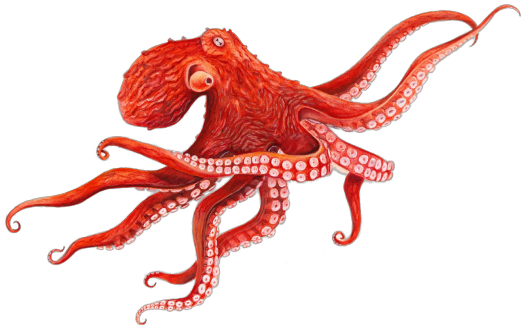
# Giant Pacific Octopus

*Enteroctopus dofleini*



## Alaska: Bering Sea & Gulf of Alaska, British Columbia: Northeast Pacific Pots

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Seafood Watch Standard used in this assessment: Fisheries Standard v3

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# About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Watch Assessment. Each assessment synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." This ethic is operationalized in the Seafood Watch standards, available on our website here. In producing the assessments, Seafood Watch seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying assessments will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Watch assessments in any way they find useful.

# Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished[1] or farmed that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following guiding principles illustrate the qualities that fisheries must possess to be considered sustainable by the Seafood Watch program (these are explained further in the Seafood Watch Standard for Fisheries):

- Follow the principles of ecosystem-based fisheries management.
- Ensure all affected stocks are healthy and abundant.
- Fish all affected stocks at sustainable levels.
- Minimize bycatch.
- Have no more than a negligible impact on any threatened, endangered or protected species.
- Managed to sustain the long-term productivity of all affected species.
- Avoid negative impacts on the structure, function or associated biota of aquatic habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.

These guiding principles are operationalized in the four criteria in this standard. Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and rating

Once a rating has been assigned to each criterion, we develop an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guide and online guide:

**Best Choice/Green:** Buy first; they're well managed and caught or farmed responsibly.

**Good Alternative/Yellow:** Buy, but be aware there are concerns with how they're caught, farmed or managed.

**Avoid/Red:** Take a pass on these for now; they're overfished, lack strong management or are caught or farmed in ways that harm other marine life or the environment.

[1] "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates

# Summary

This report assesses the sustainability of giant Pacific octopus (*Enteroctopus dofleini*) caught as bycatch by the Dungeness crab and spot prawn trap in British Columbia, and the Pacific cod pot fishery in the Gulf of Alaska (GOA) and the Bering Sea and Aleutian Islands (BSAI). Since this species does not meet the Seafood Watch criteria for a main species in any of these fisheries, this report has been prepared as a supplement to the original fishery assessments in order to allow for recommendations pertaining to retained giant Pacific octopus that end up in the North American market.

The giant Pacific octopus is a demersal cephalopod that typically inhabits shallow coastal waters (i.e., intertidal to 100m deep) along the west coast of North America. This species is also found in areas along the east coast of Asia from Russia to Japan. The largest recorded individual weighed 272 kg and had an arm-span of 9.6m; more commonly weighing 20-50 kg, this is the largest species of octopus in the world.

There is currently no target commercial fishery for giant Pacific octopus in either British Columbia or Alaska. However, incidentally landed individuals may be retained for sale. The amount of octopus caught by each of these fisheries varies by region, but is generally less than 5% of catch. There is little knowledge of the state of the stock in both BC, but there have been improvements in AK in recent years. In BC, no specific management measures exist for the giant Pacific octopus stock, but the fisheries that incidentally catch octopus are generally well managed. Octopus-specific management measures in AK include annual catch limits and ongoing stock assessments; the Pacific cod fisheries are very well managed.

With the exception of Criteria 1, scores in this assessment were obtained from the most recent Seafood Watch assessments for the target fisheries. The scores for Criterion 2 were derived from the lowest scoring bycatch species caught by each fishery. As a part of the 2021 interim update for this report, C2 species with new stock assessments were also updated. Since all retained giant Pacific octopus has been landed as bycatch, but this species constitutes a very small part of the target fishery, Criterion 3 was also scored based on the management of the target fishery, with management measures specific to octopus described in the text. Scores for Criterion 4 are identical to those previously determined in the target fishery assessments. For references and additional detailed information pertaining specifically to the management and ecological impacts of the BC spot prawn trap, BC Dungeness crab trap, and AK Pacific cod pot fisheries, please refer to those specific Seafood Watch reports.

# Final Seafood Recommendations

| SPECIES \| FISHERY | CRITERION 1 TARGET SPECIES | CRITERION 2 OTHER SPECIES | CRITERION 3 MANAGEMENT | CRITERION 4 HABITAT | OVERALL RECOMMENDATION |
|---|---|---|---|---|---|
| Giant Pacific octopus \| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia spot prawn fishery | 2.644 | 1.732 | 4.000 | 3.162 | **Good Alternative (2.759)** |
| Giant Pacific octopus \| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia Dungeness crab fishery | 2.644 | 2.644 | 3.000 | 2.449 | **Good Alternative (2.677)** |
| Giant Pacific octopus \| Bering Sea \| Pacific, Northeast \| Pots \| United States \| Alaska \| Pacific cod pot Fishery | 2.644 | 2.644 | 4.000 | 4.472 | **Best Choice (3.344)** |
| Giant Pacific octopus \| Gulf of Alaska \| Pacific, Northeast \| Pots \| United States \| Pacific cod pot Fishery | 3.413 | 3.413 | 4.000 | 4.472 | **Best Choice (3.799)** |


**Summary**

Giant Pacific octopus caught in British Columbia, Canada, with pots is a "Good Alternative." A small amount is caught as bycatch in British Columbia's Dungeness crab and spot prawn pot fisheries. Octopus stock status in BC is unknown, resulting in a yellow score for Criterion 1 for both fisheries. There are concerns with entanglement of humpback whales in the spot prawn fishery, resulting in a red score for Criterion 2. The rating for the Dungeness crab fishery is driven by moderately effective management of the fishery.

Giant Pacific octopus caught in the Alaska's Bering Sea with pots is a "Best Choice." Little is known about the Bering Sea population, but on a small amount is caught as bycatch in the well-managed Pacific cod fishery. Knowledge is improving of octopus stocks in the Gulf of Alaska, fishing levels are considered sustainable, and the management of the Pacific cod fishery is considered highly effective.

**Scoring Guide**

Scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

**Best Choice/Green** = Final Score >3.2, and no Red Criteria, and no Critical scores

**Good Alternative/Yellow** = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern2, and no more than one Red Criterion, and no Critical scores

**Avoid/Red** = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

[2] Because effective management is an essential component of sustainable fisheries, Seafood Watch issues an Avoid recommendation for any fishery scored as a Very High Concern for either factor under Management (Criterion 3).

# Introduction

### Scope of the analysis and ensuing recommendation

This report assesses the sustainability of the giant Pacific octopus (*Enteroctopus dofleini*) trap and pot fisheries on the west coast of North America. This species, along with other octopuses, is primarily caught as bycatch by the Pacific commercial cod pot in Alaska. It is also sometimes landed by the Alaskan flatfish complex trawl fishery (i.e., Pacific halibut, yellowfin sole, flathead sole, rock sole, Greenland turbot, Alaska plaice and arrowtooth flounder), cod longline fishery in the Bering Sea, and shrimp/prawn trap fishery in southeast Alaska but landings by these fisheries are small compared to the cod pot fishery and thus they are not included in this assessment. In British Columbia the spot prawn and Dungeness crab trap fisheries are the primary fisheries responsible for retained landings of incidentally caught octopus (98% and 2% respectively), and the giant Pacific octopus constitutes over 90% of the octopus bycatch associated with these fisheries. While this species is also fished in Japan, this assessment and its recommendation pertain exclusively to *E. dofleini* caught as bycatch by the Pacific cod pot fisheries in the Gulf of Alaska and Bering Sea and Aleutian Islands, and the spot prawn and Dungeness crab trap fisheries of BC.

### Species Overview

The giant Pacific octopus is a demersal cephalopod that typically inhabits shallow coastal waters (i.e., intertidal to 100m deep) along the west coast of North America (Jorgensen 2009). This species is also found in areas along the east coast of Asia from Russia to Japan (Mottet 1975). The largest recorded individual weighed 272 kg and had an arm-span of 9.6m; more commonly weighing 20-50 kg, this is the largest species of octopus in the world (Roper et al. 1984).

With the exception of interactions during mating, giant Pacific octopuses appear to be largely solitary, but not overly territorial or aggressive (Mather and Anderson 1999). Nonetheless, this species has been known to attack divers when provoked or enticed (High 1976)(Anderson et al. 2007). Individuals live in dens, and the majority of hunting and feeding occurs at night (Scheel and Bisson 2012). It is not uncommon for a giant Pacific octopus to return to its den with food to consume at a later time (High 1976). While the primary prey items for this species are other marine invertebrates (e.g. rock crabs, clams), this species is characterized as being a highly opportunistic predator (DFO 2012a). In 2010, a captive giant Pacific octopus had to be moved when aquarists learned it was consuming the spiny dogfish with which it shared a tank, and there is evidence of this species eating seagulls as well (Lacitis 2010)(McCulloch 2012).

Similar to other octopus and cephalopod species (i.e., squids, cuttlefishes), the giant Pacific octopus is capable of rapidly camouflaging or changing its appearance through the manipulation of chromatophores in its skin (Cloney and Brocco 1983) (Schwab 2003). In addition to visual changes, this species can secrete ink from an internal ink sac through its siphon (a.k.a., hypernome) to distract potential predators when it feels threatened. More commonly, the hypernome is primarily used to generate locomotion through jet propulsion, which this species combines with "walking" as a means of moving around the benthic environment (High, 1976). Research has suggested that this species possesses a high level of intelligence, and discussion of their cognition abilities is ongoing (Schwab 2003)(Mather 2008)(Mather 2011).

The giant Pacific octopus is dioecious, and localized areas of BC have shown the sex ratio of individuals to be skewed toward females, although the underlying reason for this population structure is unknown (Robinson and Hartwick 1986). Males typically mature at a smaller size than females and are outwardly recognizable by the absence of suckers in the end fifth of one arm. This arm, known as a hectocotylus, is used to deposit a large (90 cm long) spermatophore into the female's mantle cavity during mating (Gillespie et al. 1998). Research suggests that mating and fertilization rarely occur simultaneously, and females can hold on to spermatophores for months before releasing their eggs for fertilization. The cause of this delay is not well understood and it is unknown how many partners a females may have prior to releasing her eggs.

Egg-laying occurs in the female's den and it may take several days for her to deposit all of her eggs (which are usually strung along the den ceiling) (Gillespie *et al.*, 1998). Although this species can live up to five years, the giant Pacific octopus is semelparous and, once her eggs have been laid, the female devotes all her energy to parenting before she dies (Gillespie *et al.*, 1998). Females can be highly protective of their dens during this time and take care to aid the development of their

brood by using their arms to circulate water in the den to ensure oxygen dispersion and prevent them from collecting debris (Gillespie *et al.*, 1998). While caring for her eggs, the female enters a period known as 'senescence'. During this time, she ceases eating, moves in an uncoordinated manner, develops skin lesions; ultimately, death is the result of starvation or disease complications related to suppressed immune function (Anderson et al. 2002). The female may or may not live until her eggs hatch, which is approximately 6 months after they were originally laid.

Male giant Pacific octopuses typically have 8-12 spermatophores (Gillespie *et al.*, 1998). It is unknown how many copulation events they undertake, but it is not long after mating that the male also enters senescence and dies (Anderson *et al.*, 2002).

**Production Statistics**

**British Columbia Octopus**

In the past, the majority of landings in British Columbia came from the targeted dive fishery, and total catches amounted to about 20 t annually in the mid-1980s. Under this fishing technique, SCUBA divers use a chemical irritant to drive the octopus from its den then catch it in bag or net {DFO 2012}. Gillespie *et al.* (1998) suggest several limitations with understanding the impacts of fishing on octopus in BC, specifically with regard to a lack of management measures, inadequate stock information, and unreliable fisheries logbook data. In order to ensure a more precautionary approach to the directed take of octopus, DFO changed the licensing structure of the fishery in November 1999 (DFO, 2012). No commercial dive licenses were issued the following year and an experimental fishery was established instead. Under this new structure, divers could obtain scientific licensees to hunt for octopus, provided they met certain criteria (see DFO, 2003). The dive fishery has been closed since 2013 due to declines in effort and landings (Sauer et al. 2019).

The Department of Fisheries and Oceans in Canada monitors octopus through the trap fisheries targeting spot prawns and Dungeness crab. With just over 400 kg caught, giant Pacific octopus was the third most abundant species (by weight) in spot prawn research trap surveys from 1999-2008 (Favaro et al. 2010). However, since giant Pacific octopus is not a target species of these fisheries, no formal stock assessments have been conducted in recent years, and few management measures exist (G. Gillespie, pers. comm.). Landings data are recorded, however no catch limits exist. As well, available catch data pertain to *E. dolfleini* that are landed (i.e., do not include any discarded catch), thus they do not give a complete representation of the octopus catch incurred by these shellfish fisheries. Nonetheless, given the passive nature of these gears, octopus that are caught but not landed can be released without significant physical damage; observations from Alaska suggest low mortality associated with octopus that are accidentally caught by traps (Conners et al. 2013) (Ormseth et al. 2018). Octopus landings have declined substantially since the dive fishery ended in 2013 (Sauer et al. 2019).

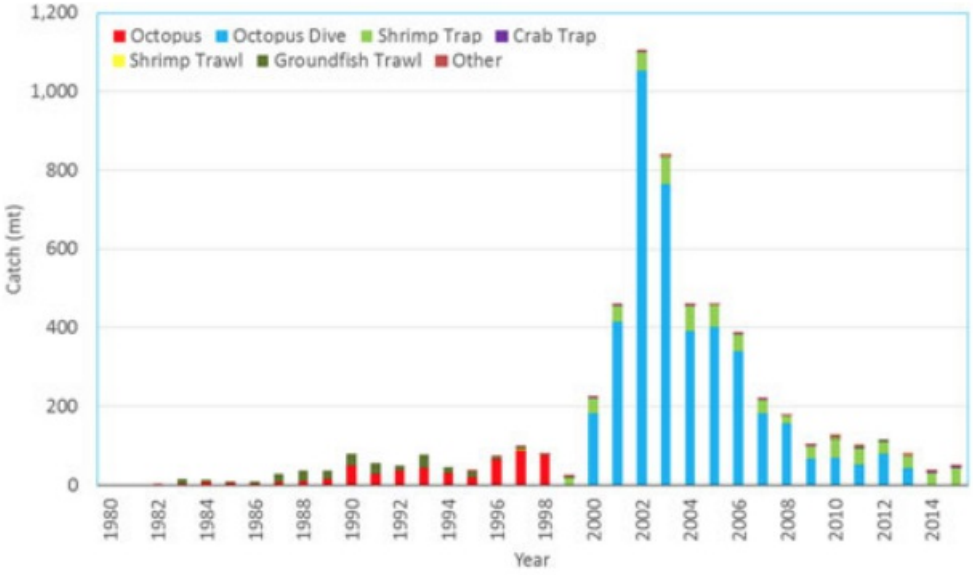


Figure 1: Landed catch (mt) of octopus from commercial fisheries in British Columbia, as reported in logbooks (1980–1999) or catch monitoring programs (2000–2015) (Sauer et al. 2019).

**Alaska Octopus**

Octopus landings in Alaska have always been associated primarily with the commercial trawl and trap fisheries for Pacific cod, as well as with the trap fishery for shrimp. From 1986-1995, landings averaged 29 t, with the largest catch occurring in 1990 at 117.7 t (Gillespie *et al.*, 1998). In the Gulf of Alaska (GOA), landings of octopus caught incidentally by the Pacific cod pot fishery remained relatively stable (i.e., 150-250 t annually) from 1997-2007, peaking at over 1,190 t in 2014 and returning to long-term averages from 2016-2019 (Ormseth 2019). The situation is similar in the Bering Sea and Aleutian Islands (BSAI) Pacific cod pot fishery, with catches averaging 300 t annually prior to a low of 57 t in 2009 and a subsequent peak of 565 t in 2011. The average annual octopus catch across all fisheries in BSAI from 2003-2018 was 320 t and has been stable in recent years (Ormseth et al. 2018).

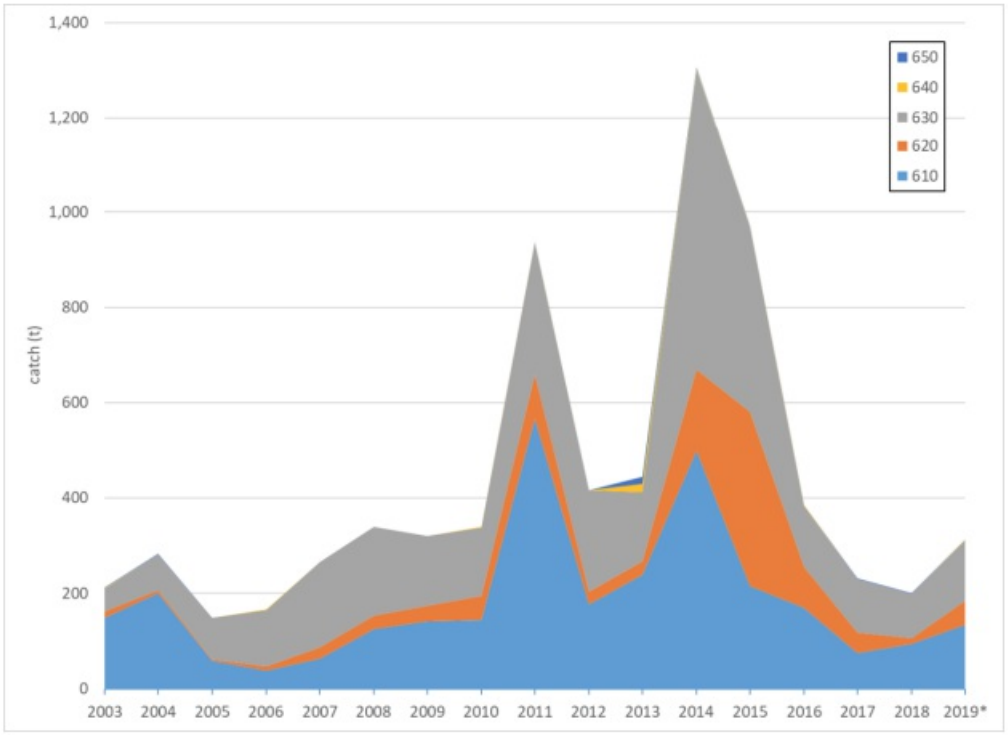


Figure 2: Incidental commercial catch of octopuses (all species) in the GOA, 2003-2019, by NMFS reporting area. 2019 data are incomplete; retrieved October 30, 2019 (Ormseth 2019).

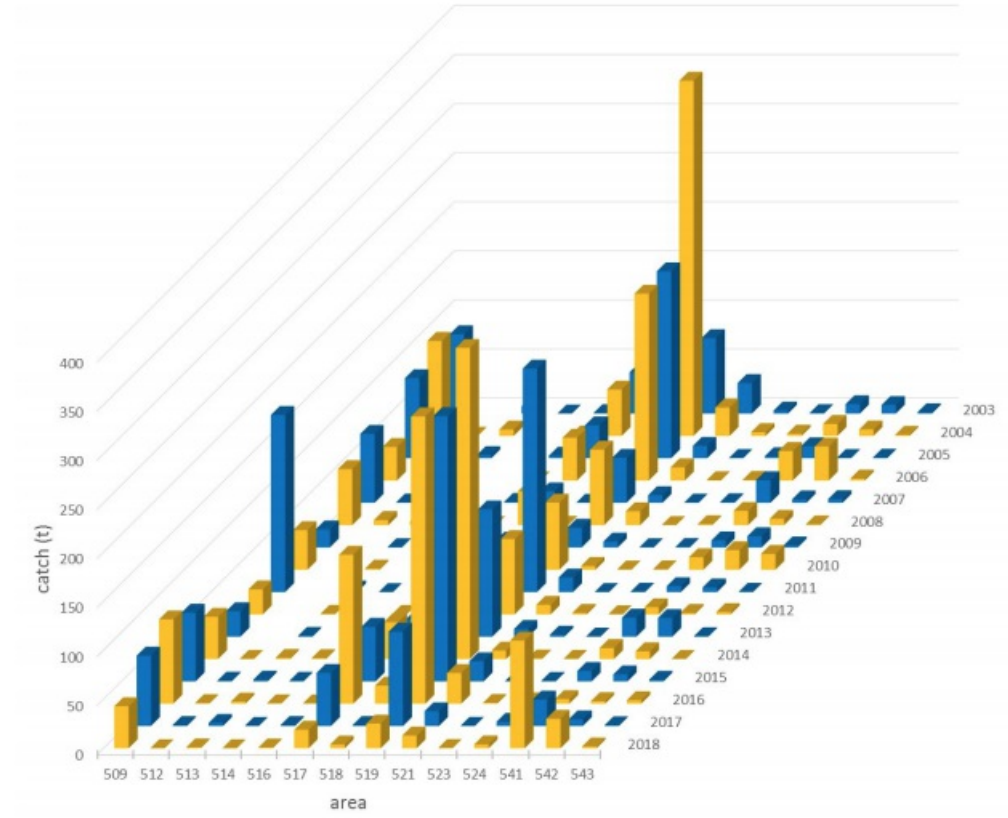


Figure 3: Incidental catches of octopus (t) in the Bering Sea and Aleutian Islands, 2003-2018, by NMFS statistical area. 2018 data are incomplete (Ormseth et al. 2018).

The State of Alaska allows directed fishing for octopus in state waters with special permit; since 2006, few permits have been requested and historical landings (1988-1995) averaged about 8 t annually (Conners and Conrath, 2013). There is no federal

directed octopus fishery in federal waters, nor do managers recommend one (Ormseth 2019). The North Pacific Fishery Management Council is responsible for the management of the Pacific cod fisheries in Alaska under which octopus continue to be incidentally landed. As of 2011, to comply with the reauthorized Magnuson-Stevens Act, a separate management plan has been developed for all species previously grouped into the 'other species' complex that were retained as bycatch (Conners *et al*, 2013; Conners and Conrath, 2013). While several data gaps exist for giant Pacific octopus in Alaska, organism and population-level research has increased in recent years, and efforts to improve the methodology in the octopus stock assessment continue. While the species composition of octopuses in Alaska is not well known, surveys in the Bering Sea and Gulf of Alaska suggest that *E. dofleini* constitutes just over 90% of the estimated total octopus biomass in both regions, and this species predominates the incidental catch of octopus in both regions' commercial fisheries (Conners *et al*, 2013; Conners and Conrath, 2013).

**Importance to the US/North American market.**

Octopus contributes a small amount to the total value of Alaskan fishery products, with an average wholesale value of $412,000 per year from 2010-2015 (Sauer et al. 2019). The value of BC octopus fisheries declined from $1.1 million CAD in 1997 to $14,000 CAD in 2015, though this is likely an underestimate (Sauer et al. 2019). In 2018, Canada imported $7 million CAD worth of octopus from the European Union and $2 million CAD from Japan (DFO 2019a) (DFO 2019b).

The U.S. exported an average of 355.5 t of *total* octopus product per year from 2016-2020; the average annual value of these exports was roughly $1.84 million (NOAA 2021b). On average, the U.S. imported 23,405 t of octopus product per year from 2016-2020, with an annual value of approximately $172 million (NOAA 2021b). U.S. imports of Canadian octopus totaled 547 kg in 2018 and 317 kg in 2017 (data unavailable im 2016, 2019, and 2020). Canada imported an annual average of 57.9 t of octopus products from the U.S. over the same time period (NOAA 2021b).

**Common and market names.**

In the scientific literature, there are several variations in the nomenclature for this species, including the Northern giant Pacific octopus, great Pacific octopus, North Pacific giant octopus, and giant octopus. It was also commonly referred to by the Latin name *Octopus dolfleini* until the early-2000s, when it was re-classified as one of four temperate species in the genus Enteroctopus, and the only one living north of the equator (Bouchet 2015). In North America, its full name is often omitted and it may be sold simply as 'octopus' in restaurants or markets. In general, octopus is a common ingredient in Japanese cuisine — where it is translated as *tako* — and in Mediterranean dishes; *pulpo* in Spanish, *polpo* in Italian, and *poulpe* in French.

**Primary product forms**

Octopus is sold in a variety of forms, including fresh, frozen, dried, salted, and brined. When prepared fresh, it is often served alongside other seafood in stews, paella, and pasta dishes, but can also be prepared on its own (usually roasted or grilled).

# Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at www.seafoodwatch.org. The specific standard used is referenced on the title page of all Seafood Watch assessments.

## Criterion 1: Impacts on the species under assessment

*This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species' inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:*

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

*Rating is Critical if Factor 1.3 (Fishing Mortality) is Critical.*

**Guiding principles**

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level*

# Criterion 1 Summary

| GIANT PACIFIC OCTOPUS | | | |
|---|---|---|---|
| **REGION / METHOD** | **ABUNDANCE** | **FISHING MORTALITY** | **SCORE** |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia spot prawn fishery | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia Dungeness crab fishery | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Bering Sea \| Pacific, Northeast \| Pots \| United States \| Alaska \| Pacific cod pot Fishery | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Gulf of Alaska \| Pacific, Northeast \| Pots \| United States \| Pacific cod pot Fishery | 2.330: Moderate Concern | 5.000: Low Concern | Green (3.413) |

Seafood Watch considers biomass and fishing mortality to be unknown and there are no reference points in place for these parameters in BC. Based on the results of the PSA, the target species have modere susceptibility, resulting in rating of "moderate" concern for stock status of BC giant Pacific octopus. Giant Pacific octopus is a semelparous species; these species can have high susceptibility to fishing pressure and score "high" concern for abundance if management measures are not in place to mitigate the impact of fisheries on semelparous species. However, there are management measures for shrimp and crab trap/pot fisheries that are expected to benefit Pacific octopus populations, including seasonal closures, protected areas, octopus-specific closure areas, and effort limits (Sauer et al. 2019)(DFO 2020a)(DFO 2020b). Additionally, the commercial dive fishery for octopus has been closed since 2013 and there is currently no targeted fishery for octopus in B.C. (Sauer et al. 2019). In the BSAI, octopus is also not targeted and the Pacific cod fishery is very well managed with areal and seasonal closures and effort limitations that are expected to benefit octopus. Effective management measures are in place that mitigate the vulnerability of octopus in BC and Alaska, and giant Pacific octopus in the BSAI are also not highly vulnerable to fishing in this region.

**Effective management measures for fisheries *targeting* semelparous cephalopods**

1. *Protected areas*: The establishment of marine protected areas (MPAs) is important for maintaining sustainability, but these must be designed with an understanding and consideration of connectivity among populations (Van Nieuwenhove et al. 2019). Important protected areas for sustainable management of octopus fisheries include known brooding sites (Guerra et al. 2015), nurseries (Pita et al. 2021), and spawning areas (Sauer et al. 2019).
2. *Seasonal closures*: Numerous fisheries establish seasonal closures to protect brooding females, while other closures occur during peak spawning seasons (Sauer et al. 2019). In order for seasonal closures to be effective, managers need a comprehensive knowledge of the life cycle of the target species, particularly with respect to the distribution of spawning sites (Rodhouse et al. 2014).
3. *Rotational closures*: Octopus fisheries in parts of Madagascar have successfully implemented rotational closures, which resulted in increased landings and CPUE (Oliver et al. 2015). The closures were chosen by communities and were typically 20% of the harvest area for two to seven months, sometimes repeatedly, but benefits of these closures are dependent upon good enforcement (ibid). Overall success was driven by 1) a legal code allowing for local management, 2) backing from seafood exporters, and 3) rapid growth rate of target species (ibid).
4. *Size and catch limits*: Almost all management requires good long-term data on catch, effort, and biological information (Rodhouse et al. 2014). Other semelparous species require catch quotas and effort controls for minimum landing size to be a suitable management measure (Pohlmann et al. 2016).
5. *Other management actions for cephalopod fisheries in general (Arkhipkin et al. 2021)*
    a. *Reference points (RPs):* Fisheries managed with reference points RPs require detailed biological data and weekly catch and effort monitoring (i.e. need to be data-rich).
    b. *Effort-based*: Effort limitation with short-term adjustments to allow a maximum percentage (40%) of available biomass to be taken by the fishery every year. Escapement can be managed by setting a limit of allowed fishing days.
    c. *Catch-based*: setting quotas and restricting access.
    d. *Mesh size restrictions*

# Criterion 1 Assessments

SCORING GUIDELINES

Factor 1.1 - Abundance
Goal: Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity.

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate target abundance level (given the species' ecological role), or near virgin biomass.*
- *3.67 (Low Concern) — Population may be below target abundance level, but is at least 75% of the target level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.*
- *2.33 (Moderate Concern) — Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.*
- *1 (High Concern) — Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.*

**Factor 1.2 - Fishing Mortality**

Goal: Fishing mortality is appropriate for current state of the stock.

- *5 (Low Concern) — Probable (>50%) that fishing mortality from all sources is at or below a sustainable level, given the species ecological role, OR fishery does not target species and fishing mortality is low enough to not adversely affect its population.*

- *3 (Moderate Concern) — Fishing mortality is fluctuating around sustainable levels, OR fishing mortality relative to a sustainable level is uncertain.*
- *1 (High Concern) — Probable that fishing mortality from all source is above a sustainable level.*

# Giant Pacific octopus

**Factor 1.1 - Abundance**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Moderate Concern**

Octopus in the BSAI are assessed and managed into a stock complex, though giant Pacific octopus (*Enteroctopus dofleini*) is the most abundant of the seven species in the complex (Ormseth et al. 2018). Octopus biomass is estimated from the biennial BSAI trawl survey and annual Bering Sea shelf survey, but surveys catch smaller octopus that do not reflect the same size octopus caught in the fishery (ibid). The Bering Sea slope survey encounters octopus in over 50% of the tows, the Aleutian Islands survey has an encounter rate of ~25%, and BS surveys encounter octopus in <15% of the tows (ibid). Biomass estimates from these surveys has high year-to-year variability and a large sampling variance, which makes it impossible to determine how much of the year-to-year variability in estimated biomass reflects true variation in abundance and how much is due to sampling variation (ibid). There is not enough information to support a stock assessment for the BSAI octopus complex (Ormseth et al. 2018), overfished status is unknown (NMFS 2021), and the species is not highly vulnerable. Therefore, a "moderate" concern score is given.

**Justification:**

Overall, the state of knowledge for this species in the BSAI is poor and data are insufficient, but improving (Ormseth et al. 2018). As such, a model-based stock assessment is not currently possible and the present abundance status of *E. dofleini* is unknown (Ormseth et al. 2018). Based on trawl surveys, the estimated total biomass of octopus in the BSAI in 2016 was 13,609 t; of which 83% is estimated to be giant Pacific octopus (Ormseth et al. 2018). There was no EBS slope survey in 2018, so estimates of total biomass in BSAI in 2018 are not available (ibid). Abundance is scored against the PSA.

Productivity-Susceptibility Analysis:

Scoring Guidelines

1.) Productivity score (P) = average of the productivity attribute scores (p1, p2, p3, p4 (finfish only), p5 (finfish only), p6, p7, and p8 (invertebrates only))

2.) Susceptibility score (S) = product of the susceptibility attribute scores (s1, s2, s3, s4), rescaled as follows: $S = [(s1 * s2 * s3 * s4) - 1/40] + 1$ .

3.) Vulnerability score (V) = the Euclidean distance of P and S using the following formula: $V = \sqrt{(P^2 + S^2)}$

Productivity-Susceptibility Analysis for giant Pacific octopus:

| Productivity Attributes | Value | Score (1 = low risk; 2 = medium risk; 6 = high risk) | Reference |
|---|---|---|---|
| Average age at maturity (years) | 3 | 1 | (Ormseth 2019) |
| Average maximum age (years) | 3 | 1 | (Ormseth 2019) |
| | | | (Ormseth |

| | | | |
|---|---|---|---|
| Fecundity (eggs/yr) | 106,800 | 1 | 2019) |
| Average maximum size (cm) (not to be used when scoring invertebrate species) | NA | | |
| Average size at maturity (cm) (not to be used when scoring invertebrate species) | NA | | |
| Reproductive strategy | Demersal egg layer or brooder | 2 | (Ormseth 2019) |
| Trophic level | 3.2 | 2 | (Kang et al. 2021) |
| Density dependence (invertebrates only) | none | 2 | |
| Productivity Subscore | | 1.5 | |

| Susceptibility Attribute | Information | Score (1 = low risk; 2 = medium risk; 6 = high risk) | Reference |
|---|---|---|---|
| Areal overlap | ≥30% fished | 3 | Default |
| Vertical overlap | High overlap | 3 | Default |
| Selectivity of fishery | Species is incidentally encountered and semelparous, but effective management measures are in place. | 2 | Default |
| Post-capture mortality | Retained species | 3 | Default |
| Susceptibility Subscore | | 2.325 | |

| | |
|---|---|
| Productivity-Susceptibility Score | 2.77 |
| Vulnerability Rating (high, medium or low) | Medium |

**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Moderate Concern**

Octopus in the GOA are assessed and managed into a stock complex, though giant Pacific octopus (*Enteroctopus dofleini*) is the most abundant of the seven species in the complex (Ormseth 2019). Octopus biomass is estimated from the biennial GOA trawl survey and CPUE trends from observer data are used to confirm survey results (ibid). Since 2015, a random effects (RE) model has been used to estimate octopus biomass. The 2019 biomass estimate from the trawl survey is 12,770 t, the estimate from the RE model is 12,257 t (Ormseth 2019). There is no abundance reference point for the GOA octopus complex and NMFS lists the overfished status of the as unknown (NMFS 2021). Because neither relative abundance of members of the octopus complex nor true species composition is well documented (Ormseth 2019), and giant Pacific octopus is not highly vulnerable, a "moderate" concern score is awarded.

**Justification:**

There is some evidence that abundance of the GOA octopus complex is stable. The standardized methods and procedures used to estimate biomass from trawl surveys is considered reliable, but there are notable uncertainties. Trawl sampling mainly occurs outside the primary habitat for Octopus (e.g. rough bottom areas and/or areas with large vertical relief) and waters shallower than 30 m are not sampled (Ormseth 2019). Additionally, the survey uses roller gear to reduce snagging, which may allow octopus to escape under the net (ibid). For these reasons, biomass estimates from surveys are probably underestimated (ibid). Results from the RE model, trawl survey, and CPUE of observed catches suggest that biomass of the complex is stable.

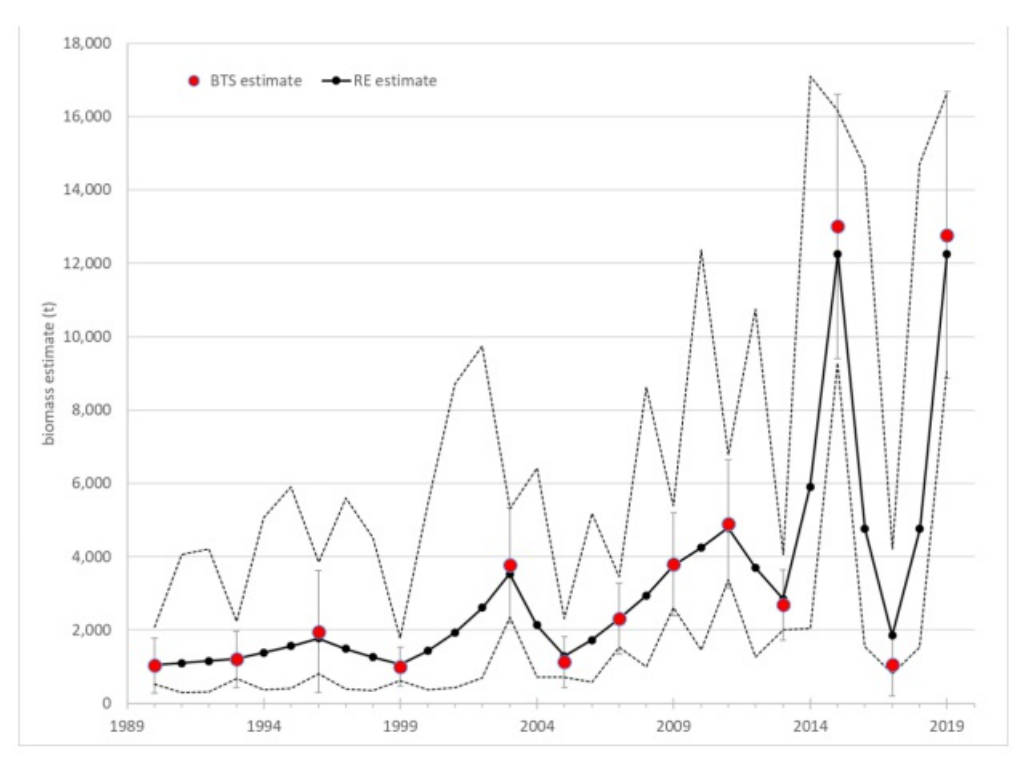


Figure 4: Biomass estimates, 1990-2019, for the Gulf of Alaska octopus complex from the random-effects model (RE; solid black line) and the AFSC bottom trawl survey (BTS; red dots). Confidence intervals are shown as dashed black lines for the random effects model and gray error bars for the survey biomass estimates (Ormseth 2019).

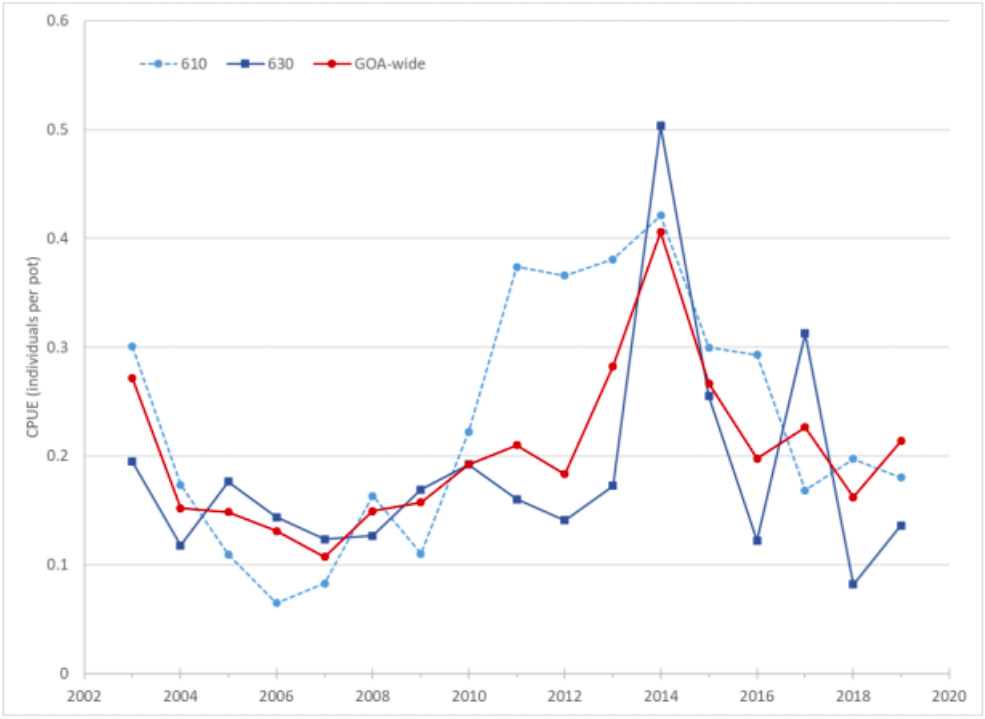


Figure 5: Time series of mean catch-per-unit-effort (CPUE; individuals/pot) of octopuses (all species combined) in observed catches by fisheries using pot gear in the Gulf of Alaska (GOA) during 2003- 2019. Data are shown for GOA-wide catches as well as catches only in statistical area 630. The 2019 data are incomplete; retrieved October 30, 2019 (Ormseth 2019).

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**
**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderate Concern**

No estimates of the biomass of giant Pacific octopus along the west coast of British Columbia currently exist, and no stock assessments have been conducted for this species in recent years. Therefore, abundance is scored using the productivity-susceptibility analysis (PSA). This species is not inherently highly vulnerable to fishing, thus a score of "moderate" concern has been applied.

**Justification:**

Productivity-Susceptibility Analysis:

Scoring Guidelines

1.) Productivity score (P) = average of the productivity attribute scores (p1, p2, p3, p4 (finfish only), p5 (finfish only), p6, p7, and p8 (invertebrates only))

2.) Susceptibility score (S) = product of the susceptibility attribute scores (s1, s2, s3, s4), rescaled as follows: $S = [(s1 * s2 * s3 * s4) - 1/40] + 1$ .

3.) Vulnerability score (V) = the Euclidean distance of P and S using the following formula: $V = \sqrt{(P^2 + S^2)}$

Productivity-Susceptibility Analysis for giant Pacific octopus:

| Productivity Attributes | Value | Score (1 = low risk; 2 = medium risk; 6 = high risk) | Reference |
|---|---|---|---|
| Average age at maturity (years) | 3 | 1 | (Ormseth 2019) |
| Average maximum age (years) | 3 | 1 | (Ormseth 2019) |
| Fecundity (eggs/yr) | 106,800 | 1 | (Ormseth 2019) |
| Average maximum size (cm) (not to be used when scoring invertebrate species) | NA | | |
| Average size at maturity (cm) (not to be used when scoring invertebrate species) | NA | | |
| Reproductive strategy | Demersal egg layer or brooder | 2 | (Ormseth 2019) |
| Trophic level | 3.2 | 2 | (Kang et al. 2021) |
| Density dependence (invertebrates only) | none | 2 | |
| Productivity Subscore | | 1.5 | |

| Susceptibility Attribute | Information | Score (1 = low risk; 2 = medium risk; 6 = high risk) | Reference |
|---|---|---|---|
| Areal overlap | ≥30% fished | 3 | Default |
| Vertical overlap | High overlap | 3 | Default |
| Selectivity of fishery | Species is incidentally encountered and semelparous, but effective management measures are in place. | 2 | Default |
| Post-capture mortality | Retained species | 3 | Default |
| Susceptibility Subscore | | 2.325 | |

| | |
|---|---|
| Productivity-Susceptibility Score | 2.77 |
| Vulnerability Rating (high, medium or low) | Medium |

**Factor 1.2 - Fishing Mortality**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Moderate Concern**

There is no targeted fishery for giant Pacific octopus, but they are taken as incidental catch in trawl, longline, and pot fisheries. The octopus complex in BSAI is managed under a modified Tier 5 approach, in which the overfishing level (OFL) is based on biological reference points derived from consumption estimates for Pacific cod (Ormseth et al. 2018). The allowable biological catch (ABC = 3,576 t) is set at 75% of the OFL (4,769 t) (ibid). The average total octopus catch from 2016-2018 was 376 t (catch data for 2018 is only through November 3, 2018), catches have never exceeded 600 t, but it is unknown if overfishing is occurring (NMFS 2021). There is insufficient information to assess the sustainability of current fishing levels. Therefore, a "moderate" concern score is awarded.

**Justification:**

Current data for *E. dofleini* are insufficient for model-based stock assessments and no estimates of the current fishing mortality for giant Pacific octopus in the Bering Sea and Aleutian Islands were provided in the most recent stock assessment (Ormseth et al. 2018). As such, there is no information regarding whether or not the giant Pacific octopus stock is undergoing overfishing.

**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Low Concern**

There is no targeted fishery for giant Pacific octopus, but they are taken as incidental catch in trawl, longline, and pot fisheries. The Pacific cod pot fishery has the highest catch rate of octopus in the GOA (Ormseth 2019). There has been a decline in catches since 2015, which is thought to be due to reduced pot fishing effort for Pacific cod (ibid). The octopus complex is managed under a modified Tier 6 approach, in which the overfishing level (OFL) is based on the maximum historical catch (ibid). The allowable biological catch (ABC = 980 t) is set at 75% of the OFL (1,307 t) (ibid). The average total octopus catch from 2016-2018 was 272 t, catches have been below the ABC since the level was established in 2011 (Ormseth 2019), and overfishing is not occurring (NMFS 2021). Historical catch rates of octopus are considered low because catches were from non-directed fisheries only, and it's thought unlikely that these rates have caused any measurable depletion (Sauer et al. 2019). Therefore, a “low” concern score is awarded.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**
**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderate Concern**

No stock assessments have been conducted for this species in recent years (G. Gillespie, pers. comm.). As such, there are no estimates of the current fishing mortality for giant Pacific octopus along the west coast of British and, thus, it is unknown if overfishing of this stock is occurring. No fishing limits currently exist and a score of “moderate” concern has been applied.

## Criterion 2: Impacts on Other Species

*All main retained and bycatch species in the fishery are evaluated under Criterion 2. Seafood Watch defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery's potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait score. The Criterion 2 rating is determined as follows:*

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

*Rating is Critical if Factor 2.3 (Fishing Mortality) is Crtitical*

**Guiding principles**

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*
- *Minimize bycatch.*

# Criterion 2 Summary

### Criterion 2 score(s) overview

This table(s) provides an overview of the Criterion 2 subscore, discards+bait modifier, and final Criterion 2 score for each fishery. A separate table is provided for each species/stock that we want an overall rating for.

| GIANT PACIFIC OCTOPUS | | | |
|---|---|---|---|
| **REGION / METHOD** | **SUB SCORE** | **DISCARD RATE/LANDINGS** | **SCORE** |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia spot prawn fishery | 1.732 | 1.000: < 100% | Red (1.732) |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia Dungeness crab fishery | 2.644 | 1.000: < 100% | Yellow (2.644) |
| Bering Sea \| Pacific, Northeast \| Pots \| United States \| Alaska \| Pacific cod pot Fishery | 2.644 | 1.000: < 100% | Yellow (2.644) |
| Gulf of Alaska \| Pacific, Northeast \| Pots \| United States \| Pacific cod pot Fishery | 3.413 | 1.000: < 100% | Green (3.413) |

### Criterion 2 main assessed species/stocks table(s)

This table(s) provides a list of all species/stocks included in this assessment for each 'fishery' (as defined by a region/method combination). The text following this table(s) provides an explanation of the reasons the listed species were selected for inclusion in the assessment.

| BERING SEA \| PACIFIC, NORTHEAST \| POTS \| UNITED STATES \| ALASKA \| PACIFIC COD POT FISHERY | | | |
|---|---|---|---|
| SUB SCORE: 2.644 | DISCARD RATE: 1.000 | **SCORE: 2.644** | |
| **SPECIES** | **ABUNDANCE** | **FISHING MORTALITY** | **SCORE** |
| Giant Pacific octopus | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Red king crab | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Southern tanner crab | 2.330: Moderate Concern | 5.000: Low Concern | Green (3.413) |
| Pacific cod | 3.670: Low Concern | 5.000: Low Concern | Green (4.284) |

| GULF OF ALASKA \| PACIFIC, NORTHEAST \| POTS \| UNITED STATES \| PACIFIC COD POT FISHERY | | | |
|---|---|---|---|
| SUB SCORE: 3.413 | DISCARD RATE: 1.000 | **SCORE: 3.413** | |
| **SPECIES** | **ABUNDANCE** | **FISHING MORTALITY** | **SCORE** |
| Giant Pacific octopus | 2.330: Moderate Concern | 5.000: Low Concern | Green (3.413) |
| Pacific cod | 2.330: Moderate Concern | 5.000: Low Concern | Green (3.413) |

| NORTHEAST PACIFIC \| POTS \| CANADA \| BRITISH COLUMBIA \| BRITISH COLUMBIA DUNGENESS CRAB FISHERY | | | |
|---|---|---|---|
| SUB SCORE: 2.644 | DISCARD RATE: 1.000 | | **SCORE: 2.644** |
| **SPECIES** | **ABUNDANCE** | **FISHING MORTALITY** | **SCORE** |
| Dungeness crab | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Giant Pacific octopus | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Benthic inverts | 2.330: Moderate Concern | 5.000: Low Concern | Green (3.413) |
| Finfish | 2.330: Moderate Concern | 5.000: Low Concern | Green (3.413) |

| NORTHEAST PACIFIC \| POTS \| CANADA \| BRITISH COLUMBIA \| BRITISH COLUMBIA SPOT PRAWN FISHERY | | | |
|---|---|---|---|
| SUB SCORE: 1.732 | DISCARD RATE: 1.000 | | **SCORE: 1.732** |
| **SPECIES** | **ABUNDANCE** | **FISHING MORTALITY** | **SCORE** |
| Humpback whale | 1.000: High Concern | 3.000: Moderate Concern | Red (1.732) |
| Quillback rockfish | 1.000: High Concern | 5.000: Low Concern | Yellow (2.236) |
| Giant Pacific octopus | 2.330: Moderate Concern | 3.000: Moderate Concern | Yellow (2.644) |
| Spot shrimp | 2.330: Moderate Concern | 5.000: Low Concern | Green (3.413) |

The inclusion of the C2 species in this report is based on the 'main species' criteria described in the respective parent reports. See Criterion 2 in the following Seafood Watch reports for more details:

- BSA and GOA Pacific cod fishery: 2019 Seafood Watch Alaska Groundfish Report
- BC Shrimp: 2021 Seafood Watch BC Shrimp Report Update
- BC Dungeness crab: 2019 Seafood Watch BC Dungeness Crab Report

The only red-scoring species in any of the fisheries is the humpback whale, which is the limiting species in the BC spot prawn trap fishery.

# Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance
*(same as Factor 1.1 above)*

Factor 2.2 - Fishing Mortality
*(same as Factor 1.2 above)*

Factor 2.3 - Modifying Factor: Discards and Bait Use
Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

*Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.*

| Ratio of bait + discards/landings | Factor 2.3 score |
|---|---|
| <100% | 1 |
| >=100 | 0.75 |

# Benthic inverts

**Factor 2.1 - Abundance**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderate Concern**
Abundance of unidentified benthic invertebrates is scored as a "moderate" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

**Factor 2.2 - Fishing Mortality**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Low Concern**
Fishing mortality of unidentified benthic invertebrates is scored as a "low" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

# Dungeness crab

### Factor 2.1 - Abundance

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderate Concern**

Dungeness crab stock health in British Columbia is evaluated based on catch per unit effort (CPUE) from pot surveys (DFO 2021a). Landings data indicate populations fluctuate cyclically, with periods of higher abundance followed by periods of lower abundance; these are likely influenced by fluctuations in annual recruitment due to environmental conditions. In the Fraser River delta, relative abundance indices from standardized catch rates (CPUEs) indicate an increase in legal crab abundance between 1991 and 2003, followed by a decrease from 2004 to 2010 (Zhang and Dunham 2013). Female abundance has been stable since 1994, but sublegal crab abundance has declined since 2005 (Zhang and Dunham 2013). Because Dungeness crab are not highly vulnerable (see Productivity-Susceptibility Analysis (PSA) in the 2019 Seafood Watch BC Dungeness Crab Report ), but lack quantitative stock assessment, stock status is considered a "moderate" concern.

### Factor 2.2 - Fishing Mortality

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderate Concern**

Adequate data are not available to determine maximum sustainable yield. Fishery mortality is managed through regulations limiting collection by size, sex, and season rather than quota. Exploitation rates have historically been high, reaching near 100% in some regions (Smith and Jamieson 1989). Despite an intense harvest, annual fishery landings fluctuate cyclically around a relatively stable mean, a pattern thought to be tied to environmental variability (DFO 2021a).

Landings decreased from 2008 to 2011, but have since been stable. A comparison of female relative abundance indices, from standardizing catch rates (CPUEs) both before and after the commercial fishing season, has shown post-season declines since 1990, which implies increased female mortality (Zhang and Dunham 2013). Fishing mortality is ranked as a "moderate" concern due to high exploitation rates that result in dependence on annual recruitment for population persistence with no reference point for maximum sustainable yield.

# Finfish

### Factor 2.1 - Abundance

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderate Concern**
Abundance of unknown finfishes is scored as a "moderate" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

### Factor 2.2 - Fishing Mortality

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Low Concern**
Fishing mortality for finfishes is scored as a "low" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

# Humpback whale

**Factor 2.1 - Abundance**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**High Concern**
DFO has not recently published information on humpback whales in BC waters. However, whales from three distinct population segments (DPSs) occur in waters that overlap with this fishery, and those DPSs have been listed under the U.S. Endangered Species Act (ESA) and stock assessments are provided by NMFS. Therefore, information from U.S. is used to score this factor.

The humpback whale has been listed as endangered under the U.S. Endangered Species Act (ESA) since 1970; however, in 2016, NMFS revised the humpback whale population designation by splitting it into 14 DPSs, three of which may interact with this fishery (Carretta et al. 2021). Stock identification between the ESA and the Marine Mammal Protection Act (MMPA) is complex. Humpback whales feeding in northern Washington and southern BC. are one of the two feeding groups in the California/Oregon/Washington stock recognized by NMFS (Carretta et al. 2021). Whales from three different DPSs (Central America, Mexico, and Hawaii) are included in the stock assessment, but whale stock delineation under the MMPA is currently under review (ibid). The most recent abundance estimate is 2,374 (CV=0.03) whales from the California and Oregon feeding group and 526 (CV=0.23) whales from the northern Washington and southern British Columbia feeding group (ibid). The minimum population estimate (taken from the lower $20^{th}$ percentile of the log-normal distribution) for this stock is 2,784 whales (ibid).

The California/Oregon/Washington humpback whale stock is listed as endangered and depleted for MMPA management purposes, the Central DPS is considered endangered under the ESA, and the Mexican DPS is threatened. Therefore, humpback whale is of "high" conservation concern.
**Justification:**
Due to historic declines in humpback whale numbers in Canada associated with historic commercial whaling, humpback whales were listed as a species of "Special Concern" by COSEWIC and under SARA in 2011 and 2017, respectively. BC humpback whales are protected under the Marine Mammals Regulations of the Fisheries Act (DFO 2013).

BC humpback whales demonstrated increasing trends in abundance over the last few decades, in line with the North Pacific population as a whole, which was estimated to be recovering at a rate of 4.9% to 6.8% annually (DFO 2013). Photo-identification data of humpbacks sighted in the Canadian Pacific from 1992 to 2006 suggests that the population utilizing BC waters, either as a migration corridor or for feeding, is estimated at approximately 2,145 animals (95% CI, 970 to 2,331) (Ford et al. 2009) (DFO 2013). More recent genetics and photo-identification research demonstrates two likely sub-populations, indicating distinct northern and southern BC feeding groups (Calambokidis et al. 2008} (Ford et al. 2009) (DFO 2013). However, there is currently insufficient evidence to delineate specific geographic boundaries of the distinct sub-populations, and SARA/DFO recognizes one North Pacific humpback whale stock (DFO 2013). It is important to note that humpback whales in BC likely represent an intermixing stock that may include members originating from endangered or threatened Distinct Population Segments under the Endangered Species Act of the United States (NMFS 2016).

**Factor 2.2 - Fishing Mortality**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Moderate Concern**

Humpback whales from multiple distinct population segments (DPSs) migrate across national boundaries and mortality data varies according to jurisdiction. There is limited information on current humpback whale mortality rates in Pacific Canadian waters. Therefore, we have have broken down mortality information on this stock into two sections. The first includes historical estimates of Potential Biological Removal (PBR) in BC, along with media reports of entanglements in recent years. The second section contains fishing mortality information from U.S. waters only. Overall, updated evaluations on entanglements and BC humpback population trends region-wide are necessary to accurately assess fishing mortality concerns. Therefore, a score of "moderate" concern is given for fishing mortality.

**Justification:**

*Fishing mortality in BC*

The BC Marine Mammal Response Network reported 40 entangled humpback whales between 1987 and 2008, including four confirmed mortalities (Ford et al. 2009). These reports involved entanglements in various types of fishing gear including unknown gear (30%), gillnets (27.5%), traps (22.5%), herring pond (7.5%), aquaculture gear (5%), longline gear (2.5%), seine nets (2.5%) and anchor lines (2.5%) (Ford et al. 2009). Trap fishing gear was not responsible for any of the four known mortalities during the time period. Entanglement events with recreational prawn trap gear specifically occurred in 2015 and 2017 in BC waters (both individuals were disentangled successfully), suggesting there is also risk for entanglement in commercial prawn trap gear. Reported entanglements may represent as little as 10% of actual entanglement events (DFO 2013).

Ford et al. (2009) estimated a PBR of 21 humpbacks in BC annually; however, the DFO does not currently assess information against the PBR since not enough is known about the prevalence and severity of certain threats to draw conclusions at the population level (DFO 2013). Over 21 humpback entanglements were reported in 2016 alone (and at least two mortalities not associated with trap gear), in large part due to the increasing number of humpback whales using the BC area throughout the year (Vancouver Sun 2016). There were seven reported and confirmed humpback whale entanglements in trap gear in 2019, but the fisheries to which the gear belonged could not be identified (DFO 2020a). In July 2020, three humpback whales were seen ensnared in fishing gear in BC waters (National Observer 2020) and another was found dead and entangled in trap gear on a BC island in April (CBC News 2020). Based on published entanglement data from 1987 to 2002, the prawn trap fishery likely takes less than 50% of the unofficial BC humpback whale PBR as estimated by Ford et al. (2009).

More recent entanglement data suggest that the unofficial PBR, as estimated by Ford et al. (2009), could be exceeded should the uptick in entanglements continue. It is important to note, however, that the Ford et al. (2009) PBR is outdated. Overall, the spot prawn trap fishery may represent a relatively small component of overall fishing mortality for BC humpback whales (DFO 2013); however, the US west coast and BC humpback whale groupings represent intermixing stocks, which could include DPS' threatened or endangered under the Endangered Species Act.

*Fishing mortality in the U.S.*

Fishing gear that interacts with humpback whale includes gillnet, pot, and trap gear. Total cumulative annual mortality and serious injury of humpback whale (22.35 whales/yr from 2013-2017) from commercial fishing gear is greater than the stock's PBR of 16.7 whales in US waters (Carretta et al. 2021). The highest estimates of mean annual mortality and serious injury ($F_{2013\text{-}2017}$ ≥8.85/yr) is from unidentified fisheries (ibid). The stock assessment states that "it is likely that most cases involving 'unidentified fisheries' represent pot and/or trap gear (ibid). Total annual human-caused mortality (which includes vessel strikes, non-fishery entanglements, and entanglements in commercial, recreational, and tribal fisheries) from 2013-2017 is estimated at 42.1 humpback whales; this exceeds the range-wide PBR estimate of 33.4 whales (ibid).

# Pacific cod

**Factor 2.1 - Abundance**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Low Concern**

Pacific cod in the BSAI is assessed annually. Beginning in 2014, the EBS and AI Pacific cod stocks were assessed and managed separately; TACs and ABCs are set independently (AI represents roughly 5% of the total BSAI biomass). The EBS Pacific cod projected female SSB for 2021 is 185,645 t under model Ensemble A and 273,584 t under model Ensemble AB. Both models estimate SSB below respective $B_{40\%}$ levels (Ensemble A; $B_{40\%}$ = 259,803 t) (Ensemble AB; $B_{40\%}$ = 308,640 t) (Thompson et al. 2020). Relative to the target reference point $B_{35\%}$ for Tier 3 stocks, estimated SSB from Ensemble A is below $B_{35\%}$, while the SSB estimate from Ensemble AB is above $B_{35\%}$. Ensemble AB was chosen as the final model in the assessment report, but results of Ensemble A were provided in case the SSC or Assessment Team decided to choose it as the final model instead (Thompson et al. 2020). SSB estimates from both models are >75% of the target reference point of $B_{35\%}$.

AI Pacific cod are managed as a Tier 5 stock and assessed with a random effects model that estimates biomass and natural mortality. Estimated biomass in the AI has been stable to increasing despite declines seen in the GOA and EBS. The EBS Pacific cod stock $B/B_{MSY}$ ratio is 1.5 and overfished status is considered unknown (NMFS 2021) (Spies et al. 2020). Although the AI Pacific cod stock represents a small fraction of BSAI Pacific cod as whole, uncertainty remains for this subpopulation. The EBS stock is >75 % of a TRP. Therefore, BSAI Pacific cod receives a score of "low" concern for abundance.

**Justification:**

Model summary from Thompson et al. (2020): "The base model and the three new models span a second 2×2 factorial design, where the factors are: B1) whether fishery catch per unit effort (CPUE) should be used as an index of abundance, and B2) whether dome-shaped survey selectivity should be allowed. The four models corresponding to the A1×A2 factorial design are labeled "Ensemble A," and the four models spanning the B1×B2 factorial design are labeled "Ensemble B," and the union of Ensembles A and B is labeled "Ensemble AB" (note that the base model is a member of both Ensembles A and B, so a total of seven models is included in Ensemble AB). Results are provided for each of the seven individual models, and also for weighted averages of the models in Ensembles A and AB."

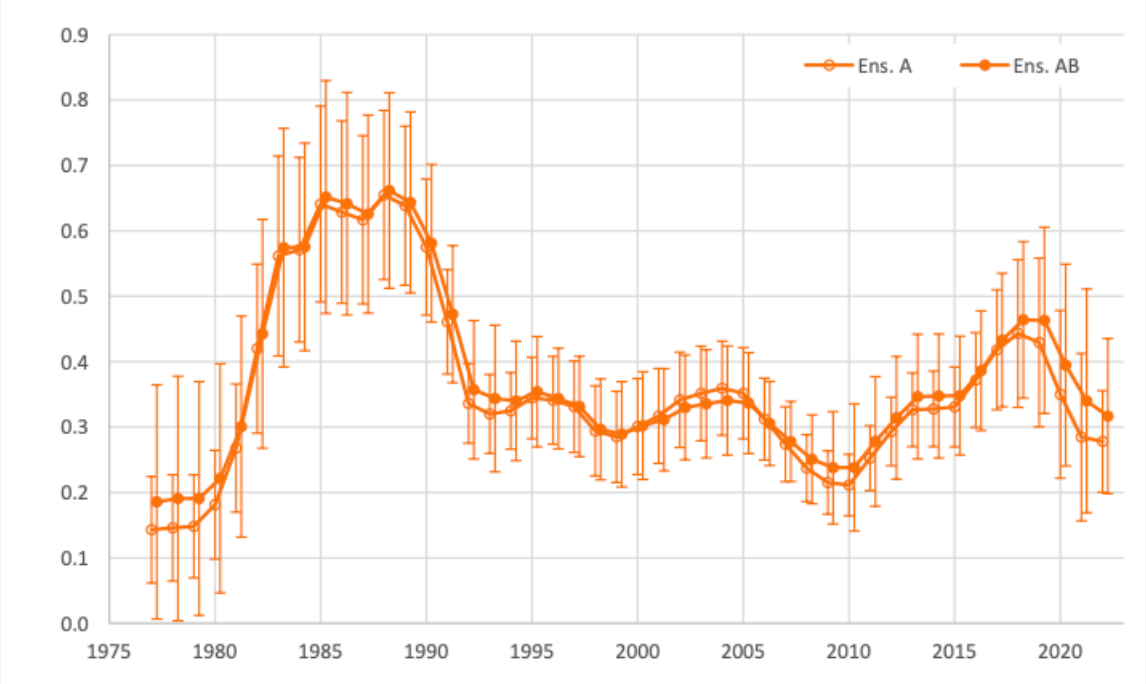


Figure 6: Eastern Bering Sea Pacific cod ensemble estimates of relative spawning biomass, +/− 2 standard deviations (Thompson et al. 2020).

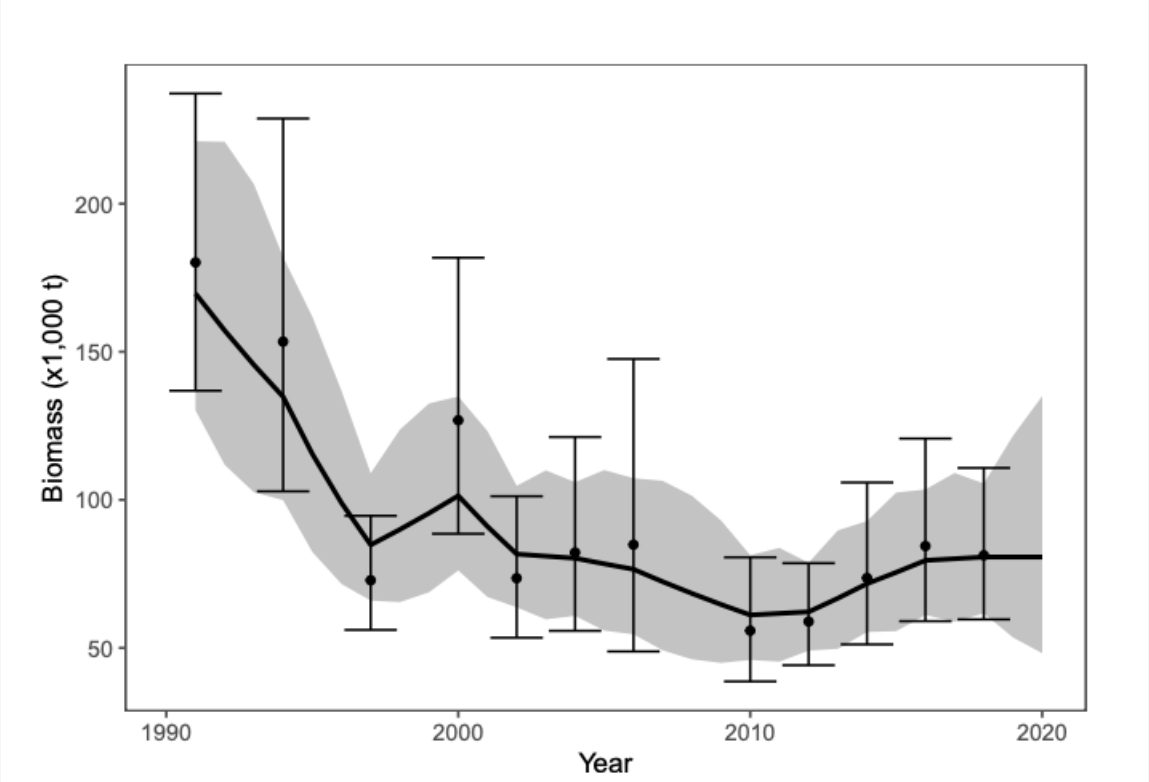


Figure 7: Aleutian Islands Pacific cod survey biomass time series, with 95% confidence intervals for the observations and the estimates. Dots indicate survey estimates and black line represents the model estimate (Spies et al. 2020).

**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Moderate Concern**

GOA Pacific Cod is assessed annually, and data inputs that inform the assessment include fishery independent data sources such as the annual longline survey and biennial trawl survey and fishery dependent data collected by on-board

observers. Female SSB for 2020 decreased to 34,631 t, the lowest level on record and 19.8% of unfished levels (Barbeaux et al. 2020). However, SB is expected to increase in 2021; at the start of 2021, the projected SB is above $SB_{20\%}$ and is expected to increase to $SB_{28.2\%}$ by the start of 2022 (ibid). NMFS does not consider this stock as overfished (NMFS 2021) and the stock is above the limit reference point of $SB_{17.5\%}$.

Recent declines in Pacific cod spawning biomass and abundance coupled with SSB values less than 70% of the target reference point $SB_{35\%}$ yield a score of "moderate" concern for abundance.

**Justification:**

Pacific cod is a transoceanic species found at depths from shoreline to approximately 500 m. Estimated 2020 SSB is at its lowest level in the time series, but is expected to improve through 2022 (Barbeaux et al. 2020). A number of factors have been discussed as potential mechanisms for the dramatic decline in Pacific cod abundance in the GOA. Anomalous warm temperatures 2014 to 2016 led to increases in sea surface temperature (SST) and seafloor temperatures in the GOA (Barbeaux et al. 2017). Research suggests a connection between water temperature and larval production, where warm SSTs are linked with low larval abundance (Doyle and Miller 2016). Additionally, warm temperatures may also negatively impact growth potential and metabolic efficiency of Pacific cod during various life history stages (Doyle and Mier 2016) (Barbeaux et al. 2017), and a substantial increase in natural mortality occurred in 2015 and 2016 (Barbeaux et al. 2017).

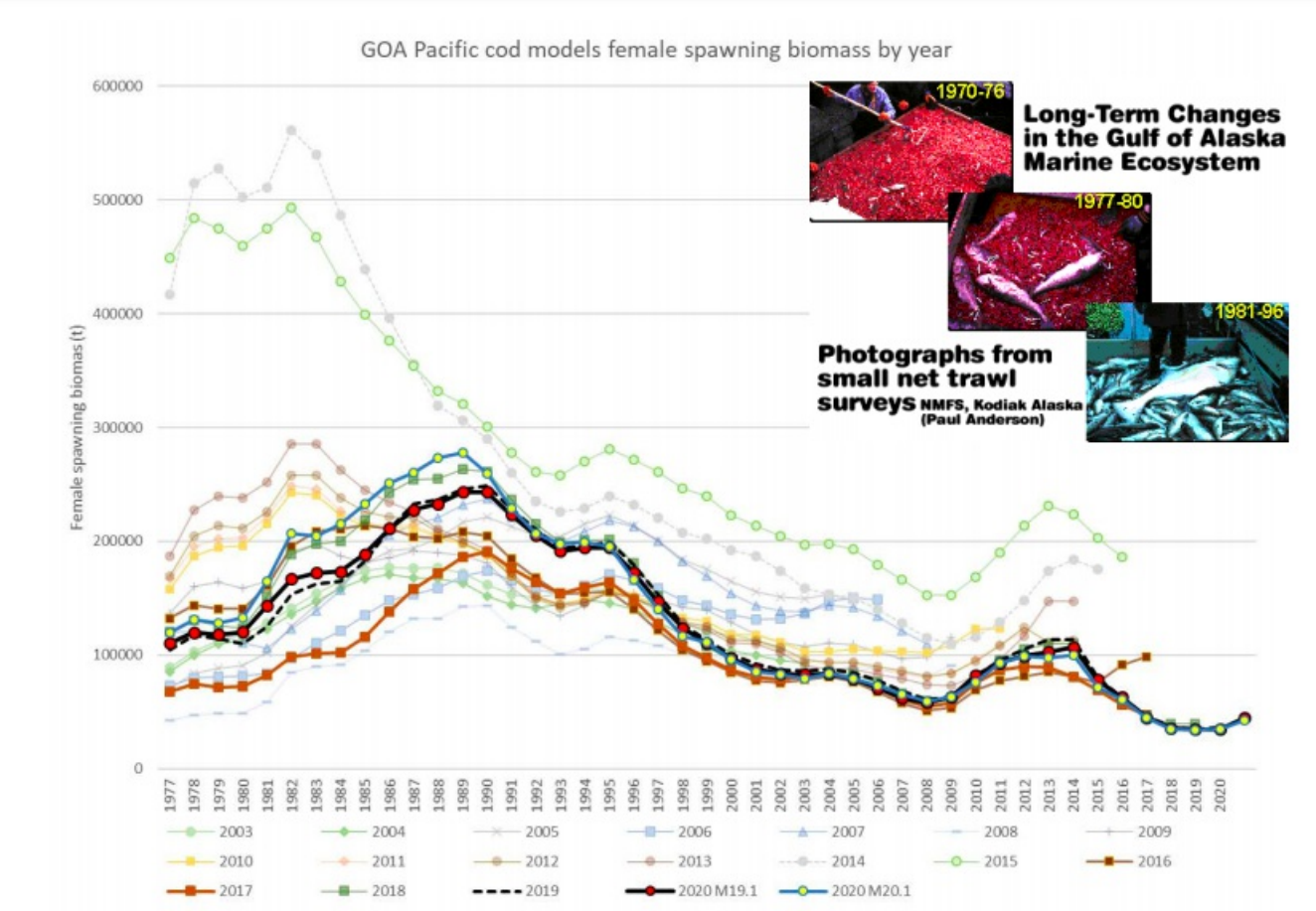


Figure 8: 1977-2021 Gulf of Alaska Pacific cod female spawning biomass from the 2003 through 2020 stock assessments with estimates from both the author's preferred (Model 19.1) and research (Model 20.1) model results and (inset) images from the NMFS small net surveys off Kodiak Alaska showing change in species composition over time from (Barbeaux et al. 2020).

**Factor 2.2 - Fishing Mortality**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Low Concern**

The estimated end of year catch of EBS Pacific cod in 2019 was 178,816 t, which was above the TAC but below the ABC and OFL. As a Tier 3 stock, 2021 EBS Pacific cod was set at $F_{ABC}$ = 0.26, which is well below the model-estimated $F_{OFL}$ (0.31), both values are from Ensemble AB (Thompson et al. 2020).

As a Tier 5 stock, AI Pacific cod F is set equal to the natural mortality rate (M), with an estimated 2018 value of F = 0.34. Prior to separate management of the AI and EBS stocks in 2014, TAC averaged about 83% of the ABC, and aggregate commercial catch averaged approximately 92% of TAC (since 1980). Catch of AI Pacific cod in 2019 was 19,162 t, which is below the ABC (21,500 t) and OFL (Spies et al. 2020).

Overall, precautionary management ensures that TACs are well below ABC for AI and EBS Pacific cod and fishing mortality has been below sustainable levels in recent years. Therefore, a "low" concern scores is given.

**Justification:**

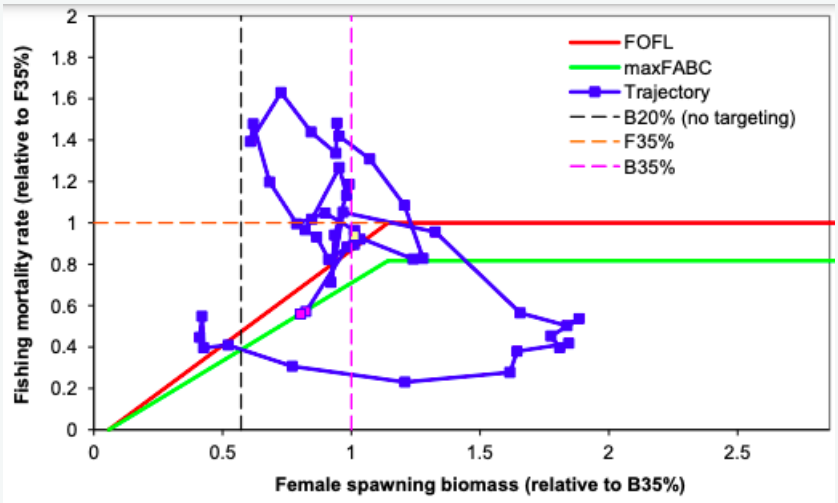


Figure 2.25a. Phase plane for Ensemble A.

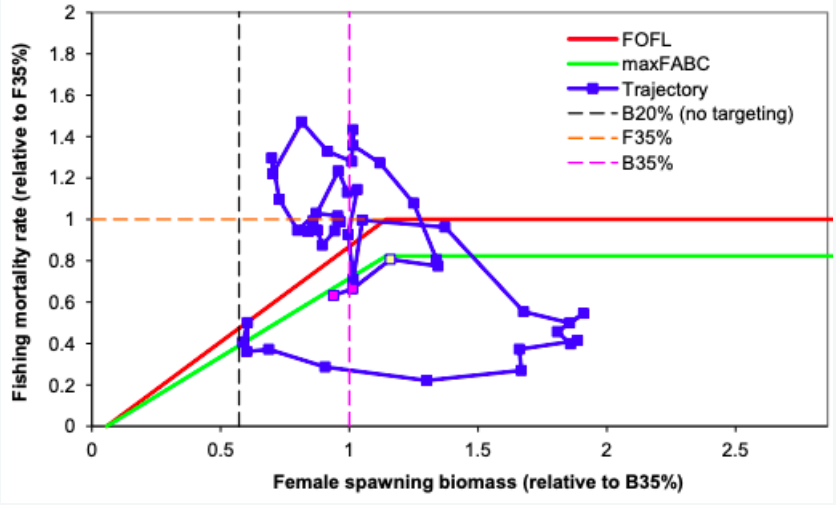


Figure 9: EBS Pacific cod Phase plane for Ensemble A (top) and Ensemble AB (bottom) (Thompson et al. 2020).

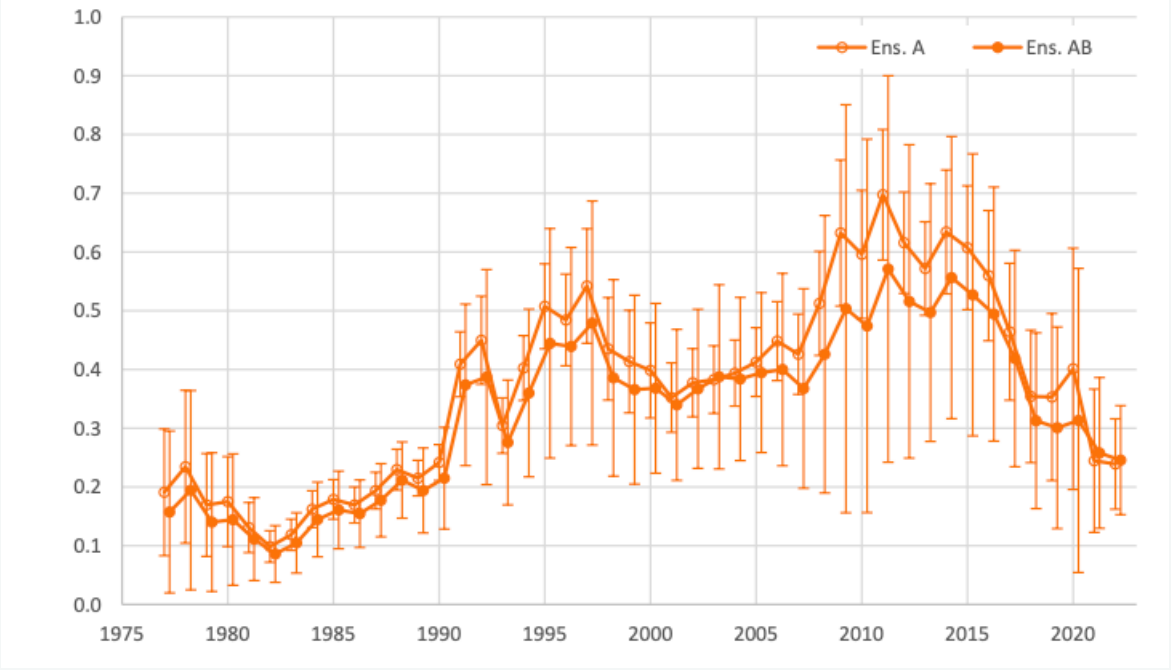


Figure 10: Eastern Bering Sea Pacific cod Ensemble estimates of full selection fishing mortality, +/− 2 standard deviations (Thompson et al. 2020).

**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Low Concern**

The estimated end of year catch of GOA Pacific cod in 2019 was 15,411 t, or 0.91 of the ABC (17,000 t). Low Pacific cod catches in 2019 were associated with recent declines in biomass seen in the GOA (Barbeaux et al. 2020). Since 2008, the Pacific cod ABC has been set at the maximum level per the Tier 3 status of the stock. However, in 2018 managers set the $F_{ABC}$ below the maximum permissible $F_{ABC}$ to increase the probability (to roughly 50%) that the stock will not fall below 20% of unfished spawning biomass for 2019 and 2020 ($F_{ABC}$ = 0.53 and 0.31 for 2017 and 2018, respectively) (Barbeaux et al. 2017). $F_{ABC}$ has been further reduced to 0.22 and 0.29 for 2020 and 2021, respectively (Barbeaux et al. 2020). The Pacific cod population is not classified as experiencing overfishing and the TAC has been reduced further to account for uncertainty (Barbeaux et al. 2020). Model-estimated F increased steadily with the decline in abundance from 1990 to 2008, with continued high F through 2017, associated with increased catches and declining recruitment. There were drastic cuts in the ABC in 2018-2020 and the federal directed fishery was closed in 2020, resulting in a sharp decrease in F (Barbeaux et al. 2020). Therefore, GOA Pacific cod receives a score of "low" concern for fishing mortality.

**Justification:**

Fishing mortality has been relatively high and increasing in the GOA Pacific cod fishery since 2000. In four years (2008, 2015, 2016, 2017), $F/F_{MSY} > 1$ and above Tier 3 target reference points set by fishery managers (Barbeaux et al. 2020).

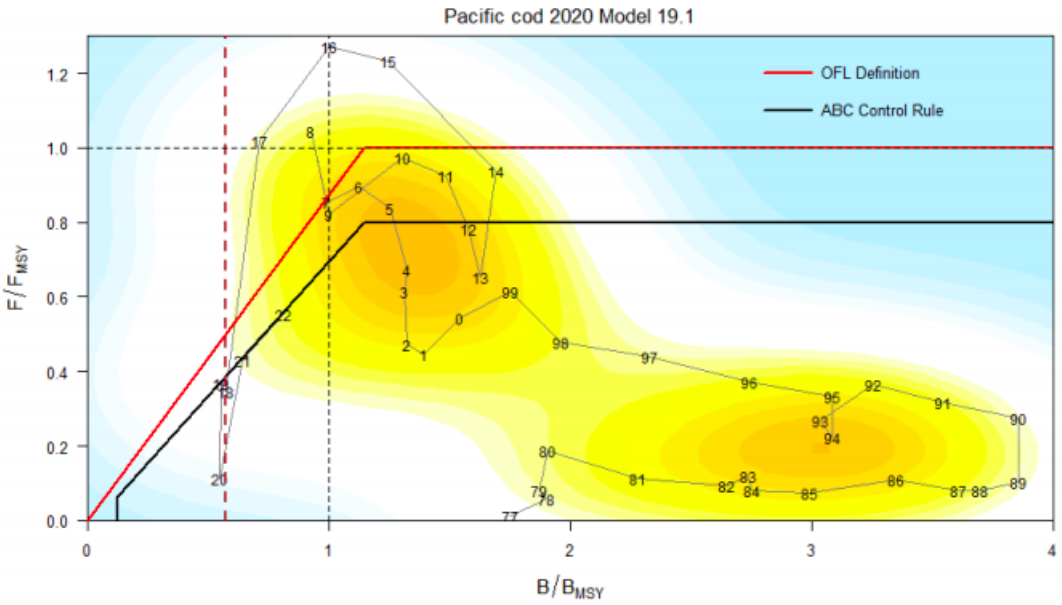


Figure 11: For Model 19.1 ratio of historical $F/F_{MSY}$ versus female spawning biomass relative to Bmsy for GOA pacific cod, 1977-2022. Note that the proxies for $F_{MSY}$ and $B_{MSY}$ are $F_{35\%}$ and $B_{35\%}$, respectively. The Fs presented are the sum of the full Fs across fleets. Dashed line is at $B_{20\%}$, Steller sea lion closure rule for GOA Pacific cod (Barbeaux et al. 2020)

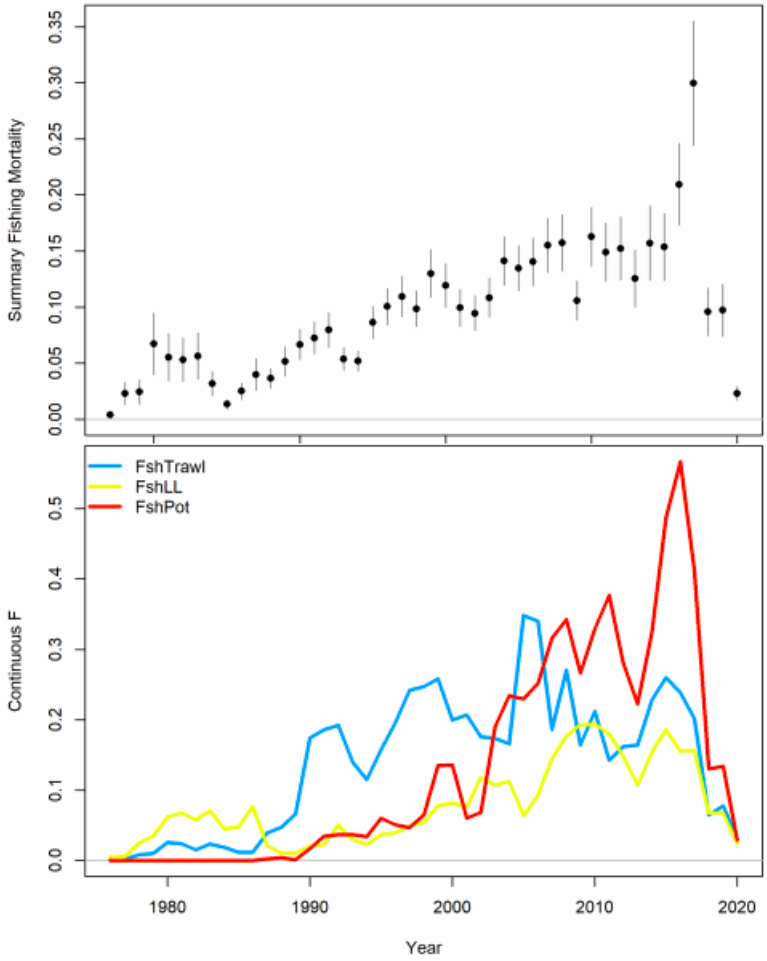


Figure 12: Model 19.1 age 3-8 true fishing mortality (top) and continuous fishing mortality by trawl (FshTrawl), longline (FshLL) and pot (FshPot) fisheries (bottom) (Barbeaux et al. 2020).

# Quillback rockfish

**Factor 2.1 - Abundance**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**High Concern**
Quillback rockfish were designated as "threatened" by COSEWIC in 2009. No overall estimate of decline is possible; however, all survey indices have declined, some by 50 to 75% since the mid-1980s. Commercial trawl and longline fisheries and recreational fisheries are the principal threats to quillback recovery. Due to the COSEWIC "threatened" status of quillback rockfish in BC, quillback rockfish receive a "high" concern score for abundance
**Justification:**
Commercial fishing pressure has been reduced as a result of strengthened rockfish conservation efforts established in the mid-1990s, including introduction of closed areas and decrease in commercial harvest quotas (COSEWIC 2009). Juvenile rockfish are encountered in the shrimp trap fishery; however, landings of quillback rockfish in the shrimp trap fishery are negligible in comparison to trawl and longline commercial and recreational landings (Favaro et al. 2010) (Rutherford et al. 2010).

In the most recent stock assessment (2011), estimates of inside and outside quillback rockfish B2011: BMSY ratios were less than the Upper Stock Reference Point (USRP), but greater than the Limit Reference Point (LRP), and both inside and outside quillback units fell in the "cautious zone" based on the DFO's Precautionary Approach (Figure 26). The outside quillback unit's B2011 : BMSY ratio was 0.736 (CV 0.57), and the inside quillback unit's B2011 : BMSY ratio was 0.493 (CV 0.41) {Yamanaka et al. 2011}.

**Factor 2.2 - Fishing Mortality**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Low Concern**
The COSEWIC assessment and status report identifies directed fishing as the principal threat to quillback rockfish (COSEWIC 2009). Quillback catch in the spot prawn trap fishery could not be estimated due to small sample size and low encounter rates (Rutherford et al. 2010). Therefore, the spot prawn fishery's contribution to overall fishing mortality is expected to be low relative to commercial groundfish fisheries and a "low" concern score is awarded.
**Justification:**
Quillbacks can still be legally landed in all fisheries. The commercial groundfish fishery has a combined TAC of 173 t of quillback in 2020 (DFO 2020b) while the recreational fishery has a combined bag limit for the 6 species of inshore rockfish (DFO 2012c). According to the stock assessment, the current levels of fishing mortality for quillback rockfish may allow recovery of this species although there are high levels of uncertainty associated with these estimates ( $F_{2011}/F_{MSY}$ for the outside unit was 1.0 ± 0.91 and 0.6 ± 0.4 for the inside unit) (DFO 2012c). The Bayesian population model shows that the outside and inside populations have leveled off their decline in recent years. Based on population trajectories and the $F_{2011}/F_{MSY}$ ratios, the estimated level of quillback fishing mortality caused by the prawn trap fishery (approximately 1.5% of the total fishing mortality) may have a negligible impact on the overall fishing mortality of this species, leading to a score of low conservation concern for this factor.

# Red king crab

**Factor 2.1 - Abundance**

**Bristol Bay Stock | Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Moderate Concern**

Although king crab is managed separately in a number of Alaska regions, Bristol Bay red king crab make up the vast majority of US king crab landings and will be the stock reviewed in this report. Red king crab is assessed annually using a sex- and size-structured population dynamics model incorporating data from the NMFS EBS trawl survey, the Bering Sea Fisheries Research Foundation trawl survey, landings of commercial catch, at-sea observer sampling, and dockside retained catch sampling. Red king crab Mature Male Biomass (MMB) for 2019/20 was estimated to be 14.24 thousand t and above (Minimum Size Stock Threshold (MSST;10.62 thousand t) (NPFMC 2020b). The stock at 2020/21 time of mating is projected to be 14.93 thousand t, which is 59% of $B_{35\%}$. (NPFMC 2020b). Red king crab biomass is above the limit reference point (> MSST) but less than 75% of a target reference point, and the stock status of red king crab is therefore deemed of "moderate" concern.

**Factor 2.2 - Fishing Mortality**

**Bristol Bay Stock | Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Moderate Concern**

Red king crab are taken in directed and non-target fisheries, primarily in BSAI Pacific cod pot and longline and flatfish and pollock trawl fisheries. Several fisheries are prohibited from catch red king crab, including the Pacific cod pot fishery; catch from these fisheries is grouped under Prohibited Species Catch (PSC) for a variety of crab species and the crabs must be discarded; handling mortality rate in groundfish fixed gear fisheries is 50% (NPFMC 2020b). Each year from 2018-2020, BSAI Pacific cod pots caught 233,768, 41,723, and 21,326 individual crabs, which accounted for 90%, 40%, and 27% of the PSC catch of red king crab in BSAI reporting areas during the 2018, 2019, and 2020 seasons, respectively (NOAA 2021c). The 2020 Bristol Bay red king crab (BBRKC) stock assessment notes that mortality from groundfish fisheries bycatch are low: estimated fishing mortality for pot female and groundfish fisheries bycatch is generally less than 0.07 (NPFMC 2020b).

The BBRKC stock is not experiencing overfishing because the 2019/20 total catch (2.22 thousand t) was less than the OFL and was roughly 0.82 of the ABC (2.72 thousand t) (NPFMC 2020b). Total catches have been well below ABCs over time, but there is a growing concern that the stock will become overfished in the near future and some members of the Crab Plan Team (CPT) have suggested reviewing the use of $F_{35\%}$ as a proxy for $F_{MSY}$ (NPFMC 2020b).

Despite catch being below reference points, the stock abundance has been declining for several years. Seafood Watch believes abundance levels at or above $B_{MSY}$ should be one of the primary goals for a sustainable fishery. The stock is currently well below the $B_{MSY}$ proxy level and is not likely to reach that target in the foreseeable future. Therefore, a "moderate" concern score is awarded.

**Justification:**

While management measures are in place to reduce the impact of bycatch in groundfish trawl fisheries (e.g. area closures and PSC catch limits), no measures are currently in place for fixed gear groundfish fisheries (NPFMC 2021). The Pacific cod pot fishery fits the Seafood Watch criteria of being a substantial contributor to fishing mortality because BBRKC regularly encountered and the fishery is not yet managed in a way that reduces impact.

# Southern tanner crab

**Factor 2.1 - Abundance**

**Eastern Bering Sea Stock | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Moderate Concern**

EBS tanner crab is assessed annually as a Tier 3 species. The assessment model is structured by crab size, sex, shell condition, and maturity, using available data on quantity and size-composition from: the NMFS trawl survey, landings and discards by the directed fishery, bycatch in the Bristol Bay red king crab, EBS snow crab, and groundfish fisheries. The Mature Male Biomass (MMB), the proxy for $B_{MSY}$ ($B_{35\%}$) for this stock, has been variable over time, and increased from from the 2017/18 estimate (43.31 thousand t) to 56.15 thousand t in 2020/21 (96% of $B_{MSY}$); the highest estimates were seen in the early 1970s at approximately 400 thousand t)(NPFMC 2020b). The stock projection for 2020/21 is 35.33 thousand t (ibid). Estimates of recruitment since 1999 have been generally low relative to the peaks estimated for the period prior to 1990; there is uncertainty around the strong recruitment estimates for 2016, 2017 and 2018 (ibid).

The MMB was estimated to be below the Minimum Size Stock Threshold (MSST; $0.5B_{MSY}$) in February 2010, and NMFS declared the stock overfished and closed the directed fishery from 2010 to 2012. NMFS determined the stock was not overfished in 2012 based on a new assessment model with a revised estimate of $B_{MSY}$ (NPFMC 2020b). However, in 2016/2017 the Alaska Department of Fish and Game (ADF&G) set the EBS tanner crab TAC to zero due to concerns about mature female biomass, allowed a directed fishery in 2019/20, and did not open the fishery in 2019/20 (ibid). This decision was based on ADF&G harvest control guidelines, not federal management protocols (Stockhausen, NMFS, 2018 pers. comm). In light of biomass estimate uncertainties and recent variability in MMB relative to MSST and mature female biomass, EBS tanner crab receives a "moderate" concern for abundance.

**Justification:**

There was a relatively strong recruitment estimated for 2018, but this estimate is very uncertain and will need to be confirmed by subsequent assessments (NPFMC 2020b).. And because MMB>MSST, the stock is not overfished. Tanner crab male pre-recruit abundance was down relative to 2016; however, levels are still above the average over the past 20 years. The most recent BS trawl data suggests a 2017 biomass estimate for legal male Tanner crab east of 166°W was 36,963 t (± 95% CI) (Lang et al. 2017).

**Factor 2.2 - Fishing Mortality**

**Eastern Bering Sea Stock | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**

**Low Concern**

EBS Tanner crab is caught in directed Tanner crab fisheries, as bycatch in the groundfish fisheries, scallop fisheries, as bycatch in the directed Tanner crab fishery (mainly as non-retained females and sublegal males), and other crab fisheries (NPFMC 2020b). Total catches of tanner crab in non-pollock groundfish trawl and hook and line fisheries are well-below PSC limits. Total catch mortality (retained + discard mortality in all fisheries) in 2019/20 was 0.54 thousand t, which was less than the OFL for 2019/20 (28.86 thousand t); consequently overfishing did not occur during this time (NPFMC 2020b). Although pot fisheries are not subject to crab PSC limits, the BSAI Pacific cod pot fishery removals would account for <15% of the overall PSC limits, and therefore tanner crab receives a score of "low" concern for fishing mortality in the BSAI Pacific cod pot fishery.

# Spot shrimp

**Factor 2.1 - Abundance**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Moderate Concern**

Pandalid shrimp abundance shows natural variability; however, recent declines from 2011 to 2018 in spot prawn landings may suggest that the spot prawn stock is not as robust as historical levels. The spot prawn fishery is managed to ensure spot prawn escapement meets target reference points, and the spot prawn fishery receives a "moderate" concern for stock abundance.

**Justification:**

The commercial spot prawn fishery has been assessed since 1979 using an escapement-based model, referred to as the Spawner Index Model (Boutillier and Bond 2000) (DFO 2020a). Growth and mortality parameters for the model are determined each year based on fishery dependent and fishery independent data. The escapement-based model (one of the few used on a non-salmonid) is a standardized CPUE model that ensures a minimum number of female spawners are available at the time of egg hatch.

The number of spawners is measured using a spawner escapement index (SI) is represented by the catch rate of prawns that would contribute to the spawning population (DFO 2008). The Limit Reference Point (LRP) for prawns is defined in SI units and was established based on work by Boutillier and Bond (2001). They estimated $B_{MSY}$ for prawns in a study site in Howe Sound to be SI=3.9. Using the default formulas in DFO (2008) this would set the LRP to be 1.56 (40% $B_{MSY}$ ). Applying the default formulas the upper stock reference (USR) point is assigned a value of 3.12 (80% $B_{MSY}$ ).

The escapement model is not used to estimate an overall biomass for spot prawns; however, fishery landings serve as proxy of overall stock abundance from a management standpoint {DFO 2017a). While landings generally increased through 2010, annual landings have been variable to moderately declining from 2011 to 2018. In 2018, preliminary commercial landings estimates (not all logbooks were available at the time of publication) were up from the two previous years (DFO 2020a).

**Factor 2.2 - Fishing Mortality**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Low Concern**

It is not possible to estimate a standard fishing mortality. The management reference point (for triggering a closure) is generally 10% higher than the Minimum Monthly Indices (MMI) to ensure that the coastwide LRP is not exceeded (pers. comm., Convey, DFO 2017) (Boutillier and Bond 2000). Triggered closures also ensure there are no reference point overages by the Pacific Fishery Management subarea. The closure protects the remaining egg bearing females from commercial fishing mortality through to the end of the larval hatching period (DFO 2020a). This precautionary, in-season approach to managing the fishery renders it highly likely that fishing mortality is at a sustainable level based on the ecological role of spot prawns in BC.; therefore, the spot prawn fishery receives a "low" concern for fishing mortality.

**Justification:**

As stated above, target reference points as escapement goals are generated each year based on commercial fishery and independent survey data. These reference points, established under the Provisional Harvest Control Rules (HCRs), are expressed as monthly base spawner index values. Seasonal closures are implemented as fishing effort approaches the index value. Once implemented, the subarea remains closed to commercial fishing to the end of the spawning cycle and the opening date of the commercial season the following year. It's important to note that spot prawns are also harvested in aboriginal and recreational fisheries that occur throughout the year. Although these landings do not count towards commercial landings, there are daily catch limits, trap limits, and seasonal closures (DFO 2020a).

**Factor 2.3 - Discard Rate/Landings**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**< 100%**
Data on catch retention and discards are available through the NMFS Catch Accounting system. Vessels fishing Pacific pots in the BSAI typically have partial observer coverage through the North Pacific Observer Program. Data were analyzed 2013 to 2017, and the BSAI Pacific cod pot fishery discard/landings ratio during that time was less than 0.05. Bait use in this fishery is unknown, and the discard mortality rate for much of the bycatch (invertebrates, snails, etc.) is likely less than 100% (Alverson et al. 1994); however, neither of these factors would alter the score for this criteria.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**< 100%**
Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). Dungeness crab mortality rate is 2%–4% for undersized crab, 22%–25% for soft shell crab and unknown for females (Alverson et al. 1994). Since female mortality is unknown, using an estimated conservative mortality rate of 50% for all discards, total dead discard rate is estimated to be 6.2%. Information on bait use is lacking as it is not quantified in the fishery. The best available estimate is 2.5 lbs. of crab landed for every pound of bait, about 40% bait-to-landings ratio (F. Bowers, pers. comm).

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**< 100%**
Data on bycatch in the BC trap fishery was collected via a fishery independent study conducted 1999 to 2008, where 17,210 traps were monitored. The total bycatch/landings (spot prawn) ratio was approximately 18% (Favaro et al. 2010). However, invertebrates composed a majority of the bycatch (>95%). The post-capture mortality rate for invertebrates is conservatively assumed to be 50% based on research from the Alaska Fisheries Science Center and additional studies suggesting discard mortality rates are relatively low for invertebrates caught in trap gear (AFSC 2017). Therefore, the dead discards to landings ratio is <0.1/1. Bait use in trap fisheries can be significant and includes pellets, cat food, small fish, etc. Exact bait use amounts for this fishery are unknown but the bait use to landings ratio is likely to be well under 0.5/1. Bait use data are limited, however, it is safe to assume the ratio of (discards + bait) / landings is well under 1.

## Criterion 3: Management Effectiveness

*Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:*

- *5 (Very Low Concern) — Meets the standards of 'highly effective' for all five factors considered.*
- *4 (Low Concern) — Meets the standards of 'highly effective' for 'management strategy and implementation' and at least 'moderately effective' for all other factors.*
- *3 (Moderate Concern) — Meets the standards for at least 'moderately effective' for all five factors.*
- *2 (High Concern) — At a minimum, meets standards for 'moderately effective' for Management Strategy and Implementation and Bycatch Strategy, but at least one other factor is rated 'ineffective.'*
- *1 (Very High Concern) — Management Strategy and Implementation and/or Bycatch Management are 'ineffective.'*
- *0 (Critical) — Management Strategy and Implementation is 'critical'.*

The Criterion 3 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

*Rating is Critical if Management Strategy and Implementation is Critical.*

**Guiding principle**

- The fishery is managed to sustain the long-term productivity of all impacted species.

*Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:*

# Criterion 3 Summary

| FISHERY | MANAGEMENT STRATEGY | BYCATCH STRATEGY | RESEARCH AND MONITORING | ENFORCEMENT | INCLUSION | SCORE |
|---|---|---|---|---|---|---|
| Bering Sea \| Pacific, Northeast \| Pots \| United States \| Alaska \| Pacific cod pot Fishery | Highly effective | Highly effective | Moderately Effective | Highly effective | Highly effective | **Green (4.000)** |
| Gulf of Alaska \| Pacific, Northeast \| Pots \| United States \| Pacific cod pot Fishery | Highly effective | Highly effective | Moderately Effective | Highly effective | Highly effective | **Green (4.000)** |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia Dungeness crab fishery | Moderately Effective | Highly effective | Moderately Effective | Highly effective | Highly effective | **Yellow (3.000)** |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia spot prawn fishery | Highly effective | Moderately Effective | Highly effective | Highly effective | Highly effective | **Green (4.000)** |

**As octopus is not a main species in any of the fisheries assessed in this report, the scores for Criterion 3 in this report are unchanged from the parent reports. However, text specific to the management of the fisheries' impacts on octopus has been added to the relevant sections in this criterion.**

Octopus are not targeted, but are caught as bycatch by all of the fisheries in this assessment. Given the nature of the gears (i.e., pots and traps), it is possible that octopus actually seek them out for shelter or because they have food inside. Damage

to octopuses that are caught is mitigated largely through quick release of unwanted individuals back into the water. Although data is limited and uncertainty high, catches appear to be conservative in the absence of a commercial, directed-fishery for this species and unless the latter is established (or there is an unforeseen market shift that results in a higher retention rate), the impacts of fishing on this species will likely remain stable**.**

Over the last fifteen years, available data suggest that about 40-80% of octopus has been discarded (i.e., released alive in most cases) by the AK fisheries (Conners et al., 2013; Conners and Conrath, 2013). At present, catch reporting for octopus in AK uses a conservative assumption of 100% mortality for all octopus caught, regardless of whether they are retained or discarded.

Given the passive nature of pots, octopuses are usually caught alive and highly active in many cases. Thus, unless fishers choose to kill and retain them for sale, they can be removed quickly and discarded without harm {Conners and Conrath, 2013}. Moreover, since octopuses lack a swim bladder, they are unaffected by pressure changes associated with depth, and can survive out of water for brief periods (Conners and Conrath, 2013). Research suggests that even when kept on-board for over 48 hours, octopuses can still be released back into the ocean in excellent condition, or at least in a state no different than when they were caught (Conners and Conrath, 2013). Despite these findings, the post-release effects of handling stress are currently unknown {Conners et al., 2013}.

test test

# Criterion 3 Assessment

SCORING GUIDELINES

Factor 3.1 - Management Strategy and Implementation
*Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do manages follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.*

Factor 3.2 - Bycatch Strategy
*Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and when applicable, to minimize ghost fishing? How successful are these management measures? To achieve a Highly Effective rating, the fishery must have no or low bycatch, or if there are bycatch or ghost fishing concerns, there must be effective measures in place to minimize impacts.*

Factor 3.3 - Scientific Research and Monitoring
*Considerations: How much and what types of data are collected to evaluate the fishery's impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.*

Factor 3.4 - Enforcement of Management Regulations
*Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.*

Factor 3.5 - Stakeholder Inclusion
*Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent, if*

*high participation by all stakeholders is encouraged, and if there a mechanism to effectively address user conflicts.*

**Factor 3.1 - Management Strategy And Implementation**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Highly effective**
*Pacific cod pot fishery management in Alaska*
Management strategy and implementation is scored "highly effective" for Alaska groundfish fisheries, including the Pacific cod pot fishery. Appropriate management and conservation targets have been defined for the majority of C1 species, and precautionary principles are in place that incorporate uncertainty. Long-term sustainability of stock biomass across groundfish fisheries confirms these management strategies are being implemented successfully over time. See justification section in C3.1 of the 2019 Seafood Watch Alaska Groundfish Report for more details.
**Justification:**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderately Effective**
*Dungeness crab fishery management in British Columbia*
Management strategy in British Columbia includes size, sex, and hardness harvest restrictions, seasonal closures, limited licensing, trap limits, gear requirements, and limits on soak time and weekly haul (DFO 2021a). This strategy has been successful in maintaining crab productivity, based on stability of annual landings on a decadal average. There is growing concern about the effects of increased fisheries effort in recent years and the resulting increased handling mortality of discarded crab. Management is ranked "moderately effective" due to a lack of biological reference points for precautionary population monitoring. See justification section in C3.1 of the 2019 Seafood Watch BC Dungeness Crab Report for more details.
**Justification:**

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Highly effective**
*Spot prawn fishery management in British Columbia*
The Canadian shrimp trap fishery is managed by the Minister of Fisheries and Oceans and Department of Fisheries and Oceans (DFO). The commercial fishery is limited entry, with seasonal closures, in-season area closures, gear limits, gear and buoy marking requirements (tags), trap mesh size requirements, minimum size limits, daily fishing time restrictions, and a daily single haul limit (DFO 2020a). Moderately stable landings data from the early 1990s to the present suggest the precautionary, assessment-based management approach used by the DFO can sustainably manage the spot prawn stock, while incorporating uncertainty and environmental variability. The spot prawn fishery receives a score of "highly effective" for management strategy and implementation. See justification section in C3.1 of the 2021 Seafood Watch BC Shrimp Report Update for more details.
**Justification:**

**Factor 3.2 - Bycatch Strategy**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Highly effective**
Bycatch is generally low in Pacific cod pot fisheries. The BSAI Pacific cod pot fishery has low bycatch rates for non-PSC species (<5%), however bycatch of king and tanner crabs in the BSAI Pacific cod pot fishery is relatively high. Pot fisheries are not subject to PSC limits, and the species count (number of individuals caught) of king crab bycatch actually exceeds the PSC allowance (which applies to trawl gear only for crabs) in aggregate from 2013 to 2017. Retention of crabs is not allowed with this fishery. Fishery managers conservatively estimate crab PSC landings using a 100% discard mortality rate (the actual discard mortality rate is estimated to be roughly 20% to 50%) (NPFMC 2017b). It's important to note that bycatch of PSC in BSAI pot fisheries has declined since 2007 (NMFS CAS data 2018). An additional conservation concern stems from potential entanglement of marine mammals, especially in light of limited to no observer coverage in this fishery. The GOA Pacific cod pot fishery has low bycatch rates (~8%) and, unlike the BSAI pot fishery, bycatch of crabs in GOA pot fisheries is not a major issue

Non-target species are returned to the water, and mortality rates for released other invertebrates are presumed to be relatively low (Alverson et al. 1999) (NPMFC 2017b). Pot fishing gear is required to have: 1) biodegradable panels to prevent lost pots from ghost fishing; and 2) a tunnel opening or escape panels to reduce bycatch of unwanted species. All pot and pot-and-line marker buoys carried on board or used must be identifiable by a federal or state registration number. Measures are in place to minimize bycatch to the extent practicable, PSC catch has declined since 2007, and most crab returned to the water survive. Although the PSC allowance (assigned to the trawl fisheries) is exceeded, and the Pacific cod pot fishery takes a significant number of crabs, managers confirm this is not a concerning issue because the majority of crabs caught are returned to the water alive. Therefore, the Pacific cod pot fishery receives a "highly effective" score for bycatch strategy.
**Justification:**
*Octopus management in the Pacific cod fishery*
As of 2011, to comply with the reauthorized Magnuson-Stevens Act, a separate management plan has been required for species retained as bycatch by Alaskan fisheries (Conners et al. 2013) (Conners and Conrath 2013). This plan was to include catch limits for all species, including those that fall under the Tier 6 category (i.e., species that are bycatch-only or data-deficient). Tier 6 catch limits are based on historical catches or an alternative method approved by the plan teams and Scientific and Statistical Committee (SSC). Pacific giant octopus falls into the Tier 6 category in the GOA and Tier 5 in BSAI; however, the catch history for this species is of incidental take only and is not considered very reliable.

In the BSAI, new methodology to derive fishing limits based on estimates of octopus consumption by Pacific cod rather than survey biomass abundance estimates has been used since 2012. As such, the OFL is not based on any biomass data and is instead a function of octopus natural mortality (obtained through cod predation data). Using a model developed by (Alverson and Pereyra 1969) and (Francis 1974), fishing mortality at OFL is assumed equivalent to natural mortality. As such, through this model, Ormseth et al. (2018) determined the OFL for octopus in the BSAI in 2019 to be 4,769 t with an associated ABC (.75*OFL) of 3,576 t. It is important to note that this estimate is derived independently of the BSAI biomass estimates, which was derived from trawl surveys. As such, this further identifies the inadequacies of using trawls to survey octopus and ultimately it should be noted that these values should not be compared.

In the GOA, current catch limits were determined by the Plan Team and SSC. These recommendations are based on the maximum historical catch (1,307 t in 2014) (Ormseth 2019). Currently, this results in an overfishing limit (OFL) of 1,307 t and an allowable biological catch (ABC) of 980 t.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Highly effective**

Management mitigates impacts of the fishery on bycatch through gear requirements (DFO 2021a). Traps must have two 105-mm diameter escape rings to allow for escape of undersized crab and females. Since use of hanging bait may increase the catch of soft-shell crab, to reduce handling mortality, hanging bait and bait cages have been banned in some regions. Managers may implement in-season closures if a high frequency of soft-shell capture is observed. The gear must be equipped with rot cord that serves as a biodegradable escape mechanism to reduce effects of ghost fishing when pots are lost at sea. Lost Dungeness fishery gear can cause marine mammal entanglement, mortality to benthic invertebrates, and habitat degradation. Impacts can be wide ranging both temporally and spatially. Derelict Dungeness crab fishery gear has been observed ghost fishing for seven years (Maselko et al. 2013), and trap tags and floats from the Oregon fishery were observed four years after loss in the Northwestern Hawaiian Islands (Ebbesmeyer et al. 2012).The use of single trap gear and permit and pot limits minimizes whale entanglement through reduction of gear in the water.

**Justification:**

*Octopus management in the dungeness crab fishery*

At present, there are no quotas or catch limits for giant Pacific octopus in the Dungeness crab trap fishery. All fishers are required to record all octopus caught in their Crab Trap logbooks, and whether the octopus was retained or discarded. The take of octopus is prohibited in several conservation areas (e.g. marine reserves, national parks), as well as at specific research sites within the Dungeness crab fishing region and, "all octopus caught in octopus closure areas must be removed from the trap and released immediately in the location where they were caught, in a manner that will cause least harm" {DFO, 2014a}. A complete list of octopus closure areas can be found in Section 5.9 of the crab IFMP (DFO 2021a). However, there is no information to suggest the effectiveness of these spatial closures.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Moderately Effective**

Bycatch in the spot prawn trap fishery is presumed to be low with minimal diversity (generally less than 6%) (Favaro et al. 2010) (Rutherford et al. 2010). The majority of species caught are invertebrates that are easily sorted and returned to the water with presumed low mortality (DFO 2020a). Both the commercial and recreational fishery require rot cord to release bycatch if traps are lost (DFO 2020a). Entanglement of humpback whales (Special Concern under COSEWIC and SARA) remains a potential issue for the prawn trap fishery, and no actions are specifically required to minimize these interactions outside of standard gear labeling. Canada has signed the Global Ghost Gear Initiative; in 2019 DFO began requiring all commercial fisheries to report lost and found gear (DFO 2020a). Gear requirements to reduce the risk of ghost fishing in conjunction with monitoring of rockfish bycatch associated with Rockfish Conservation Areas, low catch rates of threatened quillback rockfish, and risk of humpback whale entanglements result in a "moderately effective" rating for bycatch strategy

**Justification:**

*Octopus management in the spot prawn fishery*

Currently, no quotas or catch limits exist for giant Pacific octopus caught by the BC spot prawn trap fishery. A new logbook format that includes octopus information was introduced in 2004. All octopus caught must be recorded in fisher logbooks, and fishers must additionally specify whether the octopus was retained or discarded. The take of octopus is prohibited in several conservation areas (e.g. marine reserves, national parks), as well as at specific research sites within the spot prawn fishing region and any incidentally caught octopus in these regions must be released unharmed (DFO 2014b). A complete list of octopus closure areas can be found in Section 3.3 of the spot prawn IFMP (DFO 2020a). However, there is no information to suggest the effectiveness of these spatial closures.

Concerns about rockfish sustainability in the region led to the implementation of formal rockfish conservation measures in 2002. These measures included catch restrictions, fishery monitoring, assessment programs and establishment of areas closed to certain fishing activities. Rockfish encounters in the commercial prawn and shrimp trap fishery are a rare event (0.000 to 0.045 rockfish/trap) and the prawn and shrimp trap fisheries were allowed to continue in the Rockfish Conservation Areas with the collection of bycatch information. The sampling program estimates total rockfish bycatch in the commercial fishery (Rutherford et al. 2010). The most frequently encountered rockfish in the trap fishery are quillback rockfish, which have been assessed as "threatened" by the COSEWIC (COSEWIC 2009). Yet, a recent study of bycatch rates in the trap fishery found that bycatch rates of rockfish were so low that total rockfish bycatch by species could not be estimated by management region or coastwide owing to the low number of rockfish encountered (Rutherford et al. 2010).

Based on the COSEWIC assessment of recovery potential for quillback rockfish, DFO allows the shrimp trap fishery to persist (DFO 2013c). In 2014, trap modifications to include a biodegradable ('rot') cord or panel became mandatory for all commercial prawn traps. This modification was recommended by the prawn industry to facilitate release of bycatch species in the event traps are lost (DFO 2013c).

**Factor 3.3 - Scientific Research And Monitoring**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Moderately Effective**
Pot fisheries in Alaska are managed based on an independently conducted, current stock assessment process using fishery-dependent and fishery-independent data (NPFMC 2018). Bycatch is tracked by on-board observers (for some fisheries), required logbooks, electronic Monitoring Systems (EMS) in some fleets, and landings requirements. The majority of fisheries have partial to 100% observer requirements (except pot fisheries) and/or EMS requirements (NOAA 2018). Ghost fishing is mitigated by federally mandated gear labeling requirements and other measures, such as biodegradable twine in pot gear. However, reporting of lost gear can be inconsistent, and pot fishing gear in particular is demonstrated to have ghost gear impacts. Therefore, pot fisheries in Alaska receive a "moderately effective" score for scientific research and monitoring.
**Justification:**
*Scientific research and monitoring of octopus*
Until 2010, octopus was managed as part of the GOA and BSAI 'other species' complex, along with sharks, skates and sculpins. As a result of the Magnuson-Stevens Act, each of these groups has been managed separately with unique stock assessments and catch limits since 2011. While population research is ongoing, surveys are conducted largely through the use of trawls. This method is not ideal for surveying octopus for several reasons, including the fact that octopus spend a large amount of the daytime in dens and larger individuals are fast enough to avoid trawl gears (Ormseth 2019). As such, the actual biomass and size structure of octopus in the BSAI and GOA is still largely unknown. While information pertaining to octopus in Alaskan waters has improved substantially in recent years, several data gaps and research priorities have been identified for octopus and research on life history and biological traits of this species, as well as the impacts of fishing continues (Ormseth et al. 2018). Specifically, studies on the impacts of post-release discard mortality of octopus, reproductive biology, and spatial distribution and movements (tagging) have been conducted in recent years and are in various stages of publication (Conners et al. 2013) (Conners and Conrath 2013) (Ormseth et al. 2018), but studies are still needed to understand migratory patterns of giant Pacific octopus in Alaska waters (Ormseth 2019).

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Moderately Effective**
Fishery-independent stock assessments are conducted twice annually in two of seven designated fishing areas (Areas I and J) (DFO 2021a). Research surveys are performed in additional regions, on an inconsistent basis, to target specific scientific questions including stock composition, molt timing, and injury. Additional biological data are obtained through electronic monitoring programs, harvest logs, and biological sampling. The DFO acknowledges that existing biological information is insufficient for implementing future ecosystem-based management and has recently begun fishery independent surveys in additional fishing areas to collect additional biological information (DFO 2021a). As data collected do not meet the standards of "highly effective," but limited data are used to monitor and manage the stock, scientific research and monitoring is rated as "moderately effective."
**Justification:**
*Scientific research and monitoring of octopus*
There are currently no stock assessments being conducted for giant Pacific octopus in BC and current monitoring of this population appears to be limited to catch data recorded and reported by the target fisheries.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Highly effective**

Life history parameters, bycatch, lost fishing gear, and catch data are tracked through a number of fishery dependent and fishery independent sources; therefore, the shrimp trap fishery receives a score of "highly effective" for research and monitoring.

**Justification:**

Fisheries-dependent data are collected in season by on-board and on-ground observers to monitor stock status relative to the established SI reference points and to monitor rockfish bycatch fleetwide (DFO 2020a). A number of peer-reviewed studies have evaluated the efficacy of the current escapement-based model as a fishery management tool (Smith 2008) and examined bycatch in shrimp trap fisheries in the region (Rutherford et al. 2010) (Favaro et al. 2010). Overall stock abundance is determined by annual commercial landings and is considered a reasonable proxy (DFO 2020a). All traps are required to have tags, and the number of replacement tags issued is tracked by managers as a proxy to assess lost or ghost-fishing gear.

*Scientific research and monitoring of octopus*

Although octopus landings are recorded by fishers (DFO 2014b), a lack of biological estimates (e.g., biomass, abundance) or formal stock assessment suggests little ongoing analysis of data or research into giant Pacific octopus at the population level in BC. Although no current concerns with the health of the stock have been expressed by the DFO, there does not appear to be any solid foundation for determining population impacts (or deriving a catch limit) should product demand (and thus retention of incidentally-caught octopus) increase.

**Factor 3.4 - Enforcement Of Management Regulations**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Highly effective**
Methods to ensure compliance with regulations include: mandatory use of vessel monitoring systems (VMS), on-board observers, and record-keeping requirements including mandatory logbooks and the submission of product, discard, and disposition information via eLandings. NMFS (with support from NOAA Law Enforcement) enforces regulations for these safety, permit, area, and landings requirements. Additional enforcement duties fall within the purview of the Alaska State Troopers and US Coast Guard. Comprehensive regulations and enforcement in Alaska result in a "highly effective" rating for groundfish fisheries in Alaska.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**
**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Highly effective**
DFO regularly conducts self-diagnostic tools like the Fishery Checklist (a tool for internal use) to help monitor improvements that support sustainable fisheries, and identify areas of weakness that require further work. Compliance and enforcement are reviewed annually as part of this Checklist (L. Convey, pers. comm.). The post-season review for 2011 indicated that 90% of the fleet was checked for general compliance on board during the season. A compliance priority is enforcement of the single haul management program coast wide. Funding for this program is provided to DFO by industry and covers surveillance, vehicle and vessel maintenance, and prosecution of cases. Additional priorities include monitoring infractions related to time and area closures, inadequate reporting of haul time in logbooks, and illegal sales (DFO 2012b).

The DFO conducts enforcement activities to survey closed areas for illegal activity; to check gear requirement compliance; to investigate landings of undersize, female, and soft-shell crab; and to investigate fraudulent crab landing reporting (DFO 2021a). The enforcement program includes dockside monitoring, vessel inspection, electronic vessel monitoring, and fishery patrol via vessel and air surveillance.

Overall, regulations are regularly enforced and independently verified, including logbook reports, dedicated enforcement, and independent verification by Fisheries Act certified Observers (DFO 2020a) (DFO 2021a). Appropriate management and observation measures are regularly enforced and verified and there is sufficient capacity to manage and enforce the shrimp trap fishery; therefore, it receives a “highly effective” score.

**Factor 3.5 - Stakeholder Inclusion**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Highly effective**
The NPFMC meets five times per year, involves and encourages participation from all major user groups at each meeting, and addresses user conflicts as needed. Therefore, Alaska Pacific cod pot fisheries receive a "highly effective" score for stakeholder inclusion.
**Justification:**
The meetings of the NPFMC are open to the public, and public statements are taken prior to major decisions. Prior to the adoption of harvest specifications, the proposed specifications are published in the Federal Register, followed by a public review and comment period of no less than 15 days {NPFMC 2012a}. The NPFMC also takes advice from an advisory panel composed of representatives from commercial fishing companies, subsistence fishers, processors, observers, environmental organizations, and sport fishermen.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**
**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Highly effective**
The crab fishery management process is inclusive of stakeholder groups (DFO 2021a). Fishery planning involves an annual consultative process through a Crab Sectoral Committee comprised of representatives from DFO, commercial license holders, and processors.

A prawn advisory board exists to include various stakeholders in the prawn management process (DFO 2020a). Overall, the management process is transparent, with notifications and invitations to the public to participate in year-round meetings, allowing for dispute resolution and inclusion in the management process. Additionally, industry representatives are involved in the establishment and funding of a number of fishery-dependent stock monitoring and compliance measures (DFO 2020a). Both fisheries receive a score of "highly effective" for stakeholder inclusion.

## Criterion 4: Impacts on the Habitat and Ecosystem

*This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment. The final score is the geometric mean of the impact of fishing gear on habitat score (factor 4.1 + factor 4.2) and the Ecosystem Based Fishery Management score. The Criterion 4 rating is determined as follows:*

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

**Guiding principles**

- Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.
- Follow the principles of ecosystem-based fisheries management.

*Rating cannot be Critical for Criterion 4.*

# Criterion 4 Summary

| FISHERY | FISHING GEAR ON THE SUBSTRATE | MITIGATION OF GEAR IMPACTS | ECOSYSTEM-BASED FISHERIES MGMT | SCORE |
|---|---|---|---|---|
| Bering Sea \| Pacific, Northeast \| Pots \| United States \| Alaska \| Pacific cod pot Fishery | 3 | +1 | Very Low Concern | **Green (4.472)** |
| Gulf of Alaska \| Pacific, Northeast \| Pots \| United States \| Pacific cod pot Fishery | 3 | +1 | Very Low Concern | **Green (4.472)** |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia Dungeness crab fishery | 2 | 0 | Low Concern | **Yellow (2.449)** |
| Northeast Pacific \| Pots \| Canada \| British Columbia \| British Columbia spot prawn fishery | 2 | +.5 | Low Concern | **Yellow (3.162)** |

Given that giant Pacific octopus are landed as bycatch in the Alaskan Pacific cod pot fishery and the BC trap fisheries for Dungeness crab and spot prawns, all habitat impacts have already been assessed in the target fishery Seafood Watch Reports. For a detailed breakdown of each score, please refer to the *Alaska Groundfish Complex (Bottom trawl, Midwater trawl, Pot, Bottom longline, Handline) Seafood Watch Report*, the *Alaska, British Columbia, California, Washington (Pot) Dungeness Crab Seafood Watch Report* and the *British Columbia Cold Water Shrimp (Bottom Trawl, Trap) Seafood Watch Report.*

**Criterion 4 Assessment**

SCORING GUIDELINES

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate
Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

- *5 - Fishing gear does not contact the bottom*
- *4 - Vertical line gear*
- *3 - Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 - Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.*
- *1 - Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 - Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*
  *Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.*

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts
Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

- *+1 —>50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very low/limited and for trawled fisheries, expansion of fishery's footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of 'moderate' mitigation measures.*
- *+0.5 —At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery's footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.*
- *0 —No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in factor 4.1*

Factor 4.3 - Ecosystem-Based Fisheries Management
Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

- *5 — Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.*
- *4 — Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.*
- *3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 — Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 — Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

**Factor 4.1 - Impact of Fishing Gear on the Habitat/Substrate**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**3**
Identified EFH and the pot fisheries for BSAI and GOA Pacific cod largely take place over sand, mud, sandy mud, and gravel (NOAA 2005) (Thompson 2017) (Barbeaux et al. 2017). The physical impact of pot fishing gear on sand, mud, and gravel habitat receives a score of 3 based on the Seafood Watch Criteria.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**2**
The fishery uses pot/trap gear that contacts the bottom (via a vertical line) primarily in mud and sand habitats with the potential to damage biogenic structures (DFO 2021a). The physical impact of pot fishing gear on bottom habitats that include boulders or reefs receives a score of "2" based on the Seafood Watch Criteria.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**2**
The spot prawn trap fishery occurs in nearshore areas over rocky or hard bottoms that can include glass-sponge reefs or coral beds (DFO 2020a). The physical impact of pot fishing gear on bottom habitats that include boulder or reefs receives a score of "2" based on the Seafood Watch Criteria.

**Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**+1**
Although there are fewer area closures for longline and pot gear in Alaska, a substantial proportion of representative habitats are protected from bottom contact, and vulnerable habitats are strongly protected. Fishing effort is constrained by a number of factors including season durations, quota limits, and permitting requirements.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**0**
Fishing is prohibited within the Endeavour and Bowie Seamount Marine Protected Areas and in regions of the Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs to protect vulnerable cloud sponges (DFO 2021a). Fishery effort is regulated with pot limits; however, some fishers have compensated for this limitation by increasing the frequency of haul—effectively increasing spatial footprint. In the 2013 season, new regulations were implemented in some regions that restrict haul frequency to once per day. The spatial footprint is further reduced through limits on maximum trap size.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**+.5**
The shrimp trap fishery is closed in a number of regions with known vulnerable habitats, and expansion of the fishery into new zones is prohibited through enforceable regulations. Therefore, it scores +0.5 for mitigation of gear impacts.
**Justification:**
Existing measures, such as license limitation, trap limitation, and a daily single haul provision have reduced fishing effort, intensity, and the fishery's spatial footprint. The number of licenses has declined since the mid-1990s, and the fishing season also has decreased dramatically to approximately 40 days since 2012; the overall footprint of the fishery on benthic habitat has been mitigated in recent years (DFO 2020a). Area closures are also in place to protect vulnerable habitat. The Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs Marine Protected Area was established under the Oceans Act in February 2017 to conserve the biological diversity, structural habitat, and ecosystem function of glass sponge reefs, and prawn and shrimp trap fishing is prohibited (DFO 2020a). Additionally, all bottom contact fishing for shrimp (including traps) is prohibited in nine glass sponge reef areas in the Strait of Georgia to protect these areas in accordance with the Sensitive Benthic Areas Policy and its Ecological Risk Assessment Framework for cold-water corals and sponge dominated communities (DFO 2020a).

**Factor 4.3 - Ecosystem-based Fisheries Management**

**Bering Sea | Pacific, Northeast | Pots | United States | Alaska | Pacific cod pot Fishery**
**Gulf of Alaska | Pacific, Northeast | Pots | United States | Pacific cod pot Fishery**

**Very Low Concern**
Through the requirements of the Magnuson-Stevens Act and the Council's stated ecosystem policy objectives, in their vision statement and in individual FMPs, the Council approaches Alaska fishery management with EBFM principles forefront in consideration (NPFMC 2018). Harvest control rules are in place that account for ecosystem function, scientific uncertainty, and target and non-target species' ecological roles. Precautionary and effective spatial management is used, such as EFH and HAPC areas and regional fishery closures. Numerous ecosystem evaluations are ongoing, and Alaska's groundfish fisheries receive a "very low" score for conservation concern.
**Justification:**
See justification section in C4.3 of the 2019 Seafood Watch Alaska Groundfish Report for more details.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia Dungeness crab fishery**

**Low Concern**
Dungeness crab play an important role in trophic interactions both as predator and prey (Pauley et al. 1989). There is no evidence, however, that they play a disproportionate role in the ecosystem relative to their biomass. No formal assessments of ecosystem impacts of Dungeness fishing activity have been conducted. Although removal of large quantities of crab will have some impact on benthic coastal species diversity, abundance, and community structure, the effects are currently unknown.

**Northeast Pacific | Pots | Canada | British Columbia | British Columbia spot prawn fishery**

**Low Concern**
DFO recognizes pandalid shrimp as an important forage fish species because shrimp larvae are a critical source of food for a number of marine organisms. As adults, shrimp are a food source for a number of pelagic fish species such as hake, turbot, spiny dogfish, cod, rockfish, and skate (DFO 2020a). As part of an ecosystem-based fishery management (EBFM) approach, DFO emphasizes bycatch reduction (focusing on vulnerable species like rockfish and eulachon), sensitive habitat closures, marine reserves and protected areas that preserve ecosystem function, and management measures designed to preserve the viability of shrimp ecology (e.g., seasonal closures or delays to protect reproductive females). A number of policies are in place that protect ecosystem function using spatial and temporal management, and that account for the ecological role of shrimp; therefore, the trap fishery receives a score of "low" concern for EBFM.

## Acknowledgements

*Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.*

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## Appendix

**Appendix A**

Updates to the Giant Pacific Octopus Report :

# Updates to the Giant Pacific Octopus Report

**Updates to the October 5, 2015 giant Pacific octopus report were made on December 1, 2021.** This updated report is scored against the Seafood Watch Standard for Fisheries Version F3 (the previous report was in F2). Some C2 updates are relative to the 2015 Giant Pacific Octopus Report, while others are relative to the scoring in the 2019 AK Groundfish report as outlined below.

**Overall Recommendations for giant Pacific octopus** caught with pots in both BC and Alaska remained unchanged. Individual criterion updates are described below.

**Updates included:**

BC Dungeness crab pot fishery

C2.2 *Dungeness crab* downgraded from "low" to "moderate" concern because the species lacks a quantitative stock assessment and is not highly vulnerable.

BC spot prawn pot fishery

C2 *Humpback whale* was added to this report to align with the updated parent report.

C2.1 *Spot prawn* downgraded from "low" to "moderate" concern because the stock has experienced declines in recent years due to environmental conditions, but is managed conservatively.

AK Pacific cod pot fishery (GOA)

C1.2 *Giant Pacific octopus* upgraded from "moderate" to "low" concern because the stock is not undergoing overfishing.

C2.1 *Pacific cod* (update relative to the score in the 2015 Giant Pacific Octopus report) downgraded from "very low" to "moderate" concern because the stock has declined to <70% of a target level.

C2.2 *Pacific cod* (update relative to the score in the 2019 AK Groundfish report) upgraded from "moderate" to "low" concern because fishing levels have been drastically reduced in recent years to allow for rebuilding.

AK Pacific cod pot fishery (BSAI)

C2 T*anner crab* and *red king crab* were added to this report update to align with the updated parent report.

C2.2 *Red king crab* (update relative to the score in the 2019 AK Groundfish report ) downgraded from "low" to "moderate" concern because there is some uncertainty around the appropriateness of the fishing mortality reference point.

C2.1 *Pacific cod* (update relative to the score in the 2015 Giant Pacific Octopus report) downgraded from "very low" to "low" concern because there is uncertainty in the status of the Aleutian Islands subpopulation, but this subpopulation represents a small fraction of BSAI Pacific cod as a whole.

C2.2 *Pacific cod* (update relative to the score in the 2019 AK Groundfish report) upgraded from "moderate" to "low" concern because fishing rates have been below sustainable levels over the last three years.