apex predator group has been decreasing over roughly the last decade as catches of both Pacific cod and halibut have gone down. First wholesale value in the pelagic forager group has been increasing with increasing prices for Atka mackerel and Pacific ocean perch. First-wholesale value in the benthic forager group dropped in 2014 as production of the higher valued rockfish decreased. First-wholesale value in the motile epifauna group has been suppressed in many of the years in Figure 2 for confidentiality reasons due to an insufficient number of processors processing motile epifauna (king crab) in these years.

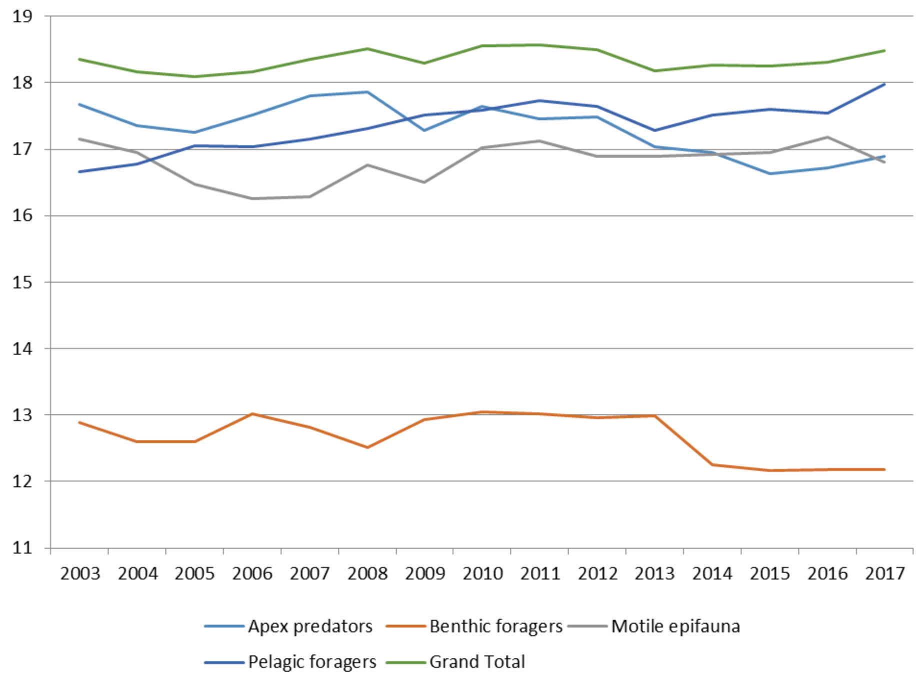

Figure 52: Aleutian Islands fishery landings by functional group (pounds in log scale).

Although first-wholesale to total catch unit value includes discards, they currently represent a relatively small fraction of total catch (Figure 53). Because of the comparatively larger first-wholesale value from pelagic foragers and apex predators, the unit value index is more heavily weighted towards these groups. The increase in the unit value index after 2010 is the result of increasing value from the pelagic foragers as prices for this group have been rising. Contrary to the Gulf of Alaska and Eastern Bering Sea, the first-wholesale total catch unit value in the Aleutian Islands has an increasing trend since 2009, with the value in 2017 being close to the all-time high of 2011–2012.

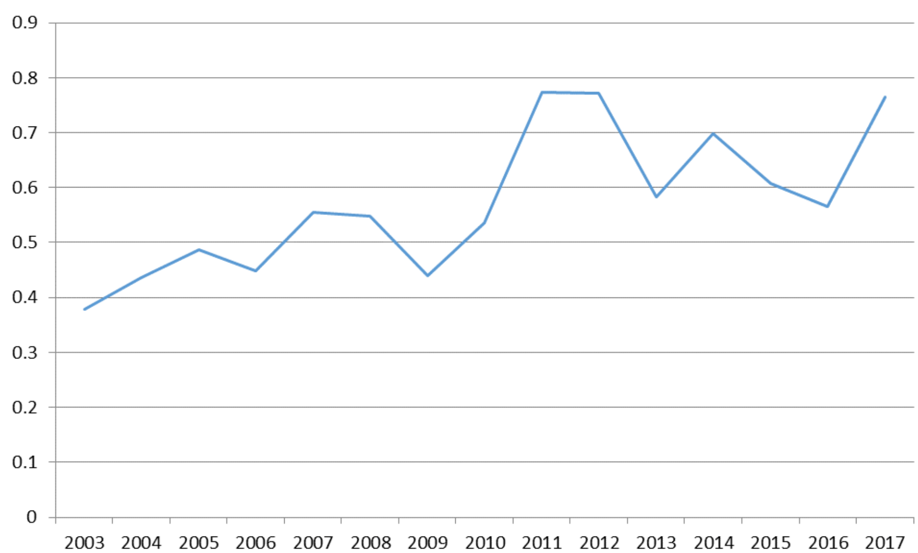

Figure 53: Aleutian Islands fishery landings by functional group (pounds in log scale).

Factors influencing observed trends: Ex-vessel value trend differences with respect to landings reflect differences in the average prices of the individual species that make up the functional groups. Hence, landings of pelagic foragers may be larger than motile epifauna, but their ex-vessel value has been fairly similar for several years because motile epifauna (especially king crab) commands a higher price. Ex-vessel price drivers include, but are not limited to, i) demand for processed products, ii) volume of supply (both from the fishery and globally), iii) first-wholesale price, iv) inflation, v) fishing costs, and vi) bargaining power between processors and fishermen. Despite this, annual variation in the ex-vessel prices tends to be smaller than variations in catch and short to medium term variation in the landings and ex-vessel revenue indices appear similar. The long-term general increasing trend are the result of increasing value in the first-wholesale market as well as inflation.

Differences between first-wholesale indices and ex-vessel indices are influenced by differences in the amount and types of value-added processing that is done. For example, Pacific cod is processed in numerous product forms which can influence the revenue generated by the processing sector. Since the total catch in the real first-wholesale to total catch unit value metric includes discards, historically, decreasing discard volumes and rates has contributed to increases in the total catch unit value. This was observed after 1998, following the pollock and Pacific cod retention program and the rationalization of flatfish in 2008 via Ammendment 80.

Implications: The economic metrics displayed here provide perspective on how the human component of the ecosystem feeds off of and receives value from the AI ecosystem. Ex-vessel value is a measure of the ultimate value from the raw resources extracted, and first-wholesale value metrics show how humans, through processing, add value to the harvest for their own uses. In contrast to the landings metrics that are heavily dominated by the pelagic forager and apex predator functional groups, ex-vessel revenues and to a lesser degree first wholesale revenues are more evenly distributed across functional groups, which indicates the importance of the groups with lower landings and higher prices to the fishing sector in this ecosystem, but also the higher reliance on volume vs added value to generate profits. Situations in which the value of a functional group are decreasing but catches are increasing indicate that the per-unit value of additional catch to humans is declining. This information can be useful in identifying areas where fishing effort could be reallocated across functional groups in times where the functional groups within the ecosystem might be constrained while maintaining value to the human component of the ecosystem. It can also indicate to the industry areas where a change in the composition/variety of processed forms could be explored. Monitoring the economic trends stratified by ecosystem functional group provides insight on the fishing related stresses on ecosystems and the economic factors that influence observed fishing patterns. The ultimate impact that these stresses have on the ecosystem cannot be discerned from these metrics alone and must be viewed within the context of what the ecosystem can provide and how it can evolve.

Recreation

There are currently no indicators to reflect recreational fishing activity in the Aleutian Island.

Employment

Unemployment Trends in the Aleutian Islands

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Last updated: September 2018

Description of indicator: Unemployment, is a significant factor in the AI and for groundfish fishery management, as most of the communities in the region rely upon fisheries to support their economies. Employment in this region is important for population retention and community viability (Rasmussen et al. 2015). Advancements in socio-ecological systems (SES) research has demonstrated the importance of incorporating social variables in ecosystem management and monitoring, and unemployment reflects the economic setting of a SES (Turner et al. 2003; Ostrom 2007). For example, variation in resource access, availability, and/or employment opportunities may influence human migration patterns, which in turn may decrease human activity in one area of an ecosystem while increasing activity in another.

This report summarizes trends in unemployment rates over time in the Aleutian Islands chain including the eastern, central, and western ecoregions. The seven AI fishing communities included in this analysis are Attu Station, Adak, Atka, Nikolski, Unalaska/Dutch Harbor, Akutan and False Pass. Unemployment data was aggregated and weighted to account for varying community populations across the Alaska East Boroughs and Aleutians West Census Areas. Estimates are presented annually from 1990–2017 (ADLWD 2018).

Status and trends: Unemployment rates in the AI, between 1990 and 2017, were lower than state and national rates (Figures 54–55). The eastern AI had higher unemployment rates than central AI. There is no update on the western AI population data as the one community (Attu Station) has had minimal or zero population for several years. According to the 2010 census, the population of 21 consisted of coast guard personnel who left the area when the Casco Cove Coast Guard Station was closed in August 2010.

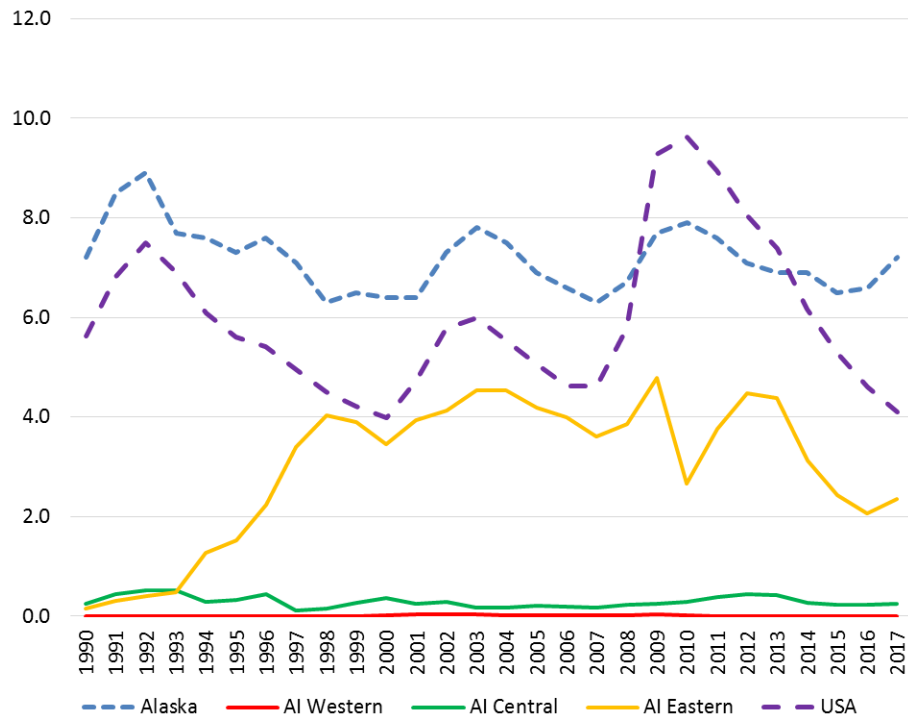

Figure 54: Unemployment rates for Aleutian Islands ecoregions, Alaska and the USA between 1990 and 2017.

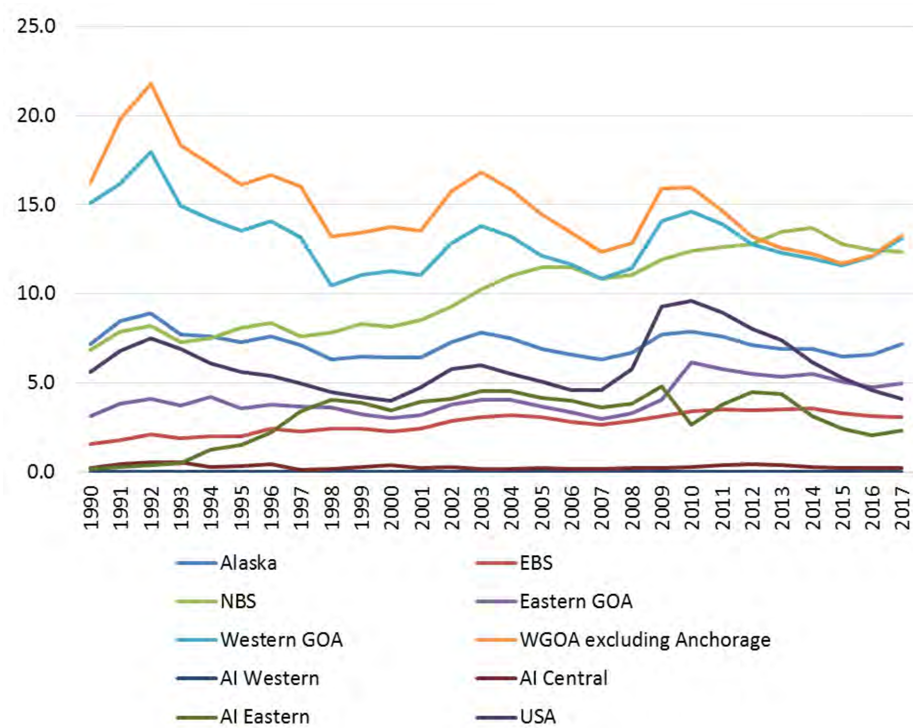

Figure 55: Unemployment rates for Alaska, regions within Alaska, and the USA between 1990 and 2017.

Unemployment rates, as of 2017, were 2.35% in the eastern AI and 0.24% in central AI. Unemployment across the AI chain peaked in 1998, 2004, 2009, and 2012 driven by eastern AI which is consistent with state and national trends. The AI region has had the lowest unemployment rates of any region of Alaska since 2014, in particular, the central AI has maintained rates less than 1.0%. Unemployment in the central AI decreased 2.53% between 1990 and 2017, and increased from 0.2% to 2.3% in the eastern AI, in accordance to AK trend but contrary to the national average.

Factors influencing observed trends: Alaska has experienced several boom and bust economic cycles. Peaks in employment occurred during the construction of the Alaska pipeline in the 1970s and oil boom of the 1980s, whereas unemployment peaks occurred following completion of the pipeline, during the oil bust of the late 1980s, and during the great recession of 2007-2009 (ADLWD 2016) . However, during the great recession, Alaskas employment decreased only 0.4% whereas the national drop was 4.3% partly because of the jobs provided by the oil industry (ADLWD 2016). Employment in the Aleutian Islands is largely driven by commercial fishing and the seafood processing industries, which stabilize employment in the region. Compared to other regions of Alaska employment is stable. Most regions are forecasted to experience job loss due to reduced oil revenues (ADLWD 2018).

Implications: Fisheries contribute to community vitality of the Aleutian Islands and reduced fishing opportunities and employment may lead to out-migration and population decline, particularly in small communities with few job alternatives (Donkersloot and Carothers 2016). Changes in groundfish policy and management, such as increased regulations, may have implications for these fishery-dependent communities.

Socio-Cultural Dimensions

Defining Fishing Communities

Within the context of marine resource management, what constitutes a fishing community is complex and has been long debated. Fishing communities can be defined, geographically, occupationally, or based on shared practice or interests. The Magnuson Stevens Fishery and Conservation Act (MSA) defines fishing communities as those "substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors that are based in such community" (Magnuson-Stevens Fishery Conservation and Management Act. Public Law, 94, 265). Within the MSA, National Standard 8 requires conservation and management measures to "take into account the importance of fishery resources to fishing communities in order to: (1) provide for the sustained participation of such communities; and (2) to the extent practicable, minimize adverse economic impacts on such communities" (MSA, National Standard 8, last updated 4/26/2018). Identifying and considering appropriate communities is central to effective marine resource management. The National Marine Fisheries Service interprets the MSA definition to emphasize the relevance of geographic place, stating "A fishing community is a social or economic group whose members reside in a specific location" (50 CFR 600.345–National Standard 8 –Communities). Pacific States Marine Fisheries adheres to this definition as well, although it is recognized that taking social networks and shared interests into account "would result in a greater understanding of socioeconomic indicators"(Langdon-Pollock, 2004). While relatively easy to determine, defining fishing community solely on geographical location risks excluding social networks

valuable to the flow of people, information, goods, and services. Some managers have turned to "multiple constructions of communities" (Olson, 2005) to better understand fishing communities.

By restricting the definition of fishing community to a geographic placeparticularly in the marine environment. St. Martin and Hall-Arber (2008) argue that geographically restricted notions of community ignore the complexity of social landscapes. The authors expand "community' to include those areas, resources, and social networks on which people depend(St. Martin and Hall-Arber, 2008). In an effort to acknowledge womens role in fisheries, Calhoun, Conway, and Russel (2016) discuss fishing community in terms of participation in the broader industry(Calhoun et al., 2016). Acknowledging power dynamics and the issue of scale when describing "fishing community', Clay and Olson (2008) complicate the MSA definition, bringing forward the importance of "political, social, and economic relationships'.

In the context of the Ecosystem Status Reports, fishing communities were identified by three criteria: 1) Geographical location, 2) Current fishing engagement (commercial and recreational); and 3) Historical linkages to subsistence fishing. Engagement was defined as the value of each indicator as a percentage of the total present in the state. The quantitative indicators used to represent commercial fisheries participation included commercial fisheries landings (e.g., landings, number of processors, number of vessels delivering to a community), those communities registered as homeports of participating vessels, and those that are home to documented participants in the fisheries (e.g., crew license holders, state and federal permit holders, and vessel owners). Recreational fisheries participation included sportfish licenses sold in the community, sportfish licenses held by residents, and the number of charter businesses and guides registered in the community. Given the heavy dependence on subsistence fishing for survival in Alaska, as well as the reliance on river networks for marine resource extraction, a buffer area was created along coastal Alaska to identify those communities living near coastal resources. Up river communities with historic ties to subsistence fishing were included. Anchorage and Fairbanks were excluded in some analyses in order to avoid skewing results.

The data used was gathered from the Alaska Department of Fish and Game Division of Subsistence database. A broad definition of subsistence fishing community was used for this analysis due to the importance of subsistence foods for daily life, particularly in rural Alaska. An estimated 36.9 million pounds of wild foods are harvested annually by rural subsistence users. Residents of more populated urban areas harvest about 13.4 million pounds of wild food under subsistence, personal use, and sport regulations. Given the reliance on subsistence foods, all communities within 50 miles of coastal waters were included in the analysis in order to capture subsistence use of marine resources. In addition, upriver communities identified as highly engaged in subsistence fisheries were included in the analysis. This included communities that historically fit the criteria (given the time period for which data is available (1991 onward). Level of engagement was evaluated by several criteria: 1) the number of Subsistence Halibut Registration Certificates (SHARC) issued to residents; 2) Total pounds harvested of all fish and marine invertebrates; 3) the number of salmon harvested; and 4) Pounds of marine mammals harvested. In order to document changes in subsistence use, communities once identified as engaged in subsistence fisheries were kept in the analysis regardless of changing engagement.

Contributed by Sarah P. Wise

Human Population Trends in the Aleutian Islands

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Description of indicator: Population stability and growth are an important indicators of community viability (Rasmussen et al. 2015). Human population trends in the Aleutian Islands (AI) are particularly relevant to groundfish fishery management because many communities in the region rely upon fisheries to support their local economies and to meet subsistence and cultural needs. Advancements in socio-ecological systems (SES) research has demonstrated the importance of incorporating social variables in ecosystem management and monitoring (Turner et al. 2003; Ostrom 2007). For example, population trends may be influenced by variation in resource access or availability or employment opportunities, resulting in migration patterns which in turn may decrease human activity in one area of an ecosystem while increasing activity in another.

This section summarizes trends in human population over time in the AI. The seven AI fishing communities included in this analysis are Attu Station, Adak, Atka, Nikolski, Unalaska/Dutch Harbor, Akutan and False Pass. Communities were divided into two categories as part of this analysis; small (population $<$1,500); and large (population $\geq$1,500). Population was calculated by aggregating community level data between 1890 and 1990 (DCCED 2016) and annually from 1990–2017 (ADLWD 2018). Populations were aggregated into the western, central and eastern AI ecoregions.

Status and trends: As of 2017 the total population including all AI communities was 5,755 people. The total population of the AI has fluctuated since 1880 with the highest population increase of 374.0% occurring between 1960 and 1970 (Table 7 and Figure 56). The population of the AI increased from 1920 to 1940 and from 1960 to 1990. Between 1990 and 2017 the population declined by 32.4%. Notable decreases occurred between 1900 and 1910, between 1940 and 1950, and between 1990 and 2000. The eastern AI has had the most steady population increase between 1880 and 2015, whereas the central and western AI have experienced large fluctuations. The western AI CDP of Attu Station has had a population of zero since 2011. Population trends of the AI are not consistent with Alaska-wide trends, where the greatest increase of 75% occurred between 1950 and 1960. Statewide, most of the population increase was in urban areas, such as Anchorage, where 40% of Alaskas population currently resides (ADLWD 2016a; 2016b).

Table 7: Aleutian Islands population 1880–2017. Percent change rates are decadal until 2010.

Year	Alaska	% change	AI East	% change	AI Central	% change	AI West	% change	AI Total	% change
1880	33426		192		132		107		431	
1890	32052	-4.11	397	106.77	132	0	101	-5.61	630	46.17
1900	63592	98.4	488	22.92	128	-3.03		-100	616	-2.22
1910	64356	1.2	281	-42.42	0	-99.22			281	-54.38
1920	55036	-14.48	448	59.43	56	5500			504	79.36
1930	59278	7.71	465	3.79	103	83.93	29		597	18.45
1940	72524	22.35	563	21.08	89	-13.59	44	-51.72	696	16.58
1950	128643	77.38	365	-35.17	85	-4.49		-100	450	-35.34
1960	226167	75.81	458	25.48	119	40			577	28.22
1970	302583	33.79	398	-13.1	2337	1863.87			2735	374
1980	401851	32.81	1611	304.77	3408	45.83			5019	83.51
1990	550043	36.88	3782	134.76	4731	38.82			8513	69.62
2000	626932	13.98	5099	34.82	408	-91.38	20		8650	-35.08
2010	710231	13.29	5456	7	387	-5.15	21	5	8895	6.1
2017	737080	3.78	4400	-0.65	362	-6.46	0	-100	5755	-1.86

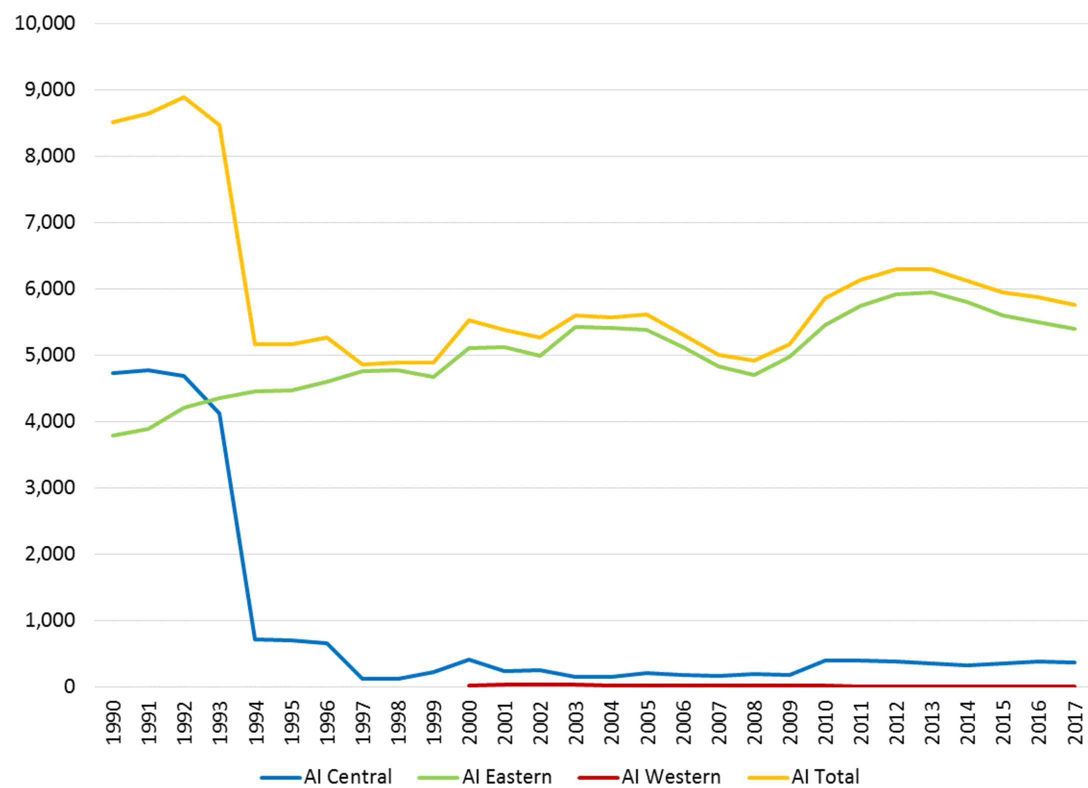

Figure 56: Aleutian Islands population by ecoregion and total.

The population of most AI communities decreased between 1990 and 2017. Adaks (central AI) population decreased by 93.35%, Nikolski CDP by 51.43%, Atka by 44.90%, and False Pass by 39.13%. Akutan and Unalaska (eastern AI) had steady population increases during this period (68.59% and 40.54% respectively). Although Indigenous Americans comprise up to 82% of the population of small communities in remote areas and more Native Americans reside in Alaska than any U.S. state (Goldsmith et al. 2004), only 42% of the AI population identified as Native American alone or combination with another race (DCCED 2016). The highest proportion of Native Americans was in Atka and Nikolski. There has been increased migration of Alaska Natives from rural to urban areas (Goldsmith et al. 2004; Williams 2004); the majority of population growth that has occurred in Alaska is of the Caucasian demographic (ADLWD 2016b).

Factors influencing observed trends: The population decrease of the AI between 1990 and 2017 (32.4%) was inconsistent with State trends (increase of 34.0%). The large decrease in population can be attributed to the closure of the Adak Naval operating base in 1997 and general migration from small communities to economic centers. Alaska has high rates of population turnover because of migration (ADLWD 2016). The main factors that affect population growth are natural increase (births minus deaths) and migration, with the latter being the most unpredictable aspect of population change (Williams 2004; ADLWD 2016). In 2010, 61% of Alaskas population was born out of state (Rasmussen et al. 2015). In terms of natural growth, from 2010 to 2014 the average annual birth rate in Alaska was 1.6 per 100 people which was higher than the national rate of 1.3 (ADLWG 2016).

Population trends in Alaska are largely the result of changes in resource extraction and military

activity (Williams 2004). Historically, the gold rush of the late 19th century doubled the States population by 1900, and later WWII activity and oil development fueled the population growth (ADLWD 2016). However, in the AI, population changes were largely driven by military activities during WWII, the establishment of Coast Guard bases, and the development of fisheries following the establishment of the EEZ (late 1970s), joint ventures (1980s), and later development of the domestic fishery in the early 1990s . Some communities in the western and central AI declined in the 1990s because of Coast Guard cut-backs and military base closures (Williams 2006). For example, the closure of the Coast Guard base in Attu Station (during 2010) in western AI left the community abandoned. Similarly, Adaks population drastically declined after closure of the Adak Naval operating base in 1997. The influence of the fishing industry is evident in the eastern AI with Unalaska and Akutan, the most populous communities of the AI, showing landings for substantial volumes of seafood. The Aleutian Islands, and Kodiak in the Gulf of Alaska, have transient populations because of the seafood processing industry (Williams 2004). Factors that influence population shifts and migration include employment, retirement, educational choices, cost of living, climate, and quality of life, (Donkersloot and Carothers 2016).

Implications: Population shifts can affect pressures on fisheries resources, however inferences about human impacts on resources should account for economic shifts and global market demand for seafood and other extractive resources of the ecoregion. Population change in Alaska is largely fueled by increased net migration rather than natural increase, and there has been increased migration from rural to urban areas. This is evident with population decline of several small communities such as Nikolski and Atka. AI communities are among the most transient with in-migration of foreigners working in processing plants, yet employment in fisheries is what maintains these communities, such as Unalaska and Akutan. Fisheries contribute to community vitality and changes in groundfish policy and management, such as increased regulations, may have implications for small communities of the Aleutian and Pribilof Island Community Development Association entity. Also, with almost half of the population of the AI being Native Alaskans and their long history of subsistence harvest, resource managers may benefit from working with communities holding traditional ecological knowledge (TEK) to incorporate these principles into ecosystem management (Huntington et al. 2004).

K–12 School Enrollment, Graduation and Dropout rates in the Aleutian Islands

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Description of indicator: Ensuring the productivity and sustainability of fishing communities is a core mandate of Federal fisheries management. Community vitality is evaluated here based on K–12 public school enrollment. Enrollment trends are particular relevant due to the value of schools to community cohesion and identity as well as reflecting conditions for resident families as opposed to the transient population. There are no schools in the Western Aleutian Islands ecoregion (WAI).

Public school enrollment and dropout rates were analyzed by borough and community level in order to examine broader regional trends as well as the social and economic vitality of individual rural communities. Enrollment statistics for K-12 grades by school and region were compiled for 1996–2018 from the Alaska Department of Education and Early Development (`http://www.eed.state.ak.us/stats/`). Current school locations and names were verified using the EPA EJ mapping tool (`https://ejscreen.epa.gov/mapper/`). The Eastern Aleutians ecoregion (EAI) is covered by two districts: the Aleutians East and Unalaska City. The Aleutians East school district includes two schools from the Gulf of Alaska (King Cove and Sand Point). Only schools that occur within the EAI region were analyzed (Akutan and False Pass). The WAI and Central Aleutians ecoregions (CAI) are within the Aleutian Region School District. The CAI includes two schools in Atka and one in Adak. School graduation rates are based off of the four-year adjusted cohort graduation rate, which was implemented in Alaska starting with the 2011–2012 school year. Graduation rates are reported for 2015–2017 cohorts based upon school district. Dropout rates are reported by school district from 1990–2017.

Status and trends: While Unalaska schools in the EAI have maintained relatively stable enrollment since 1996, Nikolski, Akutan, and False Pass have diminished dramatically and are no longer viable. Nikolski closed in 2010, and False Pass had six students in 2018. Alaska schools lose state funding if enrollment drops below 10 students. Akutan currently has 13 students enrolled (Figure 57). For the 2015–16 and 2016–17 cohorts in the EAI, the graduation rates in the Unalaska and Aleutian East school districts were at least 78.5%. The statewide average was 76.1% (2016) and 78.2% (2017). Dropout rates vary from 0–8% for the EAI. The Unalaska school district dropout rate has declined since 1999 (Figure 59) and is now the lowest dropout rate compared to other regions.

Both Adak and Atka schools in the CAI have experienced declining enrollment. As of 2018, Adak has 13students enrolled while Atka has 12 (Figure 58). Both of these communities are small and extremely remote; losing a school would be detrimental to either community. Graduation rates were at 50% in 2015, increased to 100% in 2016 and remain there. There are no data for dropout rates from the Aleutian Region School District in the CAI.

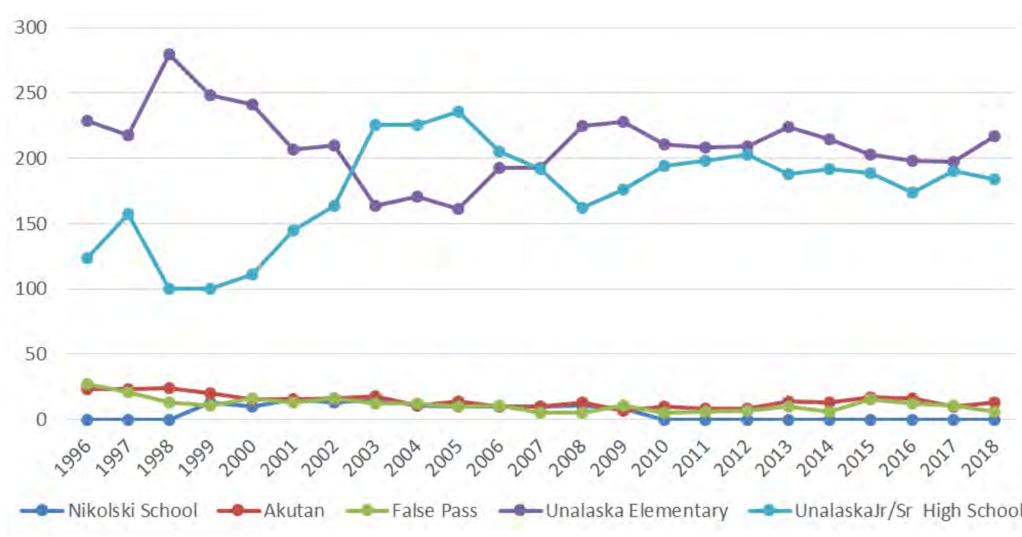

Figure 57: Eastern Aleutian Islands school enrollment 1996–2018.

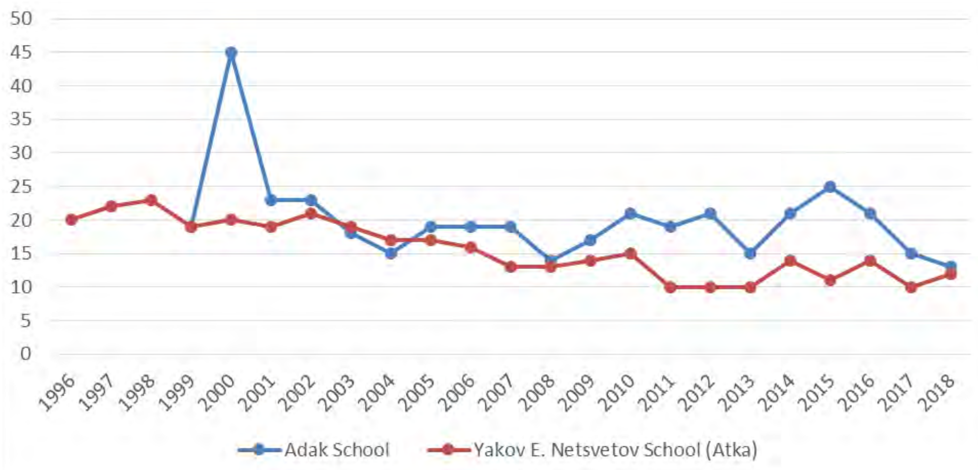

Figure 58: Central Aleutian Islands school enrollment 1996–2018.

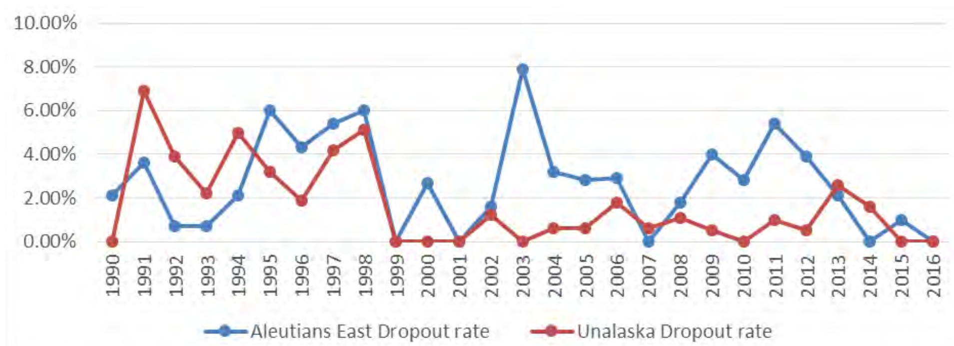

Figure 59: Dropout rates for Eastern Aleutian Islands school districts, 1990–2017.

Factors influencing observed trends: The communities within the CAI and EAI can be considered either remote or extremely remote. Rural area schools are particularly vulnerable to closure, teacher turn over, and possible community disruption. High dependence on commercial fisheries and other natural resources may drive population shifts according to season and availability. Schools are particularly important for remote community stability, as they often serve as meeting places, libraries, places of lodging and provide access to the Internet. All schools in the Aleutian Islands, except for that in Unalaska, have fewer than 30 students enrolled, which poses a risk for educational stability. The reasons for decreasing enrollment likely include various social and economic drivers including decreasing populations, migratory patterns, resource availability, and employment.

Implications: The closure of a school in these communities would have a profound effect, further discouraging families or potential families to remain in the area, amplifying the decline of local resident populations. School closures would discourage permanent residency, even when improved employment opportunities arise. Schools are cultural centers and serve as important indicators of social and economic viability, and community well-being (Lyson 2002, Thomas 2002, Thomas 2005). Within rural communities in particular, schools are valuable symbols for community identity, autonomy, and shared social values (Peshkin, 1978, 1982, Thomas 2005). Research indicates that school closures negatively affect communities and student achievement (Buzzard 2016, Thorsen

2017). Patterns of diminishing enrollment and school consolidation suggest a decrease in property values and taxes, fragmented community, and lost business, as well as declines in reported quality of life scores (Sell et al. 1996, Thomas 2002). Some research finds the rate of participation in community organizations decreases in communities experiencing school closures (Oncescu and Giles 2014, Sell et al. 1996). These finding suggest that reduced enrollment and school closures may flag disruptions in social cohesion, possibly leading to less vibrant and sustainable communities.

Responses to Comments from the Scientific and Statistical Committee (SSC)

December 2017 SSC Comments

This year, as in the past, the Ecosystem Considerations Reports are insightful, well written and well edited. Both chapters were helpful in providing a context within which to assess the stocks of commercially harvested fish in Federal waters off Alaska. The editors and authors have been very responsive to the comments and suggestions provided by the SSC in 2016. Last year the SSC raised the question as to whether sufficient resources were being devoted to the compilation and editing of the Ecosystem Considerations chapters. The SSC recognizes that this year NOAA provided additional staff resources to sustain the improvement of these documents, and that these additional resources allowed for more in-depth analyses of recent environmental changes, such as the examination of the sudden decline in Pacific cod in the Gulf of Alaska.

Thank you. As a result of continued staffing support from AFSC, this year we provide updates to the Eastern Bering Sea (Siddon & Zador), Gulf of Alaska (Zador & Yasumiishi, with Rob Suryan providing coordination with Gulf Watch Alaska), and Aleutian Islands (Zador & Ortiz) Ecosystem Status Reports.

The SSC was pleased to see the addition of the rapid zooplankton assessments included for both EBS and GOA Ecosystem reports. As requested by the SSC, these data are shown with historical context for small and large copepods, and euphausiids. Additionally, this indicator now estimates abundance rather than proportional catches, which aids in interpretation.

The RZA continues to be applied to more surveys, for example the northern Bering Sea, and we have also added some contextual information for zooplankton condition in the form of lipid percentages. We have also standardized the presentation style of maps and time-series for ease of interpretation moving forward. Finally, we will be able to present a comparison of RZA to fully processed net samples in the coming year to assess the efficacy of the RZA.

There are expanded analyses of abundance and distribution shifts of groundfish and jellyfish from AFSC bottom trawl surveys. New indicators for groundfish from these surveys (mean length, lifespan and total biomass) have remained relatively stable over the time series. The SSC appreciates the inclusion of these new indicators, but suggests that even small changes could have far reaching implications as these are relatively gross-scale indicators. The SSC requests further development

of these indicators as anomalies to better discern long-term trends. The SSC looks forward to the eventual inclusion of comparisons of events in the different LMEs, and how events in one LME may affect another LME.

The indicators for Mean Lifespan and Mean Length of the Fish Community as well as the Stability of Groundfish Biomass indicator have been revised in 2018 to include both a mean and trendline over the respective time series to better discern long-term patterns and detect significant differences in the slope of the trendline. Comparisons across LMEs remains a gap in the Reports, but something the author and Report editors will continue to work towards for future Reports. One of the issues with comparisons across LMEs is that a difference in indicator value does not necessarily indicate that one system is healthier than the other. Differences in indicators between LMEs may reflect fundamental differences in the ecosystem structures and species compositions.

The editors present a new "Groundfish Recruitment Predictions" section, which includes a new indicator for Pacific cod and five new indicators for walleye pollock. The SSC supports the development of these predictions based on ecosystem indicators that are firmly grounded in mechanistic relationships. Effort should be directed toward the eventual incorporation of these recruitment indicators in the assessment models. The SSC recommends that these species-specific predictions are transitioned to the ESPs (Ecosystem Socio-economic Profile) to ensure that they are considered by the stock assessment authors.

The contribution authors and Report editors are maintaining open communication with stock assessment authors and those involved in producing the ESPs. These species-specific indicators will be transitioned to the appropriate ESPs as they become available.

The SSC commends the ongoing efforts to expand the treatment of the Human Dimensions portion of the Ecosystem Considerations chapters. In particular, a number of new indicators have been incorporated. The SSC notes that development of indicators on the health of fishing communities lags behind that of indicators for the health of the fish stocks and that the latter were developed and refined over a long time period. The SSC encourages the continued development of this section and, in particular, the development of indicators on which the Council might be able to act in the advent of evidence of a problem. Specific to the human population indicators, regional characterizations mask rural trends relative to urban centers. The SSC recommends the inclusion of maps demonstrating finer scale shifts in population trends as well as school enrollment trends, both of which are strong indicators of community stability or vulnerability.

The Economic and Social Sciences Research program, in collaboration with the Report editors, has made further improvements to the Human Dimensions indicators for 2018, although some of these updates are reflected in the Groundfish Economic SAFE report that will be reviewed by the SSC in February 2019. For this version of the report, we have (i) re-evaluated the definition of fishing communities and redrew the boundary for inclusion in the analysis to reflect a better representation of how coastal communities are impacted on an ecosystem scale for all Human Dimensions indicators, (ii) broadened school enrollment indicator to include "school readiness" (as illustrated by graduation and drop-out rates) to examine not just number of students enrolled, but to what degree of success were communities educating their youth, and (iii) conducted the analysis on an ecosystem scale, but attention was paid to community level impacts to highlight connectivity across regions. Additional detailed information on selected groundfish communities will be highlighted in the Groundfish Economic SAFE report in February. We have considered the use of maps to display the human dimensions indicators data and are exploring ways to incorporate

this type of information in future versions of the Groundfish Economic SAFE report.

The influences on the economic and social life in Alaskas coastal communities are many and the SSC cautions against facile causal interpretations. At the same time, it would be a mistake to dismiss the indicators presented in the chapter as being disconnected from and unrelated to the Councils sphere of influence. The policy choices made by the Council and the US Congress directly influence the possibilities presented to the communities of the North Pacific. The SSC suggests that the Human Dimensions ecosystem indicators be a topic for discussion by the newly formed Social Science Planning Team.

The Report editors welcome collaborating with the Social Science Planning Team to best represent and report coastal communities and impacts of policy choices on Alaskans.

The LEO Network is a potentially valuable resource for ecosystem considerations that invites community members to record unusual observations which are then vetted by scientific consultants before being published on the network. The SSC recommends the exploration of projects within this tool that ask specific questions to solicit relevant observations from communities. It is not clear how this network is publicized or the level of community awareness and involvement. Specific to the northern Bering Sea, the SSC endorses the Plan Team recommendation for continued evaluation of approaches to incorporate local ecological knowledge into the Ecosystems Considerations chapters. In addition, the SSC encourages exploration of other more active approaches to gathering and engaging citizen science/LTK from communities.

Community awareness of, and involvement in, efforts to engage citizen science/LTK have increased, both through the LEO Network and through direct communication with NOAA employees and Report editors. For example, the observations of pollock in Bristol Bay (see EBS Ecosystem Status Report) were communicated directly from a subsistence fisher to NOAA's Alaska Regional Office who forwarded the contact to Elizabeth Siddon, editor of the EBS Ecosystem Status Report. That communication resulted in additional direct reports from fishers in the area, samples collected for processing at AFSC and NWFSC, and a LEO Network report. We attempted to initiate a project on NBS community observations but were unsuccessful this past year. However, we provide updates to the LEO reports again this year and will continue to pursue this tool as well as other avenues for communication. The Ecosystem Status Report editors believe citizen engagement will continue to increase as awareness increases.

Last year the SSC raised the issue of how well report authors have managed to address the implications of their indicator findings for the current year. One of the important reasons for the existence of the Ecosystem Considerations chapters is to provide the Council with information that may be relevant for adjusting the coming years harvest specifications or biological reference points. Thus, the indices and their implications that are most valuable will be those that provide information that inform Council decisions. The Implications Sections that merely state that an indicator might be important for management are not particularly helpful. The SSC recognizes that the editors are planning to revise the instructions to authors to clarify this issue, and looks forward to improvements in this area.

The Report editors continue to review Implications section for utility and relevance to adjusting harvest specifications or biological reference points. We provide examples of useful Implications and assist authors in better realizing direct implications of their indicators. It is an on-going effort.

The editors raised the question as to the possibility of a change in the organization of the Ecosystem

Considerations chapters. Currently, the report is organized by trophic level, reflecting the flow of energy and material to fish stocks and the fishing community within each LME. The editors are considering reformatting by ecosystem-scale management objectives created by Congress (see Table 1 in each of the chapters). The SSC questions the utility of the proposed change from a document focused on understanding of relevant portions of the marine ecosystem in which fishing is occurring to one that focuses more on fisheries management objectives. This organization could be appropriate for the fishing and human dimensions indicators, but not the physical and ecological indicators in the Ecosystem Indicators section. The SSC has been on record for many years in requesting that the Ecosystem Considerations chapters and their components follow an organization scheme based on trophic level.

The organization of the Ecosystem Status Reports remains by trophic level for physical and ecological indicators and by management objectives for the human dimensions section, as was done for the 2017 Reports (i.e., no change).

New this year, we are working with the AFSC communications staff to produce a "public-friendly" version of the ESRs. We hope to have the first edition of the EBS ESR brochure available to the public in January. We will be using the term Hot Topics to reflect the most important ecosystem assessment features for the current year. Thus, we will use Noteworthy Items as the new title for the former Hot Topics in the ESR assessments. This new title is more appropriate as this section is used for noteworthy information that cannot be presented in the format of our standard indicator contributions, but are not necessarily the most important topics of the year.

SSC Comments from Dec 2016 regarding the Aleutian Islands

The new organizational structure served to highlight the lack of information for the Aleutian Islands in particular and would like to encourage continued investigation into additional sources of data for this LME, particularly in the Western Aleutians, as patterns there appear to frequently diverge from that of the Central and Eastern subregions.

The lack of information available for the Aleutian Islands, particularly relative to the Eastern Bering Sea and Gulf of Alaska, continues to be a challenge. This region has not been the focus of a large integrated reseach project as have the eastern Bering Sea and Gulf of Alaska. This is of particular concern as changes in fishing pressure in the Aleutians can be directly related to events in the eastern Bering Sea, such as the increased cod fishing described in the Noteworthy section (p. 37). We hope to revisit the indicators selected for the report card in the next year and may need to reevaluate our selection with the realities of data availability in mind.

Continuous plankton recorder (p. 62): It would be useful to provide the names of at least the most important (by biomass and by number) of the zooplankton species (in all regions). Large and small categories, especially from places that are not often or well-studied, do not tell us whether we are dealing with the same species in the southern Bering as on the eastern Bering Sea shelf.

We requested these data and have included them in both the AI and GOA reports this year. The author emphasizes that these data require carefully interpretation as the seasonal aggregation can mask significant within season. For example, the copepod *Neocalanus plumchrus* is common in spring but nearly absent in late summer/fall. Also, biomass is a taxon specific value from literature, not actually measured. Some taxa are a group of many species, some are individual life history stages of a single species.

Weight at length of groundfish (p. 69): The reduced weight at length of many groundfish species suggests either that there are too many fish, or that the prey of the fish has declined. Another implication is that the nutritional quality of the fish taken by Steller Sea Lions in the western Aleutians may of low quality, an issue that other research has shown to be particularly problematic for juvenile sea lions.

We agree that this may be an implication that is of particular concern as length-weight residuals continue to remain negative for several groundfish species (p. 67).

Mean weighted distributions of rockfish (p. 69): It appears that the increased temperatures encountered by the fish did not lead to a deepening of their distributions. Could this indicate that the temperatures encountered so far are not stressing the fish?

While the temperatures at those depths have varied through the years, the range in temperature change has been small so has likely not had a measurable impact on the rockfish depth distribution. The range in temperature change has been higher in shallower water as expected (1.1°C at 100mm; 0.8°C at 200m). While the temperature at depth has been roughly the same for the last 20 years, despite 2016 having the highest temperatures in the record. The authors suggest that increases in overall rockfish abundance could be pushing rockfish into shallower water and possibly deeper, but depths below 500 m are not sampled. Pacific Ocean perch abundance increased in 2010 in the Aleutian Islands Bottom Trawl Survey and has remained high so is likely contributing to this pattern.

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