



Gulf of Alaska Ecosystem Assessment

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We present an initial Gulf of Alaska Report Card this year. The report card follows the format of those for the eastern Bering Sea and Aleutian Islands. This associated ecosystem assessment defines the report card indicators, describes how they were selected, and provides a synthesis of the current state of the Gulf of Alaska ecosystem based on the report card indicators as well as other indicators.

The Gulf of Alaska is characterized by topographical complexity, including: islands; deep sea mounts; continental shelf interrupted by large gullies; and varied and massive coastline features such as the Cook Inlet, Prince William Sound, Copper River, and Cross Sound, which bring both freshwater and nutrients into the GOA. The topographical complexity leads to ecological complexity, such that species richness and diversity differ from the western to eastern Gulf of Alaska. Thus, local effects of ecosystem drivers may swamp basin-wide signals. With this in mind, our goal was to create a short list of ecosystem indicators that best reflect the complexity of the Gulf of Alaska. Although there are many more people living in both large and small communities throughout the Gulf of Alaska relative to the Aleutian Islands or eastern Bering Sea, we consider the Gulf of Alaska to be data-moderate relative to the Aleutian Islands (data-poor) and eastern Bering Sea

(data-rich).

During 2014 and 2015, we used an online survey format to solicit opinions from ecosystem experts on the most appropriate indicators to include in the report card. The purpose of this format was to increase the group size and diversity in GOA expertise of the participants in the indicator selection process by soliciting information online. In the past, we had broadened the expertise of the team developed to select the Aleutian Islands indicators relative to the eastern Bering Sea team based on comments from the Scientific and Statistical Committee of the North Pacific Fisheries Management Council. We hope that by surveying a greater number of individuals than were involved with indicator selection for the eastern Bering Sea and Aleutian Islands, the survey results reflect broader expertise and an “equal voice” from all participants. We plan to review and refine these indicators in conjunction with the NPRB-sponsored GOA IERP synthesis team this coming winter. The survey was conducted under the requirements of the Paperwork Reduction Act.

Indicators

Top-ranked indicators were selected for each category: physical, plankton, benthic, forage fish, non-forage fish, seabirds, marine mammals, and humans. We include two physical and plankton indicators and one from each of the other categories. There is one set of indicators for the entire Gulf, although further refinement may include separate components to represent smaller scales such as west vs east. The final list on indicators in this report card includes:

1. The winter Pacific Decadal Oscillation
2. Fresh water input
3. Mesozooplankton biomass
4. Copepod community size
5. Motile epifauna biomass
6. Capelin abundance
7. Apex predator biomass
8. Black-legged kittiwake reproductive success
9. Steller sea lion non-pup estimates
10. Human population

Winter Pacific Decadal Oscillation

Fresh water input The GAK 1 oceanographic station is located at the mouth of Resurrection Bay near Seward. Temperature and salinity versus depth profiles have been taken there since December, 1970. Although the GAK 1 time series has been used as a measure of freshwater discharge in the past, the salinity there is affected by a number of factors, including wind mixing, evolution of stratification, and shelf advection. Thus, there is need for a better indicator, which may come available as a very high resolution discharge hind-caste (Seth Danielson, pers. comm.).

The GAK 1 discharge time series is a very low-resolution “model” (estimate) of discharge that accounts for little more than monthly mean air temperatures over the GOA drainage basin, estimated precipitation, and some seasonal lags. The data are the annually-average monthly discharge value for each calendar year. There is a new, very high resolution discharge hind-cast model by David Hill at Oregon State University that uses a snowpack model, elevations, reanalysis precipitation and streamflow routing and is tuned against USGS discharge measurements. This model is at about 1 km resolution and provides hourly estimates all along the GOA coast. We hope use this model to improve this indicator in the next edition.

Mesozooplankton biomass Mesozooplankton biomass is estimated from taxon-specific abundance data collect from Continuous Plankton Recorders (CPRs). These have been deployed in the North Pacific routinely since 2000. The transect for the region known as the Alaska Shelf is sampled monthly (~Apr-Sept) and presented here. Anomaly time series of each index are calculated as follows: A monthly mean value (geometric mean) was first calculated. Each sampled month was then compared to the mean of that month and an anomaly calculated (Log_{10}). The mean anomaly of all sampled months in each year was calculated to give an annual anomaly.

Copepod Community size Mean Copepod Community Size (Richardson et al., 2006) as sampled by Continuous Plankton Recorders is presented as an indicator of community composition. The methods used to calculate this indicator is listed above for mesozooplankton biomass.

Motile epifauna biomass The NOAA bottom trawl survey has been conducted triennially since 1984, and biennially since 2000. The motile epifauna foraging guild is calculated from the survey data modified by an ecopath-estimated catchability. This guild includes: eelpouts, octopi, crab, sea stars, brittle stars, sea urchins, sand dollars, sea cucumbers, snails, and hermit crabs. This indicator is presented to reflect the trends in the benthic community of the Gulf of Alaska.

Capelin relative abundance These data represent the percent prey composition (for each prey type, percentage of the total number of prey items) that was capelin in diets of tufted puffin chicks at East and West Amatuli islands, Alaska. Samples (“bill-loads”) were collected from burrow screening or found at burrows during chick growth and productivity monitoring by Alaska Maritime National Wildlife Refuge staff, U.S. Fish and Wildlife Service.

Apex predator biomass The NOAA bottom trawl survey has been conducted triennially since 1984, and biennially since 2000. The apex predator foraging guild is calculated from the survey data modified by an ecopath-estimated catchability. Fish in this guild include: Pacific cod, arrowtooth

flounder, halibut, sablefish, large sculpins, and skates. Marine mammals, seabirds, and some other fishes such as sharks are included as constant ecopath-estimated biomasses.

Black-legged kittiwake reproductive success Black-legged kittiwakes are common surface-foraging, piscivorous seabirds that nest in the Gulf of Alaska. Reproductive success is defined as the proportion of nest sites with fledged chicks from the total nest sites that had eggs laid. Reproductive success of this species is considered to be more sensitive to foraging conditions than that of common murre, another common seabird that has less variable reproductive success due to behaviors that can buffer the effects of poor food supply. Data are collected by the Alaska Maritime National Wildlife Refuge staff, U.S. Fish and Wildlife Service.

Steller sea lion non-pup estimates The agTrend model was used to produce abundance estimates of Steller sea lions within the bounds of the Gulf of Alaska. This region includes the ranges of two distinct populations, the western and eastern, which have shown different population trends. The eastern population has been increasing at a greater rate than the Gulf of Alaska portion of the western population. We present the sum of these distinct populations for this edition, but may revise this in the future.

Human population The combined populations of Homer, Kodiak, Sitka and Yakutat as used to represent the health of the human communities closely associated with the marine ecosystem of the Gulf of Alaska. Data are from the Alaska Population Estimates by Borough, Census Area, City and Census Designated Place (CDP), 2000-2010, and 1990 - 2009, found at the Alaska State Labor Statistics <http://laborstats.alaska.gov/index.htm>. This indicator could be refined in the future to better represent the human populations that are directly influenced by fishing and/or ecosystem state. Attributes of an improved indicator include representation of trends in rural communities (that can be swamped by signals from larger communities), responsiveness to environmental changes, and availability at annual time scales.

Current Environmental State

The current environmental state in the Gulf of Alaska is notable for the anomalously warm surface water present since early 2014. This began as the “Warm Blob” in the NE Pacific and has seen some evolution in its pattern since that time, related in part to sea level pressure and wind anomalies. The upper ocean has remained fresher than usual with a relatively strong pycnocline, also continuing conditions first seen in early 2014. The sub-arctic front in 2015 was farther north than usual, which is consistent with the poleward surface currents shown in the Ocean Surface Currents - Papa Trajectory Index section (see p. 115). The coastal wind anomalies were generally downwelling favorable during fall and winter 2015 but switched to more upwelling favorable during the spring and summer, resulting in more moderate SST anomalies along the coast as compared with the much warmer than normal water offshore by summer 2015. The PDO switched to a positive phase in 2014 and reached record positive values during winter 2015. An El Niño has developed along the equator and is predicted to be strongly positive during the upcoming 2015/2016 winter. These two

changes in climate indices signal potential shifts in ecosystem state, some of which may be observed immediately (e.g., range shifts in upper trophic organisms) and some which may be expected to be observed at a lag (e.g., recruitment of upper trophic organisms).

Notable observations during 2015 summer surveys which may or may not be attributed to the anomalously warm conditions and/or shifts in climate include: increased Pacific pomfret abundance; these pomfret were eating age-0 rockfish and sablefish; coho salmon were eating the abundant young sablefish; the second highest Icy Strait temperature was recorded; juvenile pink and coho salmon showed early outmigration; the largest body size of juvenile pink and coho on record was observed; pteropods (*Limacina*) were abundant; large ocean sunfish (*Mola mola* 900 lbs and 400 lbs) were caught in June and July; and unusual catches of Pacific saury and market squid. In addition, there was an Unusual Mortality Event for marine mammals declared as elevated numbers of dead large whales were found on beaches or floating at sea throughout the western Gulf of Alaska (see p. 54). One suspected cause is a harmful algal bloom, although this is currently under investigation. Also, while seabirds showed mostly poor reproduction in the Gulf of Alaska, there was not complete failure. However, many birds showed signs similar to that of toxicosis (H. Renner, pers. comm.). Carcasses are being analyzed to determine cause of mortality.

The NOAA summer bottom trawl survey is conducting biennially over a large part of the Gulf of Alaska shelf. However, some catch patterns align closely with those of the annual bottom trawl survey conducted by ADF&G over a more restricted area, Barnabus Gully. For example, both arrowtooth flounder and Pacific halibut appear to have increased in abundance until approximately 2003, after which there has been a general declining pattern. Both species increased in the NOAA survey in 2015 relative to 2013; 2015 results were not available for the ADF&G survey in time for this report.

Despite some increase in catch rates, groundfish condition, as indicated by length-weight residuals from the NOAA bottom trawl survey, were negative overall for all sampled species in 2015. The only areas with positive residuals were for pollock and arrowtooth flounder in southeast Alaska and Pacific cod in the Yakutat region. Age-1 pollock also showed some positive residuals by area, but remained negative overall. The reoccurrence of “mushy” halibut syndrome in 2015 provides additional supportive evidence for poor conditions for groundfish in the Gulf of Alaska. The condition is considered a result of nutritional myopathy, and thus may be indicative of poor prey conditions for halibut.

Indications of the relatively low quality of foraging conditions for groundfish, including for young of the year, are suggested in the rapid zooplankton counts, conducted for the first time this year. Abundances of the small copepods were several orders of magnitude higher than either large copepods or euphausiids. Survey stations in areas of relatively cooler water had higher large zooplankton proportions and abundances. These spatial patterns are consistent with a lower trophic response to the thermal patterns in the Gulf. Summer acoustic surveys indicated that euphausiid abundance during 2015 was slightly lower than that during 2013. Possible factors that could influence trends in abundance include bottom up forcing by temperature or top down forcing by predation, but neither appear to explain these trends in the Gulf of Alaska (Simonsen et al., in press). Few age-0 pollock were observed during late summer surveys, corresponding with the low number of pollock larvae observed earlier during spring. Thus, the current assessment of the 2015 pollock year class appears to be very small.