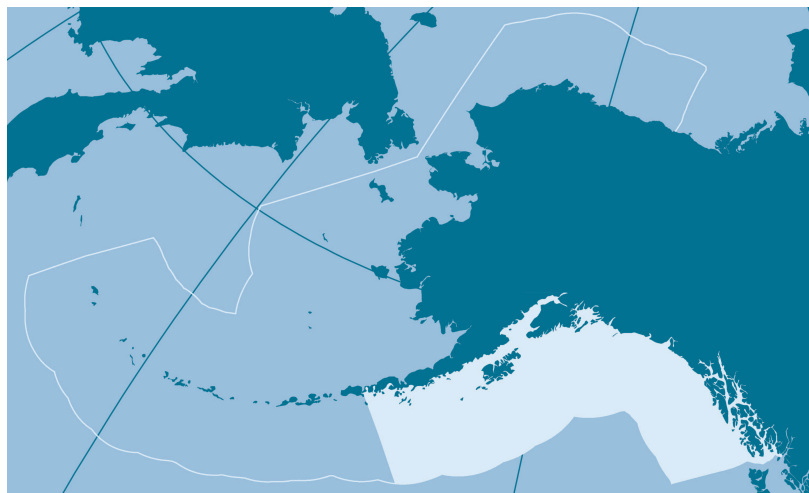


# Ecosystem Considerations 2016

## Status of the Gulf of Alaska Marine Ecosystem



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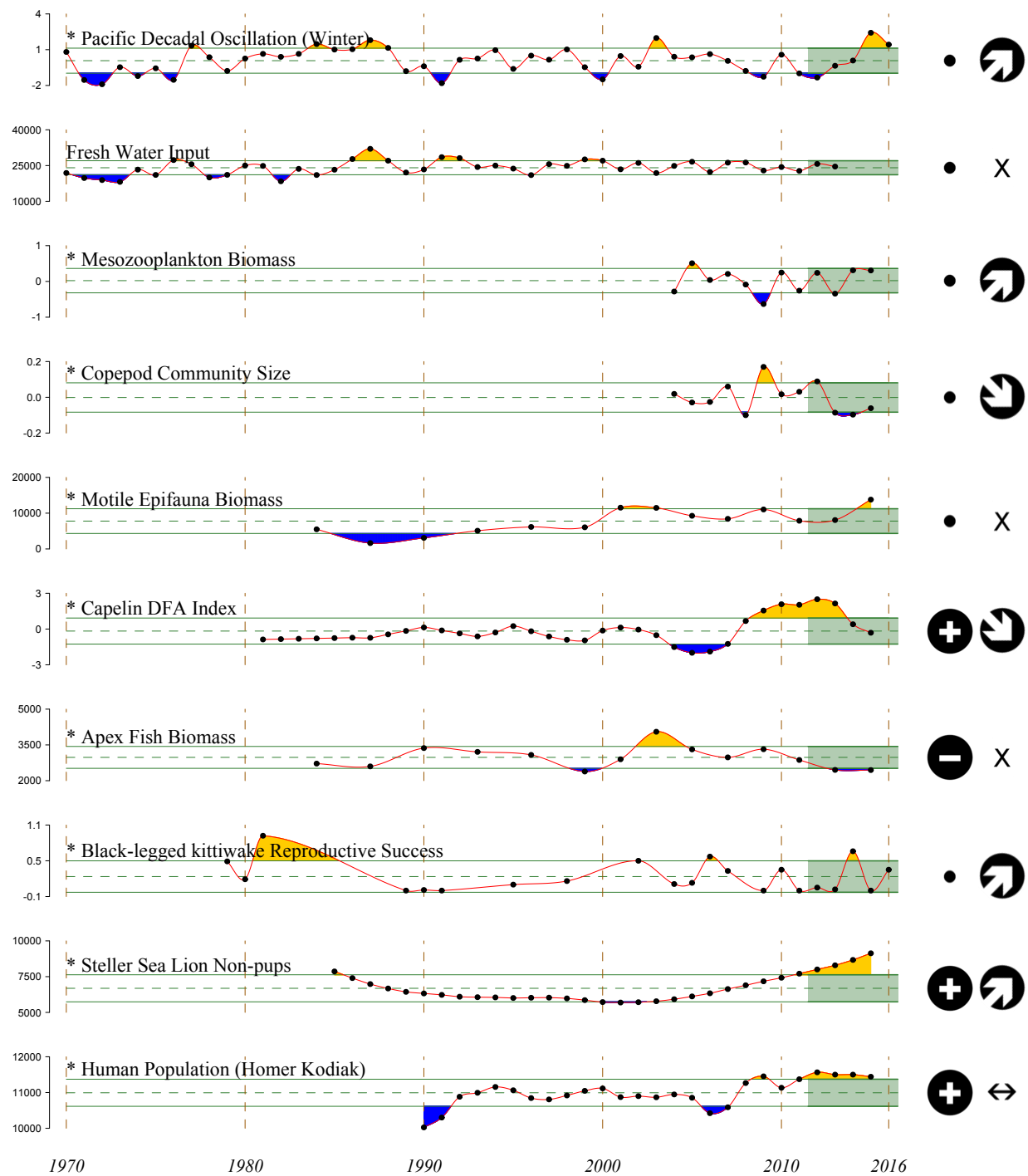
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November 14, 2016

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# Western Gulf of Alaska 2016 Report Card

- The Gulf of Alaska in 2016 was **characterized by warm conditions** that were first seen in 2014, and have continued as reflected in the **positive PDO pattern**. Anomalously warm conditions are expected to continue through the winter.
- **Fresh water input as estimated at the GAK1 station has been variable** over the long time series. The most recent data indicate an increasing trend.
- **Mesozooplankton biomass measured by the continuous plankton recorder has shown a largely biennial trend since 2009**, however biomass remained greater than average in 2015. Biomass trends can be influenced by ecosystem conditions and mean size of the community. This suggests that prey availability for planktivorous fish, seabirds, and mammals has been variable recently. The biennial patterns suggests a **possible link with biennially varying planktivorous pink salmon abundance**.
- **Copepod community size has been declining in recent years**. The prevalence of small copepods during 2015 fits predictions of warm conditions favoring small copepods. This suggests that **less lipid-rich prey were available to planktivorous predators**.
- **Survey biomass of motile epifauna** has been **above its long-term mean** since 2001. The increase from 1987 to 2001 was driven by hermit crabs and brittle stars, which dominate the biomass. Since 2001 their biomass has been stable. Record catches of octopus influenced the increased estimate in 2015.
- Trends in capelin as sampled by seabirds and groundfish have indicated that **capelin were abundant from 2008 to 2013, but have declined in the past two years**. This pattern **coincides with the period of cold water temperatures** in the Gulf of Alaska.
- **Fish apex predator survey biomass is currently below its 30-year mean**, although the declining trend seen in recent years has leveled off. **The trend is driven primarily by arrowtooth flounder** which, along with halibut, had been declining since 2005. Both increased slightly in 2015. It is unknown whether these increases were due to distributional shifts in the warm water. **Pacific cod has declined from a peak survey biomass in 2009**.
- **Black-legged kittiwakes had moderate reproductive success in 2016** at the Semedi Islands, in contrast to the complete failure in 2015 for kittiwakes as well as other seabird species. Their reproductive success is typically variable, presumably reflecting foraging conditions prior to the breeding season, during, or both.
- Modelled estimates of **western Gulf of Alaska Steller sea lion non-pups counts are above the long term mean and continuing to increase**, suggesting conditions are favorable for sea lions in the western Gulf.
- Human populations in the western Gulf of Alaska coastal towns of **Homer and Kodiak are above their 25 year mean**. Homer is the sole town with a steadily increasing trend. Kodiak saw declines until 2006 and has recovered slightly since then.



#### 2012-2016 Mean

- + 1 s.d. above mean
- 1 s.d. below mean
- within 1 s.d. of mean
- X fewer than 2 data points

#### 2012-2016 Trend

- ↗ increase by 1 s.d. over time window
- ↘ decrease by 1 s.d. over time window
- ↔ change <1 s.d. over window
- X fewer than 3 data points

Figure 1: Western Gulf of Alaska ecosystem assessment indicators; see text for descriptions. \* indicates time series updated in 2016.

# Eastern Gulf of Alaska 2016 Report Card

- The Gulf of Alaska in 2016 was **characterized by warm conditions** that were first seen in 2014, and have generally continued since. The **strong El Niño of last winter has lessened, and near neutral conditions are expected for next winter**.
- The **sub-arctic front was farther north than usual**, which is consistent with the poleward surface currents seen in the past three years.
- Total **zooplankton density in Icy Strait has been anomalously low in the past three years**. Zooplankton density has declined since peak values in 2008 and 2009. This suggests that prey availability has been low for planktivorous fish, seabirds, and mammals.
- Also in Icy Strait, **large copepod abundance has declined** over the past five years and was particularly low in 2015. The prevalence of small copepods during 2014 fit predictions of warm conditions favoring small copepods, but small copepods also declined in 2015. This suggests that **less lipid-rich prey were available to planktivorous predators**.
- A **decrease in estimated total mature herring biomass in southeastern Alaska has been observed since the peak in 2011**, although the biomass has been above the long-term (1980-2015) median since 2002.
- **Growth rates of piscivorous rhinoceros auklet chicks were anomalously low in 2015**, suggesting that the adult birds were not able to find sufficient prey to support successful chick growth. This is in contrast to 2012 and 2013, when chick growth rates were above the long term average.
- Modelled estimates of eastern Gulf of Alaska **Steller sea lion non-pups counts are above the long term mean**, although the rate of increase is slower than that for the western Gulf of Alaska.
- Human populations in the Gulf of Alaska coastal towns of **Yakutat and Sitka are around their 25-year mean**. The population of Yakutat has grown a gradually declining trend since a peak in 1997. Sitka has been increasing since that time, with two substantial declines in 2007 and 2015.

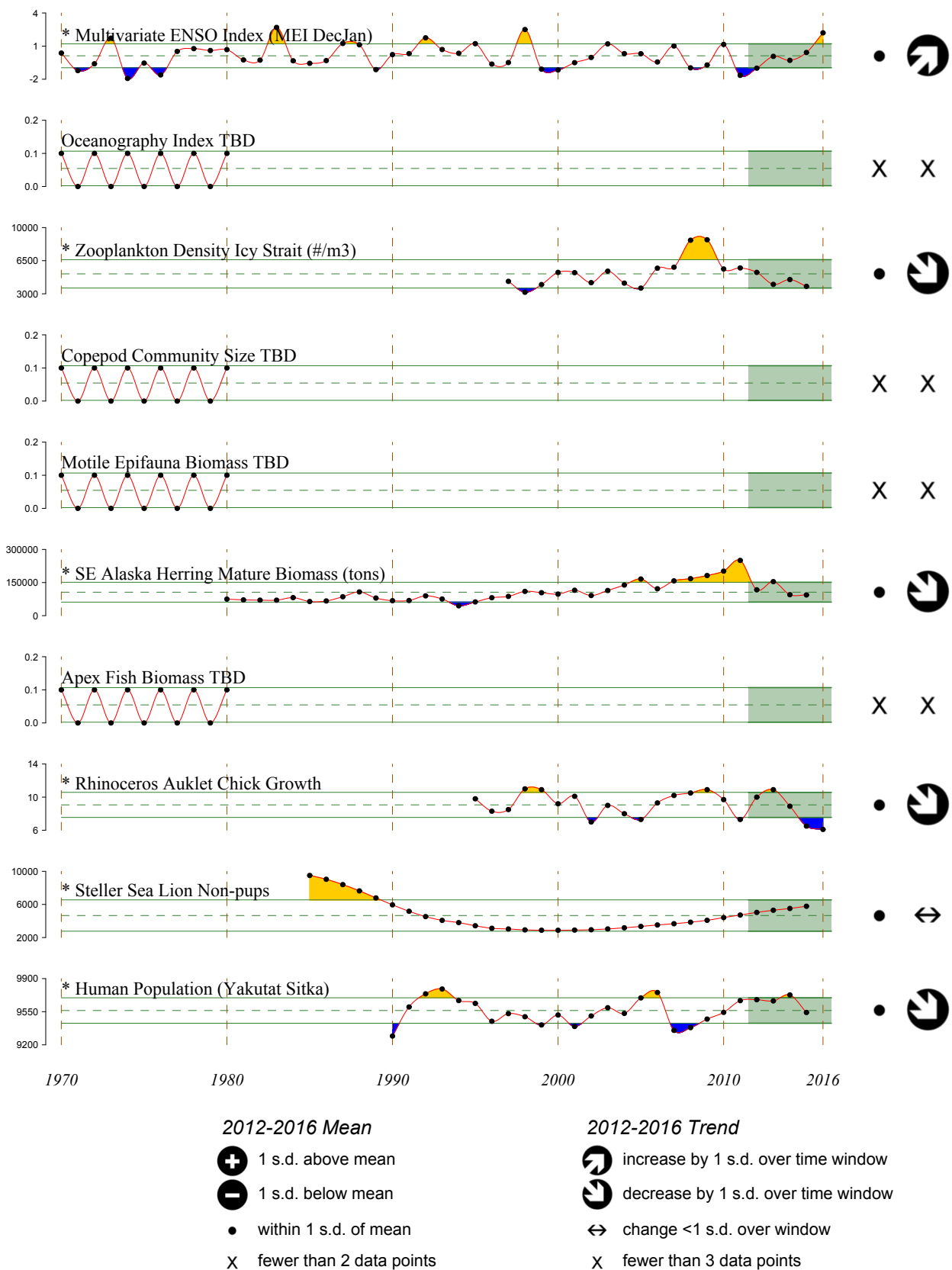


Figure 2: Eastern Gulf of Alaska ecosystem assessment indicators; see text for descriptions. Four potential indices are yet to be determined (TBD). \* indicates time series updated in 2016.

# Executive Summary of Recent Trends in the Gulf of Alaska

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 state of the North Pacific atmosphere-ocean system during 2015-2016 featured the continuance of warm sea surface temperature anomalies that became prominent late in 2013, with some changes in the pattern (p. 38).
- A strong El Niño developed during winter 2015-2016 (p. 43).
- However, the climate models used for seasonal weather predictions are indicating borderline to weak La Niña conditions for the winter of 2016-17 (p. 45).
- The Pacific Decadal Oscillation (PDO) remained positive during the past year (p. 43).
- The North Pacific Index (NPI) was strongly negative, implying a deeper than normal Aleutian Low, which was accompanied by anomalous winds from the south and relatively warm air along the west coast of North America (p. 43).
- The North Pacific Gyre Oscillation (NPGO) transitioned from negative in 2015 to near-neutral in 2016, implying that flows in the Alaska Current portion of the Subarctic Gyre and the California Current strengthened to normal (p. 43).
- Anomalously positive sea surface temperatures are predicted throughout much of the north east Pacific during the upcoming winter. The magnitude of the anomalies is projected to be greatest in the GOA and eastern Bering Sea (p. 45).
- The North Pacific climate may be in a state of rather low predictability, yet is unlikely that the upcoming winter in Alaska will be as mild as those of the last three years (p. 45).
- Model projections of a muted atmospheric response in the mid-latitudes to the equatorial Pacific during the next two seasons could be a reflection of the enormous amount of extra heat in the upper ocean now present along most of the west coast of North America (p. 45).

## Gulf of Alaska

- The coastal wind anomalies were generally downwelling favorable during winter and spring but switched to more upwelling favorable during the summer of 2016 (p. 38).
- The sub-arctic front was farther north than usual, which is consistent with the poleward surface currents shown in the Ocean Surface Currents – Papa Trajectory Index (p. 50).
- A prominent eddy formed near Yakutat in January 2016, leading to eddy kinetic energy (EKE) levels in the northern Gulf of Alaska during spring 2016 were very high (similar to 2002, the previous maximum). Thus, phytoplankton biomass was likely not confined to the shelf and cross-shelf transport of heat, salinity and nutrients was likely strong (p. 47).
- Relatively weak eddy kinetic energy was observed south of Kodiak during spring 2016 (p. 47).
- It now appears the filtered PAPA Trajectory Index has shifted back to northerly flow, which would indicate that the recent period of predominantly southern flow (mid-2000s to present) will have been the shortest and weakest in the time series (p. 50).

## Ecosystem Trends

- In the Alaskan Shelf region sampled by the continuous plankton recorder, spring diatom abundances for the Alaskan Shelf were low, but increased by the summer and fall, leading to positive anomalies and suggesting a change in the ocean conditions mid-way through the year (p. 56).
- In the same region, copepod community size anomalies remained negative from 2013-2015, while mesozooplankton biomass anomalies were positive in 2014 and 2015 (p. 56).
- A new zooplankton indicator features a hindcast of data collected from Line 8 in Shelikof Strait from 1990-2012 to compare with current zooplankton rapid assessments. Trends in euphausiid, small copepod, and large copepod abundance has varied over the time period, but small copepod abundance was always higher than the other zooplankton (p. 60).
- A fall 2015 zooplankton rapid assessment was dominated by small copepods, similar to the spring 2015 survey. Large copepods were located in deep stations in Shelikof Strait, indicating that there were a few hotspots remaining in fall where successful foraging by juvenile pollock could occur (p. 62).
- Total Icy Strait zooplankton density was anomalously low during summer 2015, continuing a declining trend over the past five years (p. 64).
- Icy Strait zooplankton were numerically dominated by small and large calanoid copepods (p. 64).
- Jellyfish biomass during 2015 GOA IERP surveys decreased relative to the peak value observed in 2014. In contrast to jellyfish catches in the EBS, the GOA catches are more diverse, with *Aequorea* and *Chrysaora* as the top two genera (p. 67).
- The ichthyoplankton abundance timeseries shows anomalously low abundances for most species in 2015. The abundance of pollock larvae in 2015 was the lowest observed, following the very high anomaly observed in 2013. Only northern lampfish and rockfish showed positive anomalies in 2015 (p. 69).
- A new forage fish indicator was developed that represents temporal trends in abundance of capelin and sand lance based on prey composition of various piscivorous seabird and groundfish species in the Gulf of Alaska. Capelin showed an increasing trend beginning in 2006 that declined beginning in 2014. Sand lance declined in the early 1990s, but recovered by the end of the decade, but have declined again since 2000 (p. 71).
- Although the estimated total mature herring biomass in southeastern Alaska has been above the long-term (1980-2015) median of 92,595 tons since 2002, a decrease in biomass has been observed since the peak in 2011. The most notable drop in biomass was observed in Hoonah Sound (p. 74).

- In the Southeast/Yakutat region, the 2015 adult pink salmon return was the lowest odd-year return since 1997. In contrast, 2015 saw the largest Prince William Sound pink salmon harvest recorded. For 2016 ADF&G has forecasted a decrease in the total commercial salmon catch in Alaska, due to an expected decrease in the number of pink salmon, possibly due to poor overwintering condition and/or increased predation on juvenile pink salmon by southern predators (p. 79 and p. 84).
- Ecosystem indicators predict a pink salmon harvest in southeast Alaska of about 30 M fish, somewhat below the historical average. However, as of October 2016, harvests have been only 18 M fish (p. 84).
- The Southeast Alaska Coastal Monitoring project Chinook salmon index is the abundance estimate of ocean age-1 fish sampled in Icy Strait, lagged two years later to their ocean year of recruitment as ocean age-3 fish, the age when most reach legal size. Based on this index of ocean age-1 fish, there appears to be two strong Chinook salmon year classes emerging: one as ocean age-3 fish in 2013 and another two years later in 2015 (p. 88).
- Late summer chlorophyll *a* values in 2014 and 2015 were used to predict 19.7 million age-2 sablefish in 2016 (average) and below average recruitment of sablefish to age-2 (3.8 million) in 2017 (p. 91).
- Arrowtooth flounder, flathead sole, and other flatfish continue to dominate the biomass in the ADF&G trawl survey but not to the same degree as seen in previous surveys. A decrease in overall biomass is apparent from 2007 to 2015 from years of record high estimates seen from 2002 to 2005 (p. 94).
- In 2015, overall gadid catches have increased in offshore area of Barnabus Gully and decreased in the inshore areas of Kiliuda and Ugak Bays. Below average anomaly values for arrowtooth flounder and flathead sole were recorded again in 2015 for both inshore and offshore areas, while Pacific halibut and skates were above average only in the offshore stations. Pollock, Pacific cod, and Tanner crab anomaly values were all below average for both areas (p. 94).
- A new regime shift indicator based on 17 biological time series from the GOA shows three distinct trends, but none provide support for a recent regime shift (p. 99).
- Total CPUE in the western GOA bottom trawl survey has varied over time with lowest abundances estimated to have occurred in 1999 and 2001, but with no significant trend from 1993 to 2015. CPUE in the eastern GOA significantly increased over time (p. 102).
- Species richness and diversity are generally higher in the eastern Gulf of Alaska than in the western Gulf. Both richness and diversity tend to be highest along the shelf break and slope, with richness peaking at or just below the shelf break (200-300m), and diversity peaking deeper on the slope as well as in shallow water. Diversity in the eastern Gulf has been declining since 2007 (p. 105).
- Some “mushy” halibut were reported during the 2016 fishing season (p. 108).
- *Ichthyophonus*, a non-specific fungus-like protozoan fish parasite, has caused epizootic events among economically important fish stocks including herring and salmon. Recent research found that of the fish sampled in lower Cook Inlet, 23% had *Ichthyophonus* in 2012, and 29% had *Ichthyophonus* in 2013. However, findings did not support the hypothesis that reduced halibut size-at-age may be caused by *Ichthyophonus* (p. 108).

## Fishing and Fisheries Trends

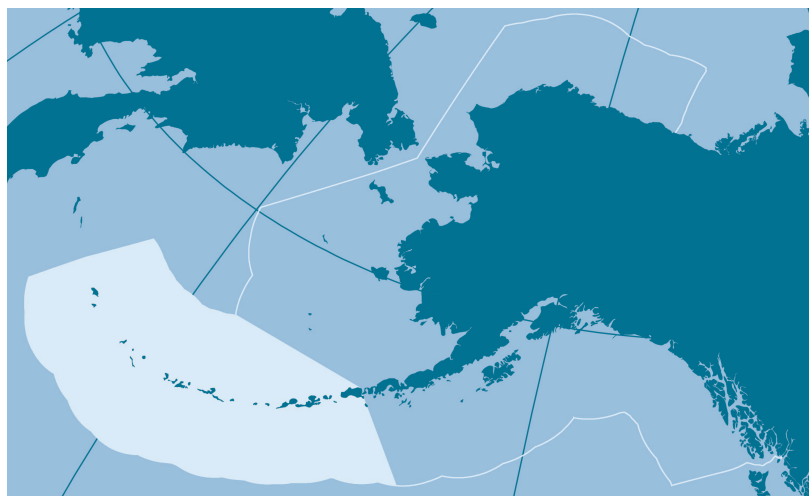
- The total catch of non-target species groups in commercial groundfish fisheries has been variable in the GOA. Catches of Scyphozoan jellyfish, structural epifauna, and assorted invertebrates all increased in 2015 relative to 2014, with the invertebrate catch (primarily sea stars) the highest in the time series (p. 110).
- The numbers of seabirds estimated to be bycaught in Gulf of Alaska fisheries in 2015 increased from that in 2014, but remained below the 2007-2014 average (p. 111).



- At present, no BSAI or GOA groundfish stock or stock complex is subjected to overfishing, and no BSAI or GOA groundfish stock or stock complex is considered to be overfished or to be approaching an overfished condition. The only crab stock considered to be overfished is the Pribilof Islands blue king crab stock, which is in year 2 of a new rebuilding plan (p. 119).
- Annual surplus production trend is characterized by occasional 1-3 year periods of high surplus production that far exceed surplus production in most years. Recent peak years include 2001/02, 2007-09 and 2014 (p. 127).
- Total exploitation rates for the groundfish complex have ranged from 2.5-5.8% over the past few decades. Overall exploitation rates have been relatively stable with occasional peaks such as in 1998/99 and in 2014 (p. 127).
- The pattern of changes in the total number of vessels harvesting groundfish and the number of vessels using hook and line gear have been very similar since 1992. Numbers of hook and line vessels have steadily decreased, then have remained stable in the past three years. Trawl vessels have also decreased over time. Numbers of jig and pot vessels have varied, but with no overall trend (p. 130).
- Human populations within 25 miles of the coast in the Gulf of Alaska have increased steadily to 450,461 people total in 2015. However 43% of communities experience population declines between 1990 and 2015 (p. 132).
- Unemployment rates in the GOA, from 1990 to 2015, were lower than state and national rates with the exception of the year 2000 when the GOA unemployment rate was 4.5%; higher than the national rate of 4.0% (p. 132).

# Ecosystem Considerations 2016

## Status of the Aleutian Islands Marine Ecosystem



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November 14, 2016  
North Pacific Fishery Management Council  
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Anchorage, AK 99301

# Aleutian Islands 2016 Report Card

## Region-wide

- **Biomass of pelagic forager and apex fish predator foraging guilds decreased across the region** between the 2014 and 2016 surveys, although patterns varied among species. The overall decrease **may indicate a response to the warmer water, such as poor condition or habitat shift, or reflect high variances commonly observed in estimated biomass among survey years.**
- The largest total biomass of both apex predators and pelagic foragers is located in the Central Aleutians, the region with the largest shelf area shallower than 500m. The lowest apex predator biomass is located in the Western Aleutians whereas that of pelagic foragers is found in the Eastern Aleutians.

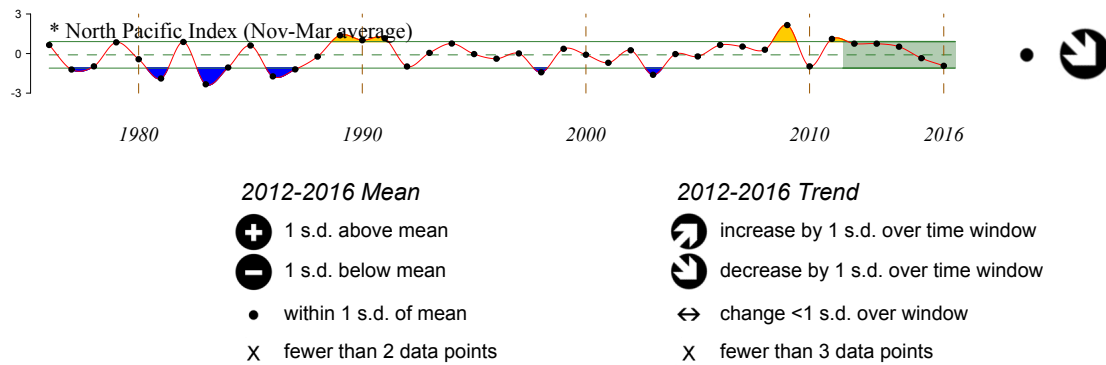


Figure 1: The winter North Pacific Index time series. \* indicates time series updated in 2016.

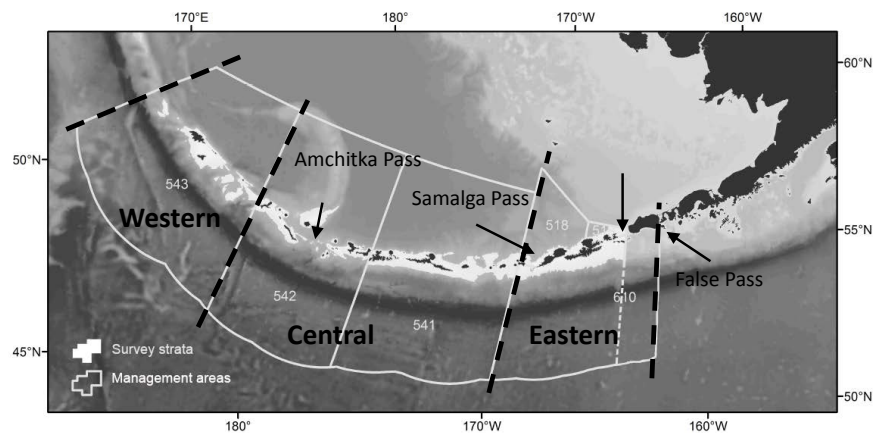
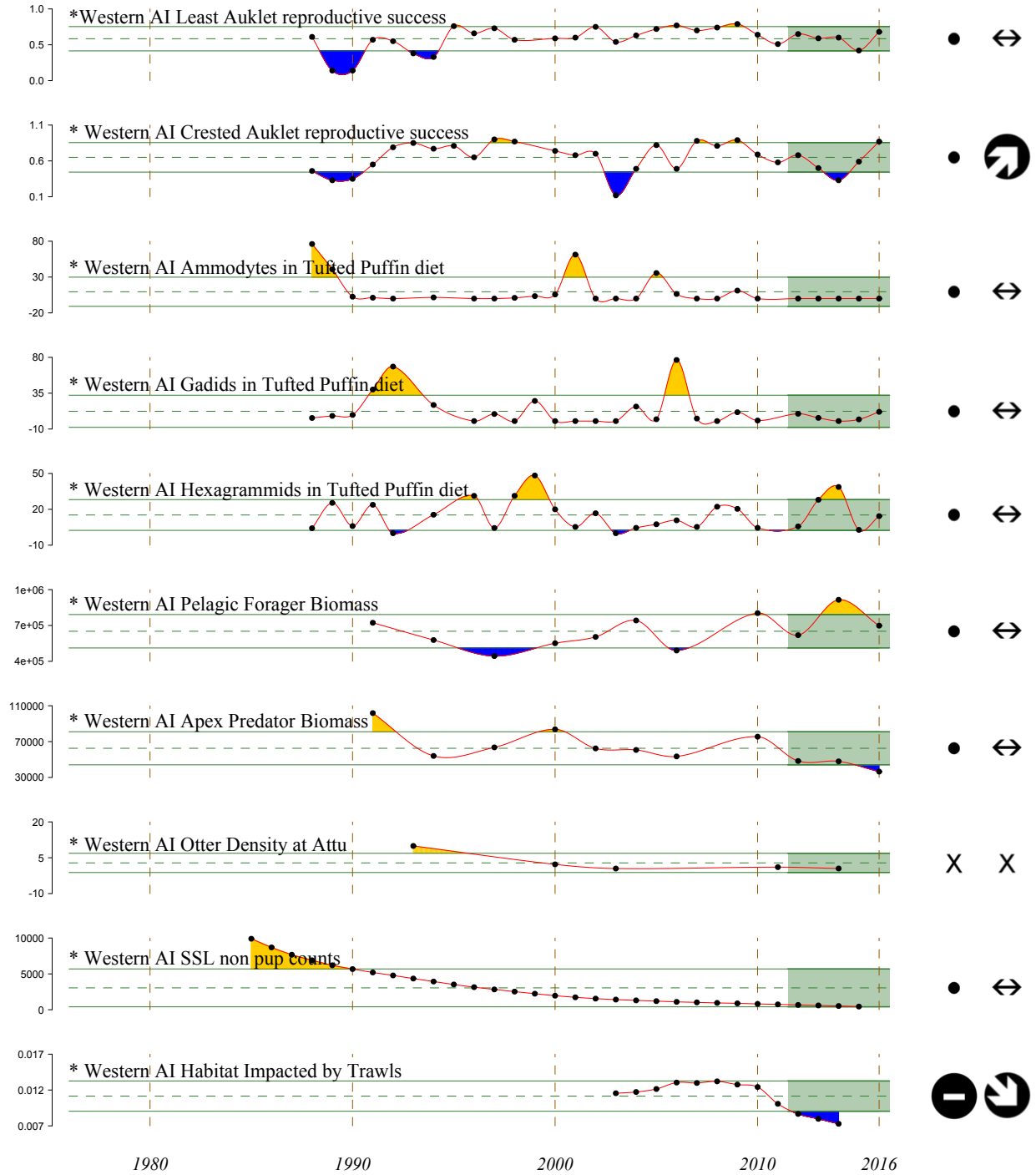


Figure 2: The Aleutian Islands ecoregions.

## Western Aleutian Islands Ecoregion 2016

- The reproductive success of planktivorous least auklets increased in 2016 relative to 2015, and that of crested auklets has continued to increase from the low level seen in 2014. Crested auklets rely more on euphausiids than the copepod-specialist least auklets, thus **we can speculate that overall zooplankton availability was sufficient to support greater than average reproductive success in 2016.**
- 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 were at the long term average in 2016. The **number of hexagrammids (likely age-0 Atka mackerel) were also at the long-term average in 2016, in contrast to the recent peak years of 2013-2014, possibly indicating favorable recruitment in those years.**
- 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 2015 counts were the lowest in the time series.



#### 2012-2016 Mean

⊕ 1 s.d. above mean

⊖ 1 s.d. below mean

• within 1 s.d. of mean

X fewer than 2 data points

#### 2012-2016 Trend

↗ increase by 1 s.d. over time window

↘ decrease by 1 s.d. over time window

<=> change <1 s.d. over window

X fewer than 3 data points

Figure 3: Western Aleutian Islands ecoregion indicators. \* indicates time series updated in 2016.

# Central Aleutian Islands Ecoregion 2016

- The most recent density estimates of sea **otters declined** from the last survey in 2011, continuing a pattern of mostly below-average abundance since 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.
- **School enrollment has shown no trend** in recent years, following a decline since peak enrollment in 2000, and potentially indicating stability in the residential communities.

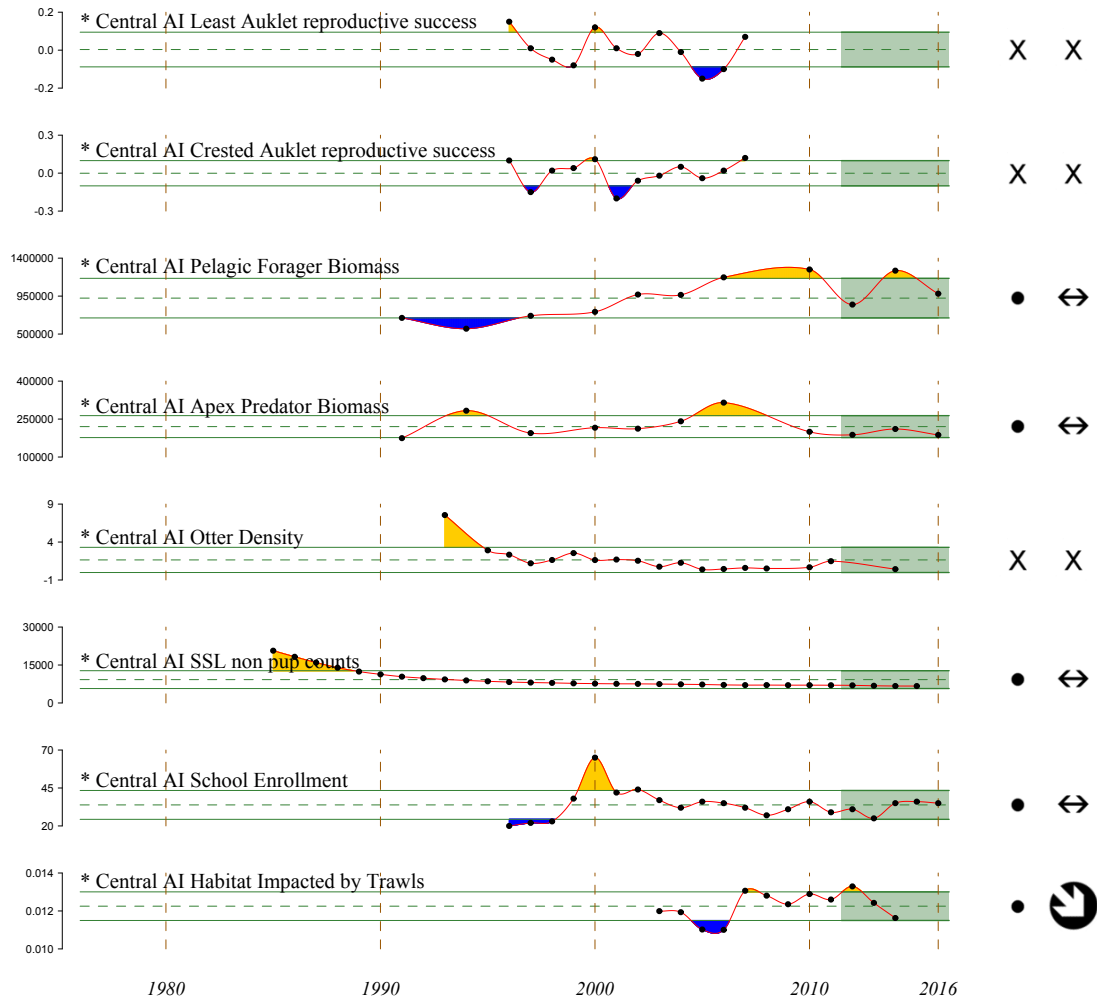


Figure 4: Central Aleutian Islands ecoregion indicators. \* indicates time series updated in 2016. See Figure 3 for legend.

# Eastern Aleutian Islands Ecoregion 2016

- Relative abundances of **gadids and *Ammodytes*** in prey brought back to feed puffin chicks **have shown opposite trends, although both increased from 2015 to 2016**. **Age-0 gadids, sand lance, and hexagrammids were near the long-term average in 2016**. Chick-provisioning patterns suggest puffins are responding to changes in forage fish availability.
- 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 dropped substantially in 2016, leading to a recent declining trend following a peak in 2013**. It is unknown if this number represents a shift in community structure, or simply demographic variability.

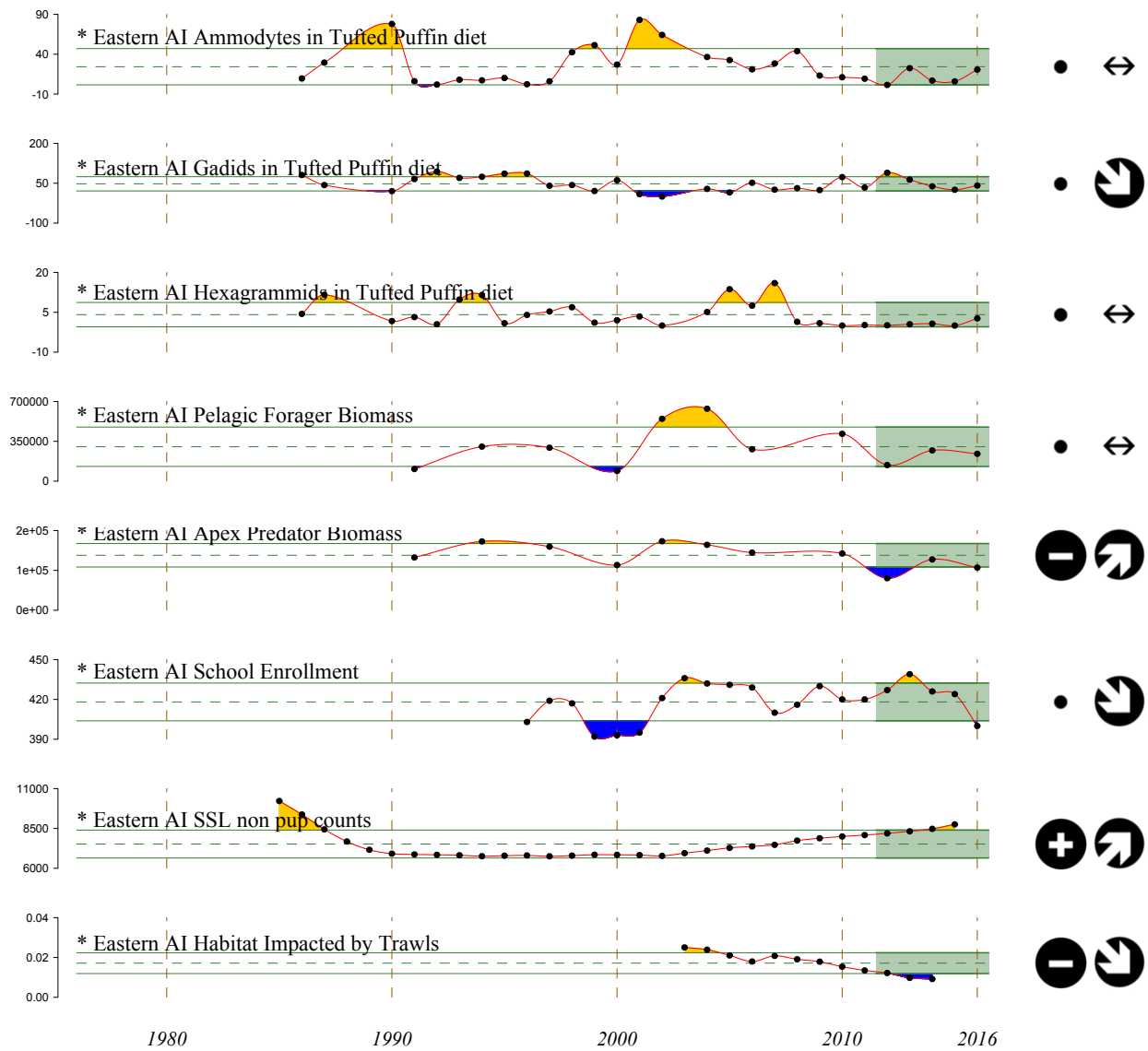


Figure 5: Eastern Aleutian Islands ecoregion indicators. \* indicates time series updated in 2016. See Figure 3 for legend.

# 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 state of the North Pacific atmosphere-ocean system during 2015-2016 featured the continuance of warm sea surface temperature anomalies that became prominent late in 2013, with some changes in the pattern (p. 40).
- A strong El Niño developed during winter 2015-2016 (p. 45)
- However, the climate models used for seasonal weather predictions are indicating borderline to weak La Niña conditions for the winter of 2016-17 (p. 47).
- The Pacific Decadal Oscillation (PDO) remained positive during the past year (p. 45).
- The North Pacific Index (NPI) was strongly negative, implying a deeper than normal Aleutian Low, which was accompanied by anomalous winds from the south and relatively warm air along the west coast of North America (p. 45).
- The North Pacific Gyre Oscillation (NPGO) transitioned from negative in 2015 to near-neutral in 2016, implying that flows in the Alaska Current portion of the Subarctic Gyre and the California Current strengthened to normal (p. 45).
- Anomalously positive sea surface temperatures are predicted throughout much of the north east Pacific during the upcoming winter. The magnitude of the anomalies is projected to be greatest in the GOA and eastern Bering Sea (p. 47).
- The North Pacific climate may be in a state of rather low predictability, yet is unlikely that the upcoming winter in Alaska will be as mild as those of the last three years (p. 47).
- Model projections of a muted atmospheric response in the mid-latitudes to the equatorial Pacific during the next two seasons could be a reflection of the enormous amount of extra heat in the upper ocean now present along most of the west coast of North America (p. 47).



## Aleutian Islands

- Waters in the Aleutian Islands region were relatively warm, especially in the fall of 2015 and summer of 2016, in part because of the overall warmth of the North Pacific and in part due to the weather, which featured above normal air temperatures (p. 40).
- Sea surface temperature values cooled to normal during winter and spring 2016 in part due to anomalous winds from northwest in association with extremely low sea level pressure (p. 42).
- The temperature anomaly profiles from the 2016 AI bottom trawl survey appear to be some of the warmest and most pervasive (vertically and longitudinally) recorded to date (p. 51).
- The Alaskan Stream had relatively strong westward flow from late 2015 into 2016, and there were pulses in the strength of the eastward flow associated with the Aleutian North Slope Current (p. 40).
- Eddy energy in the Aleutian Islands region remained low from the fall 2012 through July 2015, indicating the likelihood of smaller than average fluxes of volume, heat, salt, and nutrient fluxes through Amukta Pass, but a small eddy was present in early 2016, likely enhancing these fluxes (p. 49).
- CTD units were used to collect concurrent depth, temperature, salinity, pH, oxygen and turbidity data during most survey hauls of the bottom trawl survey in 2014 and 2016. A summary of temporal and spatial variability is presented. pH was not collected in 2016 due to equipment failure. As more of this data is collected relationships between fish and invertebrate distributions will be explored (p. 55).
- In both 2014 and 2016 there were some areas of low oxygen concentration in the farthest western areas of the survey (p. 55).

## Ecosystem Trends

- The Aleutian islands 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. 58).
- In the Bering Sea region north of the Western and Central Aleutian Islands that is sampled by the continuous plankton recorder, spring diatom abundances and mesozooplankton biomass anomalies were near neutral in 2015. However, the reduced average size of the copepod community suggests numerous, smaller prey items, which may require more work by predators to obtain their nutritional needs (p. 62).
- Likewise, copepod community size anomalies in 2015 were only represented by the fall sampling, but the values were the smallest since 2009 at this time of year (p. 62).
- Jellyfish mean catch per unit effort (CPUE) in the AI bottom trawl survey is typically higher in the western and eastern AI than in other areas. Catches and frequency of occurrence have been steadily increasing across the Aleutian Islands since the 2012 survey in all areas, but are below the “outbreak” abundances seen in 2006 (p. 66).
- Length-weight residuals (a measure of groundfish condition) 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 2014 and 2016 length-weight residuals were negative for almost all species. For northern rockfish, Pacific cod and Pacific ocean perch there has been a declining trend in residuals over the years covered by the survey. Condition in the Western Aleutians appeared to improve between 2014 and 2016 (p. 68).

- The distributions of rougheye rockfish, Pacific ocean perch, and shortraker rockfish have been shallower in the most recent surveys of the Aleutian Islands. Northern rockfish have shown a significant trend in their mean-weighted distribution towards the Western Aleutians. Mean-weighted temperature distributions for all rockfish species were stable within about 1°C over the entire time series. Increases in mean weighted temperature were been observed in 2016, likely because of the increased temperatures observed during the Aleutian Islands surveys (p. 69).
- Benthic communities and non-target species: there has been a decline in eelpout biomass in the western Aleutian Islands over the last three surveys. Poachers occur in a relatively large number of tows across the AI survey area, but mean CPUE trends are unclear. A new shrimp time series was calculated for 2016 and shows generally increasing trends in frequency of occurrence across all areas except the western Aleutian Islands since ~1990 with the exception of a single peak in 2006 in the western Aleutian Islands (p. 74).

## Fishing and Fisheries Trends

- Catch of non-target species: the non-target catch of Scyphozoan jellyfish was ~25% of the catch in 2014, but shows no trend over time. The catch of structural epifauna, primarily sponges, has been variable over time and peaked in 2015. Assorted invertebrate catches have generally trended upward from 2005 to a peak in 2013. The catch of assorted invertebrates dropped considerably from 2013 to 2014 and has remained low in 2015 (p. 77).
- The numbers of seabirds estimated to be bycaught in Aleutian Islands fisheries in 2015 is the highest in the time series, which began in 2007. Numbers increased from  $\leq 200$  to 1,204, exceeding the bycatch in the Gulf of Alaska which is typically higher. The majority of those were Northern fulmars and Laysan albatross, both numbers which were the highest in the time series. In contrast, shearwaters had the second lowest numbers in 2015. This might be related to poor ocean conditions as the increase was Alaska-wide, and seabirds have been reported to attack baited longline gear more aggressively (p. 78).
- At present, no BSAI groundfish stock or stock complex is subjected to overfishing, and no BSAI or GOA groundfish stock or stock complex is considered to be overfished or to be approaching an overfished condition. The only crab stock considered to be overfished is the Pribilof Islands blue king crab stock, which is in year 2 of a new rebuilding plan. None of the non-FSSI stocks are subject to overfishing, known to be overfished, or known to be approaching an overfished condition (Table 7) (p. 87).
- Numbers of hook and line and trawl vessels have steadily declined since 1992. Numbers of jig and pot vessels have varied, but with no overall trend (p. 100).
- As of 2015 the total population of all AI communities was 5,939. 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 had a population of zero in 2015 (p. 95).
- Unemployment rates in the AI, between 1990 and 2015, were lower than state and national rates and has been decreasing in the past few years. This trend is sustained for 2016. The eastern AI had higher unemployment rates than central AI, and western AI data was insufficient to interpret any trends (p. 95).

# Executive Summary of Recent Trends in the eastern Bering Sea

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 Trends

- The state of the North Pacific atmosphere-ocean system during 2015-2016 featured the continuance of warm sea surface temperature anomalies that became prominent late in 2013, with some changes in the pattern (p. 48).
- A strong El Niño developed during winter 2015-2016 (p. 53)
- However, the climate models used for seasonal weather predictions are indicating borderline to weak La Niña conditions for the winter of 2016-17 (p. 55).
- The Pacific Decadal Oscillation (PDO) remained positive during the past year (p. 53).
- The North Pacific Index (NPI) was strongly negative, implying a deeper than normal Aleutian Low, which was accompanied by anomalous winds from the south and relatively warm air along the west coast of North America (p. 53).
- The North Pacific Gyre Oscillation (NPGO) transitioned from negative in 2015 to near-neutral in 2016, implying that flows in the Alaska Current portion of the Subarctic Gyre and the California Current strengthened to normal (p. 53).
- Anomalously positive sea surface temperatures are predicted throughout much of the north east Pacific during the upcoming winter. The magnitude of the anomalies is projected to be greatest in the GOA and eastern Bering Sea (p. 55).
- The North Pacific climate may be in a state of rather low predictability, yet is unlikely that the upcoming winter in Alaska will be as mild as those of the last three years (p. 55).
- Model projections of a muted atmospheric response in the mid-latitudes to the equatorial Pacific during the next two seasons could be a reflection of the enormous amount of extra heat in the upper ocean now present along most of the west coast of North America (p. 55).

## Eastern Bering Sea Trends

- A warm year for 2016 followed the warm years of 2014 and 2015 in response to warm sea temperatures in the northeastern Gulf of Alaska (return of the positive Pacific Decadal Oscillation, PDO) and related higher pressures (p. 57).
- Reduced springtime sea ice extent (p. 48) and reduced summer cold pool extent continued from 2014 through 2016 (p. 57).
- Spring 2016 had the lowest sea ice cover over the Bering Sea shelf in the timeseries and the cold pool was retracted over the northern shelf (p. 57).
- Both surface and bottom temperature means for the 2016 eastern Bering Sea shelf were the highest on record in the 35 year bottom trawl survey time-series (p. 63).
- CTD data collected from EBS slope in 2012 and 2016 showed that 2016 was a much warmer year than 2012 throughout the slope, salinity was generally highest in 2016 and was fairly uniform over the slope, and oxygen concentrations were lower in 2016 than in 2012 (p. 64).
- Temperatures above the MLD were warmer than average for all regions in 2014, but only in 2 regions (Alaska Peninsula and south outer shelf) in 2015 due to fall mixing and deepening of the MLD (p. 69).
- Temperatures below the MLD were warmer than average over the southern shelf in 2014 and 2015 (p. 69).
- The 2016 springtime drift patterns on the southern Eastern Bering Sea shelf appear to be consistent with years of below-average recruitment for winter-spawning flatfish (NRS, ATF, Flathead sole) following a year of above-average recruitment (2015) (p. 72).

## Ecosystem Trends

- In 2016, the relative catch rates for both sponges and sea anemones were significantly lower (p. 74).
- The abundance of corals caught in the EBS slope environment is highly variable: lowest abundance in 2012 and highest abundance in 2016. Sponge abundance was high in 2008 and 2010, significantly decreased in 2012, and increased slightly in 2016 (still below long-term mean). Sea whips had very high abundance in 2010 and 2012 with a significant drop in 2016 to slightly below long-term mean (p. 74).
- In 2016, corals were primarily distributed in the NBS with highest abundance between Zhemchug and Pribilof Canyons. Sponges were abundant and widely distributed along the EBS slope habitat. Sea whips are patchy throughout the slope habitat (p. 77).
- Between 2003-2012, phytoplankton biomass was greatest over the southern outer shelf with large phytoplankton over the inner shelf and near the Pribilof Islands and small phytoplankton over the south middle and outer shelf (p. 81).
- Surface silicate (silicic acid) levels are positively correlated with age-0 Walleye pollock weight; silicic acid and age-0 pollock weights were above-average for 2014 and 2015 relative to 2006-2015 (p. 85).
- Higher coccolithophore levels ( $>10\%$ ) were observed in 2007, 2009, 2011, and 2014 for the middle shelf and in 2011 and 2014 for the inner shelf (p. 87).
- Zooplankton Rapid Assessment (ZRA) in Fall 2015 showed the zooplankton community was dominated by small copepods. Large copepods were seen near M5 and Unimak Pass while euphausiids were rare over the shelf (p. 91).

- ZRA in Spring 2016 showed the zooplankton community still dominated by small copepods over the shelf with large copepods near the outer shelf and some inner domain stations. High percentages of large copepods occurred near M4. Euphausiid juveniles occurred in the inner and middle domains (p. 91).
- ZRA in Early Fall 2016 showed small copepods comprised 99% of the zooplankton community in all samples across all domains while overall sample volumes appeared qualitatively low, relative to past sampling (p. 91).
- ZRA in Late Fall 2016 showed small copepods made up the majority of zooplankton at all stations sampled, with large copepods comprising as much as 20% of the zooplankton at the northern stations on the 70m isobath (p. 91).
- A time series hindcast based on ZRA categories showed agreement with the OCH with warm periods characterized by small copepods and cold periods by large copepods (p. 97).
- Summertime euphausiid density increased on the eastern Bering from 2004-2009, but subsequently declined 2010 through 2016 (2016 is the lowest value in the time series) (p. 98).
- The relative CPUE for jellyfishes in 2016 was a 79% decrease from 2015, and one of the lowest observed since 1989 (p. 103).
- In 2015 in the northern Bering Sea, jellyfish biomass decreased compared to previous years and the dominant species was *Chrysaora melanaster* (p. 104).
- Pacific herring occur in higher abundances during warm years over the EBS shelf, while in cold years they are contracted over a smaller area to the north and nearshore (p. 111).
- Chinook salmon abundance in the Arctic-Yukon-Kuskokwim region has been declining since 2007 and in 2015 Chinook salmon harvests continued to be low (p. 115).
- The 2014 harvest of coho salmon in Bristol Bay was the largest in the last 20 years, while the 2015 catch was considerably less (p. 115).
- The 2014 Bristol Bay sockeye salmon run was 55% above the preseason forecast and was 19% above the previous 20-year average (1994-2013). The 2015 run was 70% above the recent 20-year average and 12% above the preseason forecast (p. 115).
- The 2015 estimate of Canadian-origin juvenile Chinook salmon in the northern Bering Sea was above-average, a continuing trend since 2013 (p. 118).
- The current age-0 pollock energetics model indicates that the 2015 year-class is predicted to have intermediate overwinter survival to age-1 and recruitment success to age-3. In 2015, age-0 pollock may have utilized the cold pool as a refuge which could buffer against recruitment declines (p. 122).
- The energetic content of age-0 pollock diets was lower during the warm years of 2003-2005, intermediate during 2006, and reached higher levels during the cold years of 2007-2012. Diet energy density was intermediate during the warm years of 2014-2015 (p. 124).
- Increased availability of large zooplankton prey is favorable for age-0 pollock survival and recruitment to age-1 (p. 125).
- The Temperature Change (TC) index for the 2014 year class of pollock was below the long-term average, therefore lower than average recruitment to age-1 is expected. The TC index for the 2015 year class was above the long-term average, therefore slightly above average recruitment to age-1 is expected in 2016 (p. 129).
- Below average age-1 pollock recruitment is expected for the 2013-2015 year classes based on 2016 biophysical indices indicating below average ocean productivity (chum salmon growth), warm spring sea temperatures in 2016 (less favorable), and high predator abundances (pink salmon) (p. 131).
- Estimated age-1 natural mortality (based on the CEATTLE model) for Walleye pollock, Pacific cod, and Arrowtooth flounder is high in 2016 (highest in the timeseries since 1979) (p. 132).

- Length-weight residuals (measure of groundfish condition) for all groundfish species (except Arrow-tooth flounder) were less in 2015 than in 2016, indicating larger weight at length in the most recent year (p. 135).
- The 2016 CPUE of eelpouts increased by 26% and CPUE of sea stars increased by 6%. Similar trends occurred for both taxa since 2003, suggesting there may be a relationship between bottom temperature and catch rate (p. 140).
- Biomass of commercial crab stocks is highly variable over the time series with negative trends in 2016 (p. 140).
- Capelin occur in higher abundances during cold years over the EBS shelf, while in the recent warm year of 2014 they are contracted over a smaller area to the north (p. 107).
- A multivariate seabird index indicates later hatch dates for all species and lower reproductive success for cormorants and common murrelets in 2016. The dominant temporal trend among kittiwake reproductive success data continues to be an alternating biennial pattern with decreased reproductive success in 2016 (p. 144).
- The preliminary 2016 pup production estimates for St. Paul and St. George Islands indicate a change between -5.0 and 16.0% on St. George, and a decrease between 10.0 and 15.0% on St. Paul, compared to the 2014 estimates (p. 147).
- Dynamic Factor Analysis using 16 biological time series suggests the eastern Bering Sea has experienced multiple regime shifts, including the well-documented late 1970's regime shift as well as a subsequent shift in 2008 (p. 149).
- Human population of the eastern Bering Sea increased 10.3% between 1990 and 2015, and northern Bering Sea 29.0%, which was lower than State trends (34.1%). However, 41% of eastern Bering Sea communities and 19% of northern Bering Sea communities experienced population decline during this time period because of out-migration (p. 187).
- Alaska maintains high rates of population turnover because of migration; overall population increase has occurred mainly in urban areas such as Anchorage and the Matanuska-Susitna Borough (p. 187).
- Between 2010 and 2014, eastern Bering Sea and northern Bering Sea communities had among the highest rates of intrinsic population increase (1.0-3.0%) yet lowest net migration ( $<0$ ) in the State, with populations largely comprised of Alaska Natives (p. 187).
- Between 1995 and 2015, unemployment rates of northern Bering Sea communities were consistent with, yet higher, than State and National levels, whereas eastern Bering Sea rates were lower. The unemployment rate of eastern Bering Sea communities increased from 1.60 in 1990 to 3.29 in 2015, and northern Bering Sea from 6.89 in 1990 to 12.77 in 2015 (p. 187).
- Total CPUE from the EBS trawl survey shows a long-term increase from 1982-2005, followed by a decrease from 2005 to 2009, increased CPUE in 2010-2013, and a substantial increase in 2014 to the highest observed value in the time series. The increase in total CPUE in 2014 was largely due to an increase in Walleye pollock catches in the bottom trawl survey (p. 154).
- Species richness and diversity on the EBS shelf have undergone significant variations from 1982 to 2016. Both richness and diversity decreased through 2014 with a moderate increase in 2015/2016 and a large and significant increase in Shannon diversity in 2016. Richness tends to be highest along the 100 m isobath, while diversity tends to be highest on the middle shelf (p. 156).
- Both the latitudinal and depth distribution of the demersal community on the eastern Bering Sea shelf show significant distributional shifts to the north and into shallower waters. There was a gradual shift to the north from 2001 to 2005, which reversed only slightly as temperatures cooled after 2006. From 2009 through 2015, the average center of gravity has shifted between deeper and shallower waters along a SW-NE axis and was further NE and shallower in 2015/2016 than in any previous year and, in 2016, was considerably further North than in any previous year since the survey has been standardized (p. 158).

## Fishing and Fisheries Trends

- Discard rates in the Bering Sea pollock trawl sector declined to 1% in 1998 and have remained low; in the fixed gear sector, discard rates have fluctuated between 10% and 14% since 1996 (p. 161).
- Non-target species catch has been highest in the EBS compared to GOA and AI ecosystems. The catch of jellyfish peaked in 2014 then dropped by more than half in 2015. Years of high jellyfish catch are typically followed by sharp drops the following year. The catch of assorted invertebrates decreased between 2003-2009 and has generally increased between 2010-2015 (p. 163).
- The number of seabirds caught incidentally in EBS fisheries in 2015 increased from 2014, but remained below the 2007-2014 average. No short-tailed albatross and few black-footed albatross were caught. The estimated numbers of birds caught incidentally in the EBS exceeded that in the GOA and AI (p. 166).
- Habitat impacts due to fishing gear (pelagic and non-pelagic trawl, longline, and pot) interactions have decreased steadily from 2008 through December 2014 in the Bering Sea (p. 169).
- As of 2016, with the Arctic FMP closure included, almost 65% of the U.S. EEZ of Alaska is closed to bottom trawling (p. 170).
- As of June 30, 2016, no BSAI or GOA groundfish stock or stock complex is subjected to overfishing or is considered to be overfished or approaching an overfished condition. The only crab stock considered to be overfished is the Pribilof Islands blue king crab stock, which is in year 2 of a rebuilding plan (p. 175).
- Annual Surplus Production levels were low in 2004-2007 and relatively high in more recent years, largely driven by fluctuations in walleye pollock. Excluding walleye pollock, non-pollock surplus production has also been moderately high in the most recent time period (p. 182).
- The number of vessels participating in federally-managed fisheries off Alaska has generally decreased since 1992, though participation has remained relatively stable in recent years. Participating vessels are largely those using hook and line or jig gear ( 600 such vessels in 2015). The number of trawl-gear vessels has decreased steadily to around 180 in each of the last 5 years. Pot-gear activity has steadily declined, with 154 pot vessels active in 2015 (p. 186).