FEP proto Ecosystem Health Report Card for Ecosystem Objectives 4 and 5

General instructions:

One paragraph for each indicator that includes a brief description of what the indicator is, what we think it indicates, and what are the data source(s), followed by a description of the indicator status and trend. Each indicator should have a time series plot (could be ticker tape), and possibly include a second plot (e.g., radial plot).

FEP Ecosystem Objectives

4. Maintain key predator/prey relationships
5. Conserve structure and function of ecosystem components.

Indicator Status and Trends

Apex predators

The biomass of apex predators in 2021 is below their long term mean. The trend in the apex predator guild is largely driven by Pacific cod whose current (2016–2021) mean biomass is below their long term mean (1982–2021). In contrast, the current mean biomass of arrowtooth flounder, sablefish, and Alaska skate are all above their long-term means.

Benthic foragers

Benthic foragers are at their lowest biomass over the times series, more than one and a half standard deviations below 1982–2021 levels. Dominant species in the benthic foragers guild include yellowfin sole and northern rock sole, both of whom in 2021 are below their long-term means.

Motile epifauna

The biomass of motile epifauna peaked in 2017 and remains above their long term mean in 2021. Collectively, brittle stars, sea stars, and other echinoderms account for more than 50% of the biomass in this guild and current (2016–2021) mean biomass for all three of these functional groups are well above their long term means. The current mean biomass for all crab functional

groups, including hermit crabs, king crabs, tanner crab, and snow crab are all below their long term means.

Pelagic foragers

The biomass of the pelagic forager guild was generally stable from 2016 to 2019, but dropped in 2021 to their second lowest value over the time series (1982–2021). The trend in the pelagic forager guild is largely driven by walleye pollock who on average account for more than 66% of the biomass in this guild. In 2021, the survey index for pollock was the third lowest over the time series. With the exception of Pacific herring, the 2021 index for all other species and functional groups in the pelagic forager guild were below their long term means.

Pollock biomass

The biomass of pollock is down from 2019 to 2021 and is at its third lowest value over the time series, more than one standard deviation below the long term mean.

Pelagic:demersal fish ratio

The pelagic:demersal fish ratio has declined from 2019 to 2021 and is more than one standard deviation below the long-term mean. This is largely driven by declines in walleye pollock.

Total biomass

Total biomass is at its fourth lowest value over the time series, having decreased each year from 2015 to 2021, to be now more than one standard deviation below the time series mean. This decline is largely driven by declines in the pelagic foragers guild and benthic foragers guild.

Stability of groundfish biomass

The state of this indicator in 2021 is 6.18, which is down from the series high of 8.54 in 2019. The previous high of 7.90 was observed in 1992, which was followed by a steady decrease to a low of 3.84 in 2002. Since then it gradually increased to a value of 5.84 in 2018 before sharply increasing to its new high in 2019. The status in 2020 is unknown. This indicator is currently above the long term mean of 5.2.

Mean length of groundfish

The mean length of the eastern Bering Sea groundfish community in 2021 is 35.7 cm, down from a peak value of 38.3 cm in 2018, but still above the long term mean of 32.4 cm. The mean length trended upward from 2012 to 2018 and has decreased each survey year since. The status in 2020 is unknown.

Mean lifespan of groundfish

The mean lifespan of the eastern Bering Sea demersal fish community in 2021 is 30.54 years and is the second highest over the time series, just up from 30.53 years in 2019. Mean

groundfish lifespan has generally been stable over the time series with only a small amount of year-to-year variation, and shows no indication of a long-term trend.

Shannon diversity (evenness)

The Shannon diversity index is up in 2021 from 2019 and is nearly equal to the long-term mean.

Pollock catch

The catch of pollock in 2021 is nearly equal to the catch in 2020 and is well above the long-term mean.

Groundfish catch (FMP)

The total catch of federally managed groundfish in the eastern Bering Sea.

Crab catch

The total harvest of crabs has increased each year from 2017 to 2020 but remains below the recent 10 year mean and long term mean. Note: 2021 catch data is incomplete.

Total catch

The total catch in 2020 is down from 2019 but remains above the long-term mean. Note: catch data from 2021 is incomplete.

Shannon index of the catch (evenness)

The Shannon index of the catch has declined each year from 2014–2020 and is below the long-term mean. During this time period the catch of federally managed groundfish, in particular pollock, has remained relatively constant, the catch of commercial crabs has declined. Note: catch data incomplete for 2021.

Mean trophic level of the catch

The mean trophic level of the catch has declined each year from the time series peak value in 2016 to 2021 and is nearly equal to the long-term mean.

Inverse landings over biomass

The inverse landings over biomass decreased each year from 2017 to 2019 and is below the long term mean. The decline in this indicator is largely driven by declines in total biomass from 2015–2019 while total landings have remained relatively constant over this same time period (Note: no biomass data for 2020 and incomplete landings for 2021).

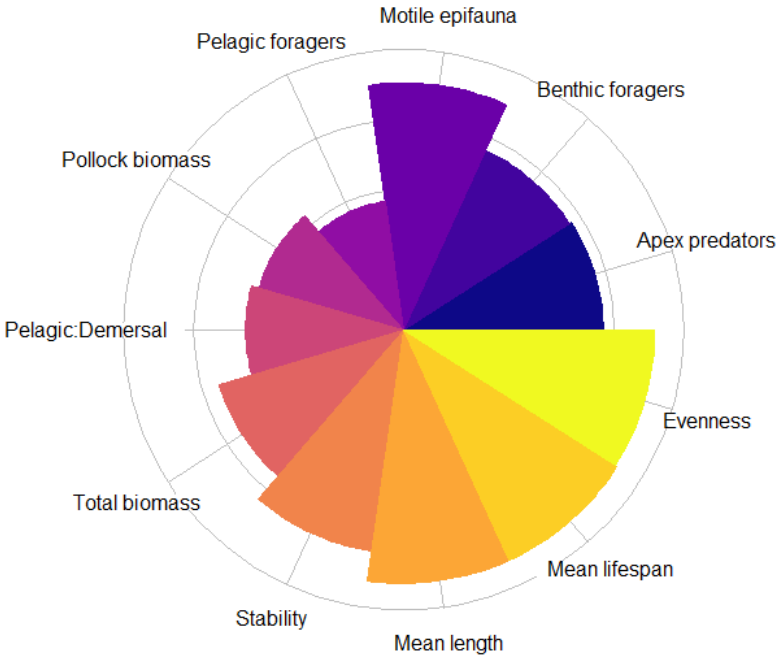

Figure 1. Indicator scores from 2021 for biological indicators based [in part] on trawl survey biomass. Indicator wedge sizes are scaled by area to their maximum value (i.e., 100) over the time series (1982-2021).

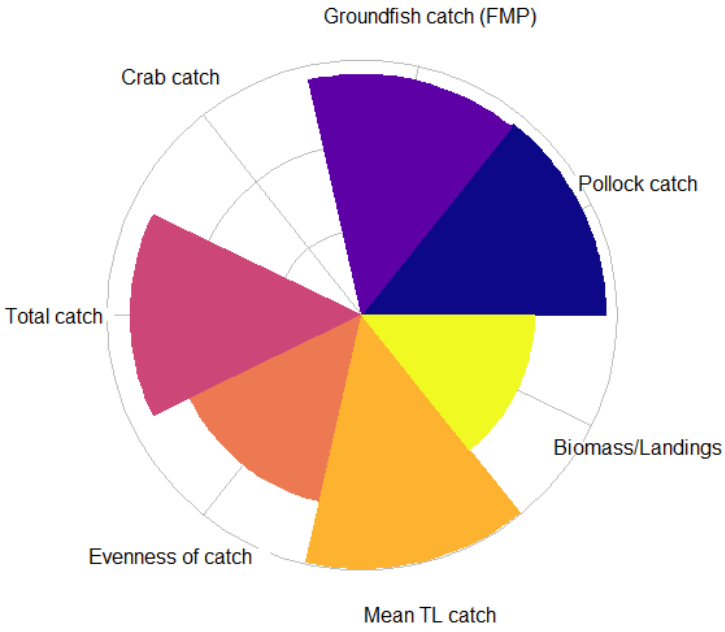

Figure 2. Indicator scores from 2021 for indicators based [in part] on commercial fisheries catch. Indicator wedge sizes are scaled by area to their maximum value (i.e., 100) over the time series (1982-2021). NOTE no crab, herring, or halibut catch reported in 2021.

Indicator definitions

Indicators 1–4 track the aggregate biomass trends of four foraging guilds in the eastern Bering Sea. The status and trends of foraging guilds represent major structural components of the food web, are indicators of predation pressure and prey resources, and the maintenance of predator prey relationships and energy flow in the food web. The biomass of these four foraging guilds represent fish and invertebrates consistently caught in the AFSC annual summer bottom trawl survey. Animals not targeted by or reliably caught in the bottom trawl survey are not included in the foraging guilds, such as infauna, zooplankton, rockfish, seabirds, and marine mammals.

1. **Apex predators:** This guild includes Pacific cod (*Gadus macrocephalus*), arrowtooth flounder (*Atheresthes stomias*), Kamchatka flounder (*A. evermanni*), Pacific halibut (*Hippoglossus stenolepis*), Greenland turbot (*Reinhardtius hippoglossoides*), sablefish (*Anoplopoma fimbria*), Alaska skate (*Bathyraja parmifera*), and several species of large sculpins (*Myoxocephalus* spp., *Hemilepidotus* spp., and *Hemitripterus bolini*). Trends in the biomass of apex predators indicate relative predation pressure on juvenile fishes and forage fishes in the ecosystem.

2. **Benthic foragers:** The species that comprise the benthic foragers guild are greenlings, small sculpins, and several flatfish species, including yellowfin sole (*Limanda aspera*), northern rock sole (*Lepidopsetta polyxystra*), Alaska plaice (*Pleuronectes quadrituberculatus*), flathead sole (*Hippoglossoides elassodon*), dover sole, rex sole, and other miscellaneous flatfishes. Trends in the biomass of benthic foragers are an indicator of the availability of infaunal prey (e.g., bivalves, polychaetes, etc.)
3. **Motile epifauna:** This guild includes both commercial and non-commercial crabs, sea stars, snails, octopuses, other mobile benthic invertebrates such as brittle stars and other echinoderms, and eelpouts. There are ten commercial crab stocks in the BSAI FMP; we include seven found on the eastern Bering Sea shelf; two red king crab *Paralithodes camtschaticus* (Bristol Bay and Pribilof Islands), two blue king crab *P. platypus* (Pribilof district and St. Matthew Island), one golden king crab *Lithodes aequispinus* (Pribilof Islands), tanner crab *Chionoecetes bairdi*, and snow crab *C. opilio*. The dominant species of eelpouts are marbled eelpout (*Lycodes raridens*), wattled eelpout (*L. palearis*), and shortfin eelpout (*L. brevipes*). The composition of seastars in the shelf trawl survey catch is dominated by the purple-orange seastar (*Asterias amurensis*), which is found primarily in the inner/middle shelf regions, and the common mud star (*Ctenodiscus crispatus*), which primarily inhabits the outer shelf. Trends in the biomass of motile epifauna indicate benthic productivity and/or predation pressure, although individual species and/or taxa may reflect shorter or longer time scales of integrated impacts of bottom-up or top-down control.
4. **Pelagic foragers:** This guild consists of walleye pollock (*G. chalcogrammus,* hereafter referred to as pollock), other forage fish such as Pacific herring (*Clupea pallasi*), capelin (*Mallotus villosus*), eulachon (*Thaleichthys pacificus*), and sandlance (*Ammodytes* sp.), atka mackerel (*Pleurogrammus monopterygius*), salmon, and Scyphozoid jellies. Trends in the biomass of pelagic foragers indicate relative predation pressure on zooplankton. The biomass of pelagic foragers largely track the biomass of pollock, which is important both as predator and as prey.
5. **Pollock biomass:** Pollock are the biomass dominant species of groundfish in eastern Bering Sea and are a critical node in the food web as both a predator of lower trophic levels and as prey for apex predators such as seabirds and marine mammals. The status and trends in pollock biomass indicate predation pressure on and availability of zooplankton prey, and the availability of prey to piscivorous predators.
6. **Pelagic fish: Demersal fish biomass ratio:** This is the biomass ratio of the pelagic forager guild to the sum of the benthic forager guild, the apex predator guild, and eelpouts. The pelagic forager guild includes pollock which are a biomass dominant species in the eastern Bering Sea. This ratio provides an indicator of ecosystem structure and fishing pressure (Fulton et al. 2005). This ratio may increase as a result of increasing pollock and/or other pelagic biomass or as a result of decreasing demersal fish biomass.
7. **Total biomass:** This indicator is the sum of biomass from five foraging guilds, including apex predators, benthic foragers, pelagic foragers, and motile epifauna which are reported separately in this report card, and the structural epifauna guild, which consists of sessile invertebrates that are consistently caught in the AFSC summer bottom trawl

survey such as anemones, corals, sponges, tunicates, sea pens, and sea whips. Total biomass is an indicator of the overall resource potential of the community and overall productivity of the portion of the community available to the trawl survey.

8. **Stability of groundfish biomass (1/[CVBiomass]):** The stability of the groundfish community total biomass is measured with the inverse biomass coefficient of variation (1/CV[Biomass]). 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 to fishing and is expected to increase with increasing fishing pressure (Blanchard and Boucher 2001). The CV is the standard deviation of the groundfish biomass index over the previous ten years divided by the mean over the same time span (Shin et al. 2010). Since 10 years of data are required to calculate this metric, the indicator values start in 1991, the tenth year in the trawl survey time series (1982–2021). 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.
9. **Mean length of the groundfish community:** 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). This indicator is also sensitive to shifting community composition of species with different mean sizes. Mean lengths are calculated for groundsh species (or functional groups of multiple species; e.g., eelpouts) from the length measurements collected during the annual summer bottom trawl survey. The mean length for the groundsh community is calculated with the species mean lengths, weighted by biomass indices (Shin et al., 2010) calculated from the bottom-trawl survey catch data.
10. **Mean lifespan of the groundfish community:** The mean lifespan of the groundfish community is a proxy for the turnover rate of species and communities and reflects the resistance of the community to perturbations (Shin et al. 2010). Lifespan estimates of groundsh species regularly encountered during the NMFS/AFSC annual summer bottom trawl survey of the eastern Bering Sea were retrieved from the AFSC Life History Database. The groundsh community mean lifespan is weighted by biomass indices calculated from the bottom trawl survey catch data.
11. **Shannon diversity index (Evenness):** The Shannon diversity index provides a measure of biodiversity in the surveyed community. In the context of the functional groups used in the survey index, the total number of species is largely fixed. This reduces the Shannon index to a measure of evenness (Suprenand and Ainsworth 2017). This indicator would decrease in years when a small number of species dominate the biomass or would increase when there is increasing evenness across species.
12. **Pollock catch:** The harvest of pollock is the largest single species catch in the eastern Bering Sea and typically accounts for greater than 50% of the total catch of federally managed groundfish. The catch of pollock is a measure of fishery productivity and fishery pressure on the ecosystem.
13. **Groundfish catch (FMP):** The total catch of federally managed groundfish stocks (BSAI FMP stocks) in the eastern Bering Sea. Data are from the BSAI SAFE, 2021.

14. **Crab catch:** This is the aggregate harvest and bycatch (with respective mortality rates applied) of seven commercial stocks of crabs found on the eastern Bering Sea, including Bristol Bay red king crab, Pribilof Islands red king crab, Pribilof Islands blue king crab, St. Matthew Island blue king crab, Pribilof Islands golden king crab, tanner crab, and snow crab. Data on catch and bycatch are retrieved from the single species stock assessments. The harvest of crabs provides an indicator of the fishing pressure on the benthic community and the productivity of the benthic environment.
15. **Total catch:** The aggregate catch of federally managed groundfish fisheries, Pacific halibut, Pacific herring, and commercial crab species in the eastern Bering Sea. This indicator provides a measure of the relative fishing pressure on the ecosystem.
16. **Shannon diversity of total catch (Evenness):** Applying the Shannon diversity index to the catch provides a measure of evenness of the catch across targeted species. Since the number of targeted species is fixed, this index reduces to a measure of evenness (Suprenand and Ainsworth 2017). This indicator will decrease when a small number of species increasingly dominate the total catch and it will increase when the catch is spread more evenly across a greater number of species.
17. **Mean TL of the catch (groundfish, halibut, herring, and crabs):** This indicator is the mean TL of exploited species weighted by their landings (Shin et al. 2010). This indicator will increase if higher trophic level species are increasingly exploited and it will decrease if fisheries are targeting more lower trophic level species. The trophic levels used to calculate this indicator were acquired from an Ecopath model of the eastern Bering Sea (Aydin et al. 2007).
18. **Inverse landings over biomass (1/[Landings/Biomass]) of retained species (groundfish and crabs):** The inverse level of exploitation is a measure of resource potential because it is specific to the parts of the ecosystem that are targeted by fisheries (Shin et al. 2010). The ratio of Landings: Biomass is inverted so the indicator will decrease under increasing fishing pressure and increase when biomass is increasing. The indicator includes landings and biomass of all federally managed groundfish stocks, Pacific halibut, Pacific herring, seven stocks of king crabs found on the Bering Sea shelf, tanner crab, and snow crab. Landings data are taken from the Catch Accounting System and/or stock assessment documents for federally managed groundfish, the International Pacific Halibut Commission for Pacific halibut, the Alaska Department of Fish and Game for Pacific herring, and from stock assessments for all crab stocks. Estimates of biomass are based on the catch of the AFSC summer bottom trawl survey.
19. Primary Production (still need this)