Giant Pacific Octopus

Enteroctopus dofleini

Alaska, British Columbia

Pot

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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 Report. Each report 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." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, 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 Seafood Reports 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 Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

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.

Based on this principle, Seafood Watch had developed four sustainability **criteria** for evaluating wild-catch fisheries for consumers and businesses. These criteria are:

- How does fishing affect the species under assessment?
- How does the fishing affect other, target and non-target species?
- How effective is the fishery's management?
- How does the fishing affect habitats and the stability of the ecosystem?

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 the Safina Center's online guide:

Best Choice/Green: Are well managed and caught in ways that cause little harm to habitats or other wildlife.

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

Avoid/Red: Take a pass on these for now. These items are overfished or caught 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 traps 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 (*Enteroctopus dofleini*) is a demersal cephalopod that typically inhabits shallow coastal waters (i.e., intertidal to 100 m 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 9.6 m; more commonly weighing 20-50 kg, this is the largest species of octopus in the world. The giant Pacific octopus is dioescious and semelparous but it has a low inherent vulnerability to fishing.

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; from 1997 to 2013 it was less than 5% of the Pacific cod pot catch in AK (i.e., BSAI: <1%; GOA: 1%). In 2013, retained octopus constituted <1% of the Dungeness crab catch in BC, and 2% of the spot prawn catch the previous year. There is little knowledge of the state of the stock in both BC and AK, and no model-based stock assessments exist for this species. In BC, no specific management measures exist for the giant Pacific octopus stock; management measures in AK include annual catch limits and ongoing stock assessments.

With the exception of Criteria 1 (1.1, 1.2, and 1.3), 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. Except for the spot prawn fishery, this was always the target species. 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.

Table of Conservation Concerns and Overall Recommendations

Stock / Fishery	Impacts on the Stock	Impacts on other Spp.	Management	Habitat and Ecosystem	Overall Recommendation
North Pacific giant Octopus Alaska Gulf of Alaska: Pacific Cod pot–Pot	Yellow (2.64)	Green (4.75)	Green (3.87)	Green (3.74)	**Best Choice (3.673)**
North Pacific giant Octopus Alaska Bering Sea Aleutian Islands: Pacific Cod Pot–Pot	Yellow (2.64)	Green (4.75)	Green (3.87)	Green (3.74)	**Best Choice (3.673)**
North Pacific giant Octopus British Columbia North Pacific–Pot	Yellow (2.64)	Yellow (2.75)	Green (3.46)	Yellow (3.12)	**Good Alternative (2.978)**
North Pacific giant Octopus British Columbia Northeast Pacific–Pot	Yellow (2.64)	Yellow (2.57)	Green (4.47)	Yellow (2.74)	**Good Alternative (3.022)**

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 Concern[2], **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).

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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.

Overview of the Species and Management Bodies

The giant Pacific octopus (*Enteroctopus dofleini*) 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 used primarily 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 dioescious, 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, ensuring oxygen dispersion and preventing 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, and 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

Octopus fisheries have existed along the Pacific coast of North America as far back as the 1950s (Gillespie et al. 1998). The giant Pacific octopus, as well as the red octopus (*Octopus rubescens*), were the primary targets of these fisheries.

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 (Table 1). 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). No sharp instruments or environmentally harmful substances are permitted in this type of octopus fishing in BC (DFO 2012).

Year		Trap[1]					
	Dive[1]	Octopus[2]	Shrimp	Crab	Other	Trawl[3]	Other[4]
1983	12.32	2.34	0.80	0.00	0.00	10.20	1.43
1984	9.53	2.63	1.63	0.05	2.61	6.84	1.27
1985	16.94	0.94	2.50	0.36	0.00	4.53	3.00
1986	38.89	0.61	1.53	0.09	0.00	5.70	2.85
1987	76.48	0.12	5.66	0.13	0.22	21.09	1.55
1988	154.08	1.45	6.19	0.16	0.30	28.40	3.22
1989	152.64	0.00	7.90	0.00	1.37	22.49	5.28
1990	154.32	1.85	15.92	0.78	0.18	31.25	4.96
1991	33.52	2.36	19.40	1.41	0.00	28.71	5.41
1992	43.84	0.93	29.55	0.91	1.65	12.43	2.55
1993	67.44	2.52	37.32	0.79	0.47	34.58	2.71
1994	48.07	2.55	21.54	0.54	0.60	17.18	1.21
1995	46.80	0.00	18.31	0.63	0.00	13.17	2.66
1996	76.17	0.00	61.58	2.45	0.00	11.84[5]	1.32

Notes: 1 - from harvest logbook data.
2 - includes wooden, mesh and plastic trap categories
3 - includes groundfish and shrimp trawl landings from sales slip records
4 - includes longline, salmon troll, freezer troll, dipnet and handline landings from sales slip records.
5 - from onboard observer records for groundfish trawl and sales slip records from shrimp trawl.

Annual octopus landings (t) of octopus in British Columbia by gear type (1983-1996). (From Gillespie et al. 1998).

A substantial increase in landings occurred from 1988 to 1990 due to a high demand of octopus for use as bait in the halibut fishery, but this interest quickly declined due to alternative bait sources (DFO 2003). In general, landings of octopus in BC have been highly variable since the late 1990s with a peak catch of 217 t (all gears) occurring in 1997 (DFO, 2003).

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). Concerns with the use of scientific licenses resulted in the implementation of non-transferable exploratory fishing licenses in 2007. Since 2009, conversations among stakeholders discussing the possibility of converting back to commercial licenses have been ongoing (DFO 2012).

Presently, 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 to 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 (see Fig. 1 and Fig. 2), 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).

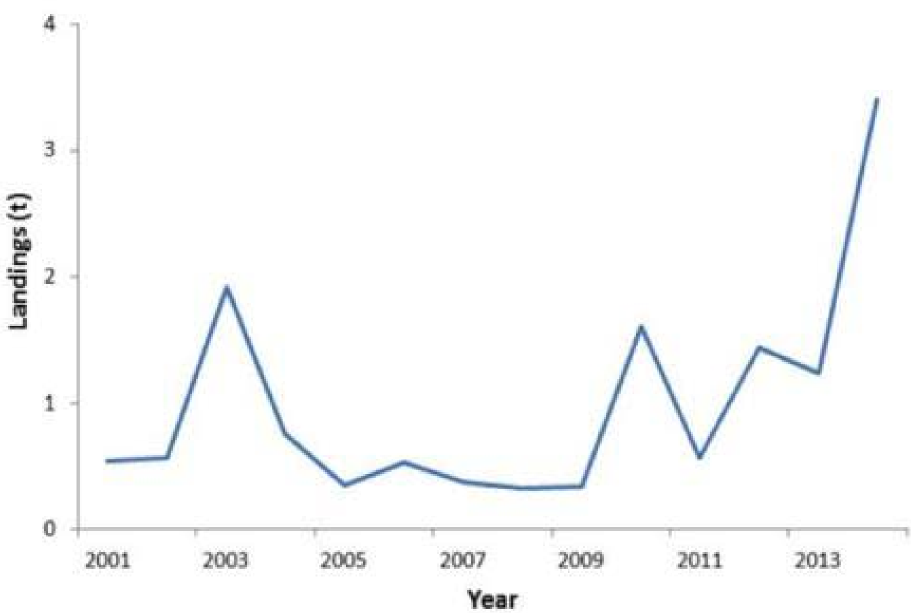

Figure 1: Landings of giant Pacific octopus incidentally caught by BC Dungeness crab trap fishery from 2001 to 2014. (Data provided by DFO.)

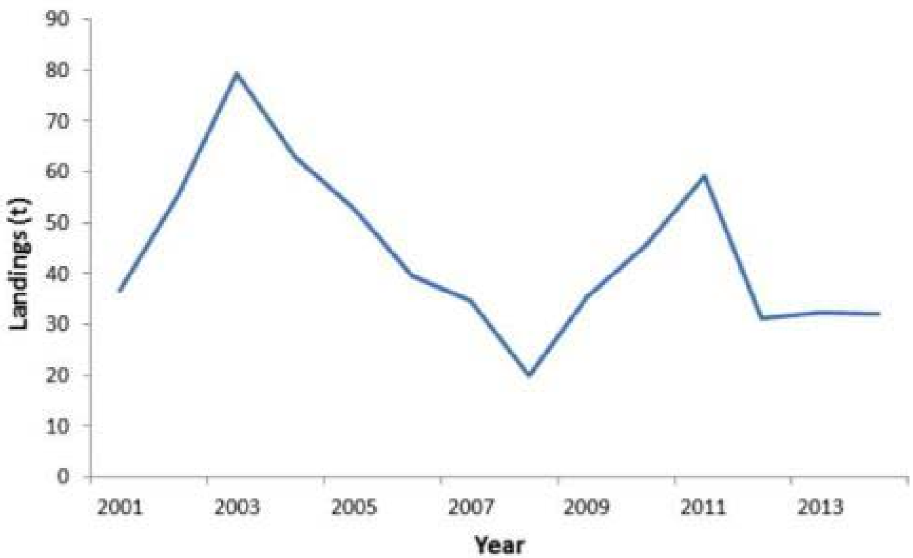

Figure 2: Landings of giant Pacific octopus incidentally caught by BC prawn trap fisheries from 2001-2014. (Data provided by DFO.)

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 to 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 to 2007, but have increased substantially in recent years, peaking at over 860 t in 2011 (Fig. 3). 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 (Fig. 5). In both regions, not all octopus landed is retained. Retention in the BSAI averaged 32% between 2003 and 2013; little data are available regarding the amount of octopus retained in the GOA, although 100% was kept in 2011 (Conners et al. 2013)(Conners and Conrath 2013) and 68% was retained in 2013 (Fig. 4).

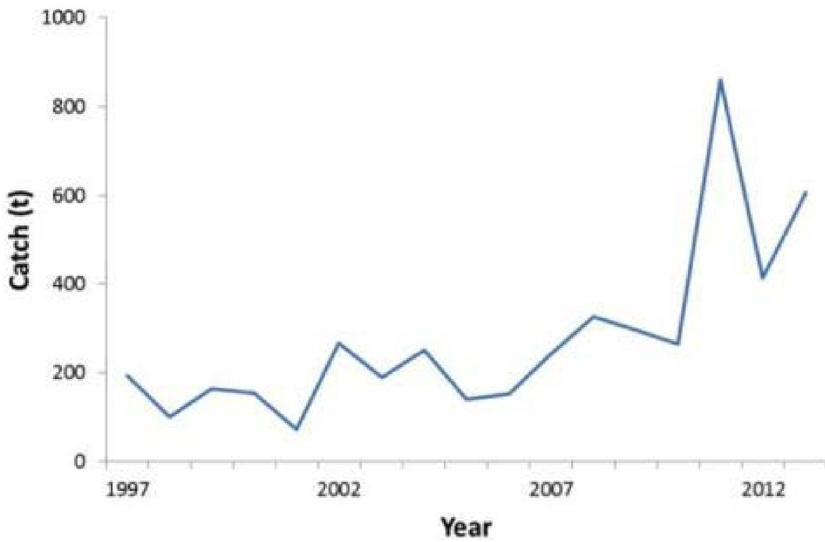

Figure 3. Catch of octopus (all species) by the Gulf of Alaska Pacific (GOA) cod pot fishery between 1997 and 2013. (Data for 1997-2012 from Table 2 in Conners and Conrath, 2013.) During this time period, this fishery has been responsible for an average of 92% of all octopus caught in the GOA. No detailed information on the amount of octopus that was retained was available but in 2011, about half of the 860 t of octopus caught was kept for sale or bait, and in 2013, 412 t was retained. (Data for 2013 from Cathy Tide, NOAA Fisheries, December 2014).

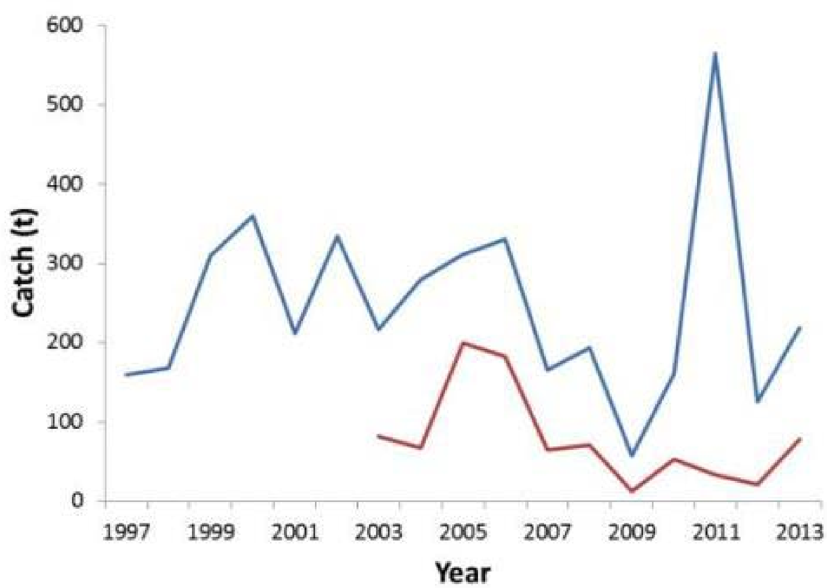

Figure 4. Total catch (blue) and retained landings (red) of octopus (all species) by the Pacific cod pot fishery in the Bering Sea and Aleutian Islands (BSAI) from 1997-2012. During this time period, this fishery was responsible for an average of 88% of all octopus caught in the BSAI. (Data for 1997-2012 from Table 2 in Conrath *et al.*, 2013; 2013 data from Cathy Tide, NOAA Fisheries, December 2014.)

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 are no records of federally directed fishing for octopus in Alaskan waters (Conners and Conrath 2013) and 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 re-authorized 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).

The amount of octopus incidentally caught by each of the target fisheries in this report varies by region (Fig. 5); from 1997 to 2013, it was less than 5% of the Pacific cod pot catch in AK (i.e., BSAI: <1%; GOA: 1%). In 2013, retained octopus constituted <1% of the Dungeness crab catch in BC, and 2% of the spot prawn catch the previous year.

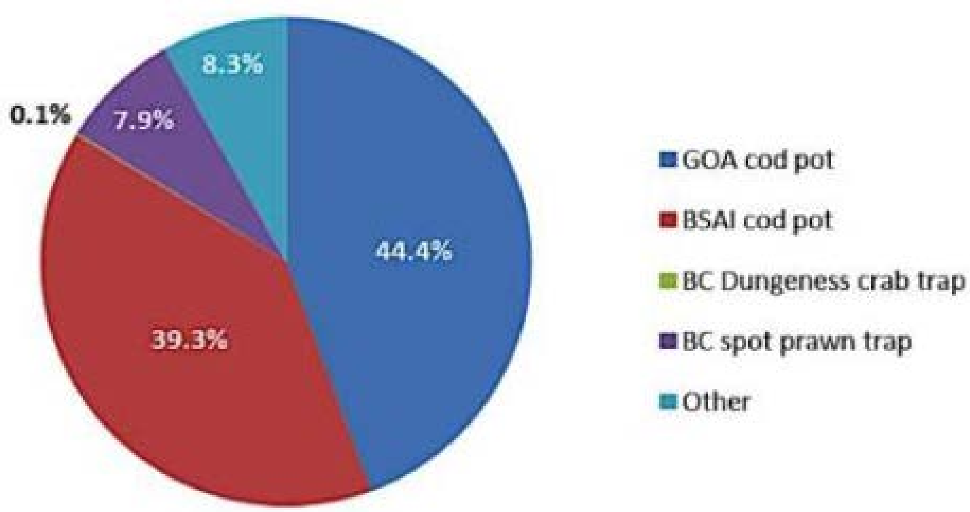

Figure 5. Breakdown of octopus landed as bycatch by commercial fisheries in Alaska and British Columbia (average from 2001-2012). Unpublished data obtained from DFO and recent stock assessments for giant Pacific octopus in the GOA and BSAI (see Conners *et al*., 2013 and Conrath and Conners, 2013). 'Other' refers primarily to catches from the Alaskan flatfish and groundfish fisheries.

Importance to the US/North American market

Compared to many countries, Canada exports very little octopus. Prior to the 1990s, much of the octopus commercially landed in BC was exported to Portugal and Spain (Gillespie *et al*., 1998). From 1988-1990, Canada exported just under 140 t of octopus (probably mostly *E. dofleini*), of which only 16% was exported fresh. The majority of this product went to the United States, with some also exported to Brazil and Portugal (Anonymous 1991). Between 2010 and 2013, the United States imported 13 t of octopus from Canada. Conversely, from 2009 to 2012, 210 t of octopus (assumed to be primarily *E. dofleini*) was exported from Anchorage, AK. The primary destination of this product was Portugal (76%). In 2014, only 37 t were exported and none was sent to Portugal; 36% was imported by South Korea and 2% was imported by the Netherlands, two countries which do not previously appear in the export database (NOAA 2015). As Conners and Conrath (2013) suggest “recent increases in global market value have increased retention of incidentally-caught octopus in [Alaska],” and the current local ex-vessel price is about US$ 1.10 per kilogram.

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 Mediterranean dishes and in Japanese cuisine—where it is translated as *tako*; *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 Criteria for Fisheries, available at http://www.seafoodwatch.org.

Criterion 1: Stock for which you want a recommendation

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. The inherent vulnerability to fishing rating influences how abundance is scored, when abundance is unknown. 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.

Criterion 1 Summary

NORTH PACIFIC GIANT OCTOPUS				
Region / Method	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
Alaska Bering Sea Aleutian Islands: Pacific Cod Pot Pot	3.00:Low	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**
Alaska Gulf of Alaska: Pacific Cod Pot Pot	3.00:Low	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**
British Columbia North Pacific Pot	3.00:Low	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**
British Columbia Northeast Pacific Pot	3.00:Low	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**

Criterion 1 Assessment

NORTH PACIFIC GIANT OCTOPUS

Factor 1.1–Inherent Vulnerability

Scoring Guidelines

- *Low—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing).*
- *Medium—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).*
- *High—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make is particularly vulnerable to fishing, (e.g., long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator).*
  Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling, aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Low

Using the criteria in this rubric suggests that giant Pacific octopus has a low inherent vulnerability (Table 2).

Rationale

Maturity in *E. dofleini* is estimated to be >2 years of age, however, there is no established procedure for aging this species in the wild (Conrath and Conners 2014). In Alaskan waters, females are believed to mature at a weight of 10-20 kg and males around 14.2 kg (Conrath and Conners 2014). Along the coast of BC, maturity occurs at a slightly lower weight for males (12 kg) (DFO 2012). It is believed that both sexes mate with multiple partners during their lives, and females often store spermatophores for extended periods before fertilization occurs (Gillespie et al. 1998). Nonetheless, both males and females die within months of spawning (or, for males, after depositing their spermatophores). Females do not release all their eggs during spawning and thus actual fecundity is lower than potential fecundity (Hartwick 1983 in Gillespie et al. 1998). The estimated actual fecundity for this species in BC ranges from 18,000 to 74,000 eggs (with potential fecundity up to 100,000). In Alaska, peak spawning occurs during the winter and early spring, and lifetime potential fecundity ranges from 41,600 to 239,000 eggs per female (Conrath and Conners 2014). In both regions, fecundity is strongly correlated to the size of the female and the life expectancy for this species is likely five years old (Gillespie et al. 1998, Conrath and Conners 2014).

Attribute	Details	Score	Source
Average age at maturity	2-3 years (estimated)	3	DFO (2012); Conrath and Conners (2014)
Average maximum age	4-5 years	3	Gillespie *et al.* (1998)
Reproductive strategy	Dioecious and semelparous; fertilization is internal as a result of direct mating; females brood eggs externally	2	Gillespie *et al.* (1998)
Density dependence	Not likely as *E. dofleini* is not sessile and highly mobile	2	Gillespie (pers. comm., 2015)
Mean score		**2.50**	

This life history score appears to be less precautionary than that of SeaLifeBase, which suggests this species has a very high vulnerability (i.e., 90 out of 100; Pauly and Palomares 2013).

British Columbia North Pacific, Pot

British Columbia Northeast Pacific, Pot

Low

Using the criteria in this rubric suggests that giant Pacific octopus has a low inherent vulnerability (Table 2).

Rationale

Maturity in *E. dofleini* is estimated to be >2 years of age, however, there is no established procedure for aging this species in the wild (Conrath and Conners 2014). In Alaskan waters, females are believed to mature at a weight of 10-20 kg and males around 14.2 kg (Conrath and Conners 2014). Along the coast of BC, maturity occurs at a slightly lower weight for males (12 kg) (DFO 2012). It is believed that both sexes mate with multiple partners during their lives, and females often store spermatophores for extended periods before fertilization occurs (Gillespie et al. 1998). Nonetheless, both males and females die within months of spawning (or, for males, after depositing their spermatophores). Females do not release all their eggs during spawning and thus actual fecundity is lower than potential fecundity (Hartwick 1983 in Gillespie et al. 1998). The estimated actual fecundity for this species in BC ranges from 18,000 to 74,000 eggs (with potential fecundity up to 100,000). In Alaska, peak spawning occurs during the winter and early spring, and lifetime potential fecundity ranges from 41,600 to 239,000 eggs per female (Conrath and Conners 2014). In both regions, fecundity is strongly correlated to the size of the female and the life expectancy for this species is likely five years old (Gillespie et al. 1998, Conrath and Conners 2014). This life history score appears to be less precautionary than that of SeaLifeBase, which suggests this species has a very high vulnerability (i.e., 90 out of 100; Pauly and Palomares 2013).

Attribute	Details	Score	Source
Average age at maturity	2-3 years (estimated)	3	DFO (2012); Conrath and Conners (2014)
Average maximum age	4-5 years	3	Gillespie *et al.* (1998)
Reproductive strategy	Dioecious and semelparous; fertilization is internal as a result of direct mating; females brood eggs externally	2	Gillespie *et al.* (1998)
Density dependence	Not likely as *E. dofleini* is not sessile and highly mobile	2	Gillespie (pers. comm., 2015)
Mean score		**2.50**	

Life history attributes of the giant Pacific Octopus.

Factor 1.2–Stock Status

Scoring Guidelines

- *5 (Very Low Concern)—Strong evidence exists that the population is above target abundance level (e.g., biomass at maximum sustainable yield, BMSY) or near virgin biomass.*
- *4 (Low Concern)—Population may be below target abundance level, but it is considered not overfished.*
- *3 (Moderate Concern) —Abundance level is unknown and the species has a low or medium inherent vulnerability to fishing.*
- *2 (High Concern)—Population is overfished, depleted, or a species of concern, OR abundance is unknown and the species has a high inherent vulnerability to fishing.*
- *1 (Very High Concern)—Population is listed as threatened or endangered.*

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Moderate Concern

Overall, the state of knowledge for this species in the BSAI is poor and data are insufficient. As such, a model-based stock assessment is not currently possible and the present abundance status of *E. dofleini* is unknown (Conners et al. 2013). A rating of 'moderate concern' has been applied as stock status is unknown and the species does not have an inherently high vulnerability to fishing.

Rationale

Based on trawl surveys, the estimated total biomass of octopus in the Bering Sea and Aleutian Islands (BSAI) in 2013 was 1,810 t; of which 91% is estimated to be giant Pacific octopus (Conners et al. 2013).

This biomass estimate is slightly lower than estimates from the two previous years, but is also probably conservative and unreliable given the nature of the trawl surveys (see section on the GOA).

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Moderate Concern

In general, the state of knowledge for this species in the GOA is poor and there are insufficient data to determine whether *E. dofleini* is currently overfished or nearing an overfished state. Since Pacific giant octopus does not have a high inherent vulnerability to fishing, a score of ‘moderate concern’ has been applied.

Rationale
The estimated survey biomass of all octopus species in the Gulf of Alaska (GOA) in 2013 was 2,686 t, 90% of which was identified as giant Pacific octopus. Over time, biomass estimates have ranged from 994 t in 1999 and 2001, to 3,767 t in 2003, to 3,791 t in 2009. However, Conners and Conrath (2013) identifed several limitations with regard to trawl surveys as a proxy for estimating octopus abundance. Specially, these surveys occur in locations and at times in which octopus may not be present, and larger species (i.e., *E. dofleini*) are believed to be more successful at evading the trawling gear and avoiding capture. Thus, these values are likely under-estimates of *E. dofleini* biomass in the region; one independent estimate of abundance of octopus determined through ecopath modeling suggests there may be upward of 200,000 t in the GOA (Conners and Conrath 2013).

British Columbia North Pacific, Pot

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 (G. Gillespie, pers. comm.). While stock status is unknown, a score a ‘moderate concern’ has been used here since this species has a low inherent vulnerability to fishing.

British Columbia Northeast Pacific, Pot

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 (G. Gillespie, pers. comm.). This species is not inherently highly vulnerable to fishing, thus a score of ‘moderate concern’ has been applied given the absence of known stock status.

Factor 1.3–Fishing Mortality

Scoring Guidelines

- *5 (Very Low Concern)—Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY), OR fishery does not target species and its contribution to the mortality of species is negligible (≤ 5% of a sustainable level of fishing mortality).*
- *3.67 (Low Concern)—Probable (>50%) chance that fishing mortality is at or below a sustainable level, but some uncertainty exists, OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible, OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught).*
- *2.33 (Moderate Concern)—Fishing mortality is fluctuating around sustainable levels, OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery and, if species is depleted, reasonable management is in place.*
- *1 (High Concern)—Overfishing is occurring, but management is in place to curtail overfishing, OR fishing mortality is unknown, species is depleted, and no management is in place.*
- *0 (Critical)—Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Moderate Concern

Current data for *E. dolfleini* 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 (Conners et al. 2013). As such, there is no information regarding whether or not the giant Pacific octopus stock is undergoing overfishing.

Rationale

The overfishing limit (OFL) and allowable biological catch (ABC) for this region are currently derived from Pacific cod consumption estimates. For 2015, the OFL was set to 3,450 t, with an associated ABC of 2,590. These limits far exceed recent catches of octopus in the BSAI (i.e., an average of 220 t from 2008 to 2012). However, although they appear to be conservative, there is insufficient information on the impacts of fishing and a score of ‘moderate concern’ has been applied.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Moderate Concern

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. As such, there is no information regarding whether or not the giant Pacific octopus stock is undergoing overfishing.

Rationale

The most conservative estimate of natural mortality for this species is M=0.53 (based on Rikhter and Efanov's 1976 equation) and is calculated based on an age of maturity of three years old (Conners and Conrath 2013). Using this estimate of mortality, and octopus biomass estimates from the three most recent biological surveys, the GOA Plan Team derived a current OFL of 2,009 t and an ABC of 1,507 t. Both of these limits exceed current landings of octopus in the GOA (i.e., an average of 432 t from 2008 to 2012). Nonetheless, a score of 'moderate concern' has been applied given the overall lack of biological data and uncertainty surrounding this species.

British Columbia North Pacific, Pot

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.

British Columbia Northeast Pacific, Pot

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. Given the poor knowledge of the impacts of fishing on octopus in BC, 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 in the same way as the species under assessment were evaluated in Criterion 1. 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 ghostfishing. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard rate score (ranges from 0-1), which evaluates the amount of non-retained catch (discards) and bait use relative to the retained catch. 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 Critical.

Criterion 2 Summary

North Pacific Giant Octopus: Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Subscore:	5.000	Discard Rate:	0.95	C2 Rate:	4.750

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
NORTH PACIFIC GIANT OCTOPUS	Low	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
PACIFIC COD	Medium	5.00: Very Low Concern	5.00: Very Low Concern	**5.000**

North Pacific Giant Octopus: Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Subscore:	5.000	Discard Rate:	0.95	C2 Rate:	4.750

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
NORTH PACIFIC GIANT OCTOPUS	Low	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
PACIFIC COD	Medium	5.00: Very Low Concern	5.00: Very Low Concern	**5.000**

North Pacific Giant Octopus: British Columbia North Pacific, Pot					
Subscore:	**3.053**	**Discard Rate:**	**0.90**	**C2 Rate:**	**2.748**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
NORTH PACIFIC GIANT OCTOPUS	Low	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
DUNGENESS CRAB	Low	4.00: Low Concern	2.33: Moderate Concern	**3.053**
BENTHIC INVERTS	Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**
FINFISH	Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**

North Pacific Giant Octopus: British Columbia Northeast Pacific, Pot					
Subscore:	**2.709**	**Discard Rate:**	**0.95**	**C2 Rate:**	**2.574**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
NORTH PACIFIC GIANT OCTOPUS	Low	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
QUILLBACK ROCKFISH	High	2.00: High Concern	3.67: Low Concern	**2.709**
SPOT PRAWN	Low	4.00: Low Concern	5.00: Very Low Concern	**4.472**

Criterion 2 Assessment

BENTHIC INVERTS

Factor 2.1–Inherent Vulnerability

Scoring Guidelines (same as Factor 1.1 above)

British Columbia North Pacific, Pot

Medium

Invertebrates have moderate inherent vulnerability according to Seafood Watch criteria.

Factor 2.2–Stock Status

Scoring Guidelines (same as Factor 1.2 above)

British Columbia North Pacific, Pot

Moderate Concern

Stock status is scored as a ‘moderate concern’ using Seafood Watch criteria.

Factor 2.3–Fishing Mortality

Scoring Guidelines (same as Factor 1.3 above)

British Columbia North Pacific, Pot

Low Concern

Fishing mortality is scored as low under Seafood Watch criteria for invertebrates caught as bycatch via the pot fishery.

Factor 2.4–Discard Rate

British Columbia North Pacific, Pot

40%–60%

Discard data specific to the Dungeness crab fishery are unavailable, however, average discard rate for global crab catch is 12.4 % (Kelleher 2005). Dungeness crab mortality rate is 2%–4% for undersize 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.).

DUNGENESS CRAB

Factor 2.1–Inherent Vulnerability

Scoring Guidelines (same as Factor 1.1 above)

British Columbia North Pacific, Pot

Low

Dungeness crab have low inherent vulnerability (score of 2.67) due to their early age at sexual maturity, high fecundity and short lifespan. In Alaska, sexual maturity is reached at 2 years for females and 3 years for males (Hoopes 1973), and maximum lifespan is 8-13 years (ADFG 1994) (see Table 1 in Seafood Watch Dungeness Crab Report).

Factor 2.2–Stock Status

Scoring Guidelines (same as Factor 1.2 above)

British Columbia North Pacific, Pot

Low Concern

The Dungeness crab stock assessment in British Columbia is based on CPUE from pot surveys (DFO 2013a). Populations fluctuate cyclically, with periods of higher abundance followed by periods of lower abundance, 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 while sublegal crab abundance has declined since 2005. The population of Dungeness crab in British Columbia is not considered to be overfished by the Canadian Department of Fisheries and Oceans.

Factor 2.3–Fishing Mortality

Scoring Guidelines (same as Factor 1.3 above)

British Columbia North Pacific, Pot

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 been historically high, reaching near 100% in some regions (Smith and Jamieson 1989). Despite intense harvest, annual fishery landings fluctuate cyclically around a relatively stable mean, a pattern thought to be tied to environmental variability (see Figure 3 in Seafood Watch Dungeness Crab Report; DFO 2013a, DFO 2013b). Fishery mortality is ranked as a 'moderate concern' due to high exploitation rates resulting in dependence on annual recruitment for population persistence.

Rationale

Landings have decreased in 2011 to the lowest commercial harvest level since 2000. Although regulations limit collection by size, sex and season, there is growing concern about the extent of mortality to undersize, female, and soft shell crab due to handling. 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, implying increased female mortality (Zhang and Dunham 2013).

Factor 2.4–Discard Rate

British Columbia North Pacific, Pot

40%–60%

Discard data specific to the Dungeness crab fishery are unavailable, however, average discard rate for global crab catch is 12.4 % (Kelleher 2005). Dungeness crab mortality rate is 2%–4% for undersize 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.).

FINFISH

Factor 2.1–Inherent Vulnerability

Scoring Guidelines (same as Factor 1.1 above)

British Columbia North Pacific, Pot

Medium

Finfishes have moderate inherent vulnerability under Seafood Watch criteria.

Factor 2.2–Stock Status

Scoring Guidelines (same as Factor 1.2 above)

British Columbia North Pacific, Pot

Moderate Concern

Stock status is scored as ‘moderate concern’ using Seafood Watch criteria.

Factor 2.3–Fishing Mortality

Scoring Guidelines (same as Factor 1.3 above)

British Columbia North Pacific, Pot

Low Concern

Fishing mortality is scored as ‘low concern’ under Seafood Watch criteria for finfishes caught as bycatch via the pot fishery.

Factor 2.4–Discard Rate

British Columbia North Pacific, Pot

40%–60%

Discard data specific to the Dungeness crab fishery are unavailable, however, average discard rate for global crab catch is 12.4 % (Kelleher 2005). Dungeness crab mortality rate is 2%–4% for undersize 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).

PACIFIC COD

Factor 2.1–Inherent Vulnerability

Scoring Guidelines (same as Factor 1.1 above)

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Medium

The FishBase vulnerability score for Pacific cod is 50, and the species' productivity score in Table 1 in the Seafood Watch Alaskan Groundfish Report is 2.11 (Cope, J.M. et al. 2011).

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Medium

The FishBase vulnerability score for Pacific cod is 50, and the species' productivity score in Table 1 in the Seafood Watch Alaskan Groundfish Report is 2.11 (Cope, J.M. et al. 2011).

Factor 2.2–Stock Status

Scoring Guidelines (same as Factor 1.2 above)

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Very Low Concern

The BSAI Pacific cod stock were classified as ’not overfished’ for 2012, and for 2013, BSAI Pacific cod SB_{2013}:$SB_{40\%}$ is 1.18. BSAI Pacific cod are therefore scored ’very low concern’ for Factor 1.2.

Rationale

The estimated spawning biomass of BSAI Pacific cod generally declined from 1984 through 1993, remained relatively steady through 2003, declined until 2009, and increased in the subsequent years (Table 2.26 in Thompson, G.G. & Lauth, R.R. 2012). The estimated 2013 BSAI Pacific cod spawning is 422,000 t, which is the highest value since 1992 (Table 2.26 in Thompson, G.G. & Lauth, R.R. 2012), taking the 93% conversion rate into account). The estimated 2013 spawning biomass also exceeds $SB_{40\%}$ (358,000 t; Thompson, G.G. & Lauth, R.R. 2012). The BSAI Pacific cod stock was classified as ’not overfished’ for 2012 (NMFS 2012).

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Very Low Concern

GOA Pacific cod were classified as ’not overfished’ for 2012, and estimated SB_{2013}:$SB_{40\%}$ is 1.15. GOA Pacific cod are therefore scored ’very low concern.’

Rationale
GOA Pacific cod spawning biomass declined over most of the past three decades, from approximately 258,000 t in 1983 to 81,890 t in 2008 (Figure 23; Table 2.14 in A'mar, T., et al. 2012b). Spawning biomass has increased since 2008, and for 2013, the estimated spawning biomass of GOA Pacific cod is 108,491 t (S.D. = 15,806 t; Table 2.14 in A'mar, T., et al. 2012b), while $SB_{40\%}$ is 93,900 t (A'mar, T., et al. 2012b). In 2012, the GOA Pacific cod stock was classified as ’not overfished,’ with a B:B_{MSY} ratio of 1.198 (NMFS 2012).

Factor 2.3–Fishing Mortality

Scoring Guidelines (same as Factor 1.3 above)

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Very Low Concern

Catch of BSAI Pacific cod was 80.9% of the Tier 3a OFL in 2011 (Thompson, G.G. & Lauth, R.R. 2012), and the stock was classified as not experiencing overfishing for 2012 (NMFS 2012). BSAI Pacific cod fishing mortality is therefore scored ’very low concern’ for the BSAI Pacific cod longline, trawl, pot, and jig fisheries, and the BSAI flatfish trawl fishery.

Rationale
Fishing mortality rates for BSAI Pacific cod have been relatively steady in recent years, varying between 0.202 and 0.264 since 1998 (Table 2.19d in Thompson, G.G. & Lauth, R.R. 2012). For reference, the estimated F_{OFL} for 2013 is 0.34 (Thompson, G.G. & Lauth, R.R. 2012). Catch of BSAI Pacific cod has not exceeded OFL since 1992 (Table 2.3 in Thompson, G.G. & Lauth, R.R. 2012). In 2011, total catch of BSAI Pacific cod was 220,134 t, while the OFL and ABC were 272,000 t and 235,000 t, respectively (Table 2.3 in Thompson, G.G. & Lauth, R.R. 2012). The 2011 BSAI Pacific cod catch was taken primarily in the Pacific cod longline fishery (53.8% of catch), Pacific cod trawl fishery (16.6%), Pacific cod pot fishery (12.7%), and flatfish trawl tows for yellowfin sole (7.4%) (Table 4 in Fissel, B. et al. 2012). For 2012, the BSAI Pacific cod stock was classified as not experiencing overfishing (NMFS 2012).

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Very Low Concern

For 2011, catch of GOA Pacific cod in federal and state fisheries was 82.7% of the OFL (A'mar, T., et al. 2012b), and the stock was classified as not experiencing overfishing in 2012 (NMFS 2012). Fishing mortality of GOA Pacific cod is therefore scored ’very low concern’ for the GOA Pacific cod pot, longline, trawl, and jig fisheries.

Rationale
The total catch of GOA Pacific cod by federal and state fisheries has not exceeded the OFL since at least 1992 (Table 2.2 in A'mar, T., et al. 2012b). In 2011, the total catch of GOA Pacific cod was 84,839 t, with 62,821 t caught in federal fisheries and 22,018 t caught in state fisheries (Table 2.1 in A'mar, T., et al. 2012b), while the OFL and ABC were 102,600 t and 86,800 t, respectively (Table 2.2 in A'mar, T., et al. 2012b). The 2011 catch of GOA Pacific cod was caught primarily in the Pacific cod pot (47.3%), Pacific cod longline (25.9%), and Pacific cod trawl (18.6%) fisheries (Table 3 in Fissel, B., et al. 2012). For 2012, the stock was classified as not undergoing overfishing (NMFS 2012).

Factor 2.4–Discard Rate

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

20%–40%

There is no quantitative information available for the amount of bait used by the longline and pot fisheries in Alaska. Pot fisheries in particular are known to often use significant quantities of bait, and so are assigned a score that is one 'step' below the one that corresponds to their discards/landings ratio.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

20%–40%

There is no quantitative information available for the amount of bait used by the longline and pot fisheries in Alaska. Pot fisheries in particular are known to often use significant quantities of bait, and so are assigned a score that is one 'step' below the one that corresponds to their discards/landings ratio.

QUILLBACK ROCKFISH

Factor 2.1–Inherent Vulnerability

Scoring Guidelines (same as Factor 1.1 above)

British Columbia Northeast Pacific, Pot

High

Quillback rockfish have a high vulnerability score of 64 on FishBase.

Factor 2.2–Stock Status

Scoring Guidelines (same as Factor 1.2 above)

British Columbia Northeast Pacific, Pot

High Concern

Stock status is currently under review for the SARA listing. COSEWIC identifies the entire BC quillback rockfish population as one DU (with two management units), and lists quillback rockfish as 'threatened' (COSEWIC 2009). This determination is based on data through 2004/2005.

Rationale

In a recent stock assessment, inside and outside quillback rockfish B_{2010}:B_{MSY} ratios were less than the upper stock reference point (USR), but greater than the limit reference point (LRP) (the outside unit's B_{2011}:B_{MSY} ratio was 0.736 (95% confidence intervals = 0.266-1.814), and the inside unit's B_{2011}:B_{MSY} ratio was 0.493 (0.252-0.945)) (DFO 2012c). Although between LRP and USR, the high levels of uncertainty in the B_{2010}:B_{MSY} estimates lead to the score of high conservation concern for this factor.

Factor 2.3–Fishing Mortality

Scoring Guidelines (same as Factor 1.3 above)

British Columbia Northeast Pacific, Pot

Low Concern

Quillback rockfish fishing mortality is currently under review for the SARA listing, but a COSEWIC assessment and status report identifies directed fishing as the principal threat.

Rationale

Quillbacks can still be legally landed in all fisheries. The commercial groundfish fishery has a combined total allowable catch (TAC) which includes quillback and other rockfish species (Copper–*Sebastes maliger*, China–*S. nebulosus* and Tiger–*S. nigrocinctus*), 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.

Factor 2.4–Discard Rate

British Columbia Northeast Pacific, Pot

20%–40%

Spot prawns comprise roughly 84% of the catch (Favaro et al. 2010). Assuming all of these are retained, discards (incorporating estimated mortality) comprise approximately 10% of the catch (see Figure 11 in BC Coldwater Shrimp Report). Bait use in the trap fishery is likely to contribute to the discard rate. Pellet bait is used (L. Convey, pers. comm.), but DFO has no information on how much bait is used per pot nor on which species are used to make the pellets. This assessment assumes that the weight of bait is around 20% of landings, thus increasing the discards+bait/landings rate by 20% to approximately 30%.

SPOT PRAWN

Factor 2.1–Inherent Vulnerability

Scoring Guidelines (same as Factor 1.1 above)

British Columbia Northeast Pacific, Pot

Low

All coldwater shrimp species are considered to have low inherent vulnerability.

Factor 2.2–Stock Status

Scoring Guidelines (same as Factor 1.2 above)

British Columbia Northeast Pacific, Pot

Low Concern

Stock assessments are performed annually and estimates of total biomass are based on fishery-independent surveys of pink and sidestripe shrimp. Results indicating biomass and abundance trends are published in-season in shrimp survey bulletins. Assessments determine whether shrimp within an SMA are in the healthy zone, cautious zone, or critical zone (see Fig 10 in Seafood Watch BC Coldwater Shrimp Report). These zones are defined by an upper stock reference (USR) point and a limit reference point (LRP). Stocks that are above the USR are considered healthy, those that fall between the USR and LRP are considered cautious, and stocks that fall below the LRP are deemed critical and immediately closed. SMAs are not reopened until assessments determine the stock is out of the critical zone. The most recently published assessment found that the majority of the SMAs assessed were in the healthy zone (9 healthy, 3 cautious, and 1 critical) (DFO 2011). This is indicative of the biomass estimate generally being above an appropriate target reference point. Although not all of the SMAs are healthy, given that most are and that the critical SMA was immediately closed (i.e., critical populations are not fished), a score of 'low conservation concern' is appropriate.

Factor 2.3–Fishing Mortality

Scoring Guidelines (same as Factor 1.3 above)

British Columbia Northeast Pacific, Pot

Very Low Concern

Provisional harvest control rules (PHCRs) that incorporate the precautionary approach were developed using an upper stock reference point (80% B_{msy}) and a limit reference point (40% B_{msy}) (see Table 2 in Seafood Watch BC Coldwater Shrimp Report). The PHCR is currently set at 35% of the estimated total biomass, thus protecting a large portion of the stock. The total allowable catch (TAC) is defined and set annually based on the results of the stock assessments, which form the biological basis for these catch ceilings. If a TAC for any species is reached during the fishing season, the fishery is closed, making it likely that fishing mortality is at or below a sustainable level. In 2010, only two of the 36 SMAs were assessed as below the limit reference point and were closed to fishing (DFO 2011).Overall, fishing effort in the trawl fishery across SMAs has dramatically declined over time and is currently only 12% of 2005 effort (Schweigert et al. 2012) and is well below the TAC.

Factor 2.4–Discard Rate

British Columbia Northeast Pacific, Pot

20%–40%

Spot prawns comprise roughly 84% of the catch (Favaro et al. 2010). Assuming all of these are retained, discards (incorporating estimated mortality) comprise approximately 10% of the catch (see Figure 11 in BC Coldwater Shrimp Report). Bait use in the trap fishery is likely to contribute to the discard rate. Pellet bait is used (L. Convey, pers. comm.), but DFO has no information on how much bait is used per pot nor on which species are used to make the pellets. This assessment assumes that the weight of bait is around 20% of landings, thus increasing the discards+bait/landings rate by 20% to approximately

30%.

Criterion 3: Management effectiveness

Management is separated into management of retained species (harvest strategy) and management of non-retained species (bycatch strategy).

The final score for this criterion is the geometric mean of the two scores. 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 or either the Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern = Red or High Concern*
  Rating is Critical if either or both of Harvest Strategy (Factor 3.1) and Bycatch Management Strategy (Factor 3.2) ratings are Critical.

Criterion 3 Summary

Region / Method	Management of Retained Species	Management of Non-Retained Species	Overall Recommendation
Alaska Bering Sea Aleutian Islands: Pacific Cod Pot Pot	5.000	3.000	Green(3.873)
Alaska Gulf of Alaska: Pacific Cod Pot Pot	5.000	3.000	Green(3.873)
British Columbia North Pacific Pot	3.000	4.000	Green(3.464)
British Columbia Northeast Pacific Pot	5.000	4.000	Green(4.472)

Factor 3.1: Harvest Strategy

Scoring Guidelines

Seven subfactors are evaluated: Management Strategy, Recovery of Species of Concern, Scientific Research/Monitoring, Following of Scientific Advice, Enforcement of Regulations, Management Track Record, and Inclusion of Stakeholders. Each is rated as 'ineffective,' 'moderately effective,' or 'highly effective.'

- *5 (Very Low Concern)—Rated as 'highly effective' for all seven subfactors considered.*
- *4 (Low Concern)—Management Strategy and Recovery of Species of Concern rated 'highly effective' and all other subfactors rated at least 'moderately effective.'*

- *3 (Moderate Concern)—All subfactors rated at least 'moderately effective.'*
- *2 (High Concern)—At minimum, meets standards for 'moderately effective' for Management Strategy and Recovery of Species of Concern, but at least one other subfactor rated 'ineffective.'*
- *1 (Very High Concern)—Management exists, but Management Strategy and/or Recovery of Species of Concern rated 'ineffective.'*
- *0 (Critical)—No management exists when there is a clear need for management (i.e., fishery catches threatened, endangered, or high concern species), OR there is a high level of Illegal, unregulated, and unreported fishing occurring.*

Factor 3.1 Summary

Factor 3.1: Management of Fishing Impacts on Retained Species							
Region / Method	Strategy	Recovery	Research	Advice	Enforce	Track	Inclusion
Alaska Bering Sea Aleutian Islands: Pacific Cod Pot Pot	Highly Effective	N/A	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
Alaska Gulf of Alaska: Pacific Cod Pot Pot	Highly Effective	N/A	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
British Columbia North Pacific Pot	Moderately Effective	N/A	Moderately Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
British Columbia Northeast Pacific Pot	Highly Effective	N/A	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective

Subfactor 3.1.1 – 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? To achieve a 'highly effective' rating, there must be appropriate management goals, and evidence that the measures in place have been successful at maintaining/rebuilding species.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

Management strategy and implementation is scored 'highly effective' for all fisheries in this assessment. The standards for "management strategy and implementation," and the degree to which the management of Criterion 1 species meets them, are summarized below.

Rationale

1. Appropriate reference points

Each managed stock is placed into one of six tiers based upon the information available for the stock. Stocks in

Tiers 1-3 have biomass reference points (BMSY for Tiers 1 and 2, and B35% for Tier 3). There are no estimates of BMSY or B35% for Tiers 4-6.

2. Harvest control rules that adjust for declining biomass
The harvest control rules for stocks managed under Tiers 1-3 incorporate measures that automatically reduce fishing mortality when the stock's biomass passes beneath a threshold and which set fishing mortality to zero if the biomass falls below a minimum threshold. Stocks in Tiers 4 and 5 lack biomass reference points, and as such the fishing mortality rates used to calculate OFL are not affected by stock status (NPFMC 2012a). The OFL for Tier 6 stocks is generated from estimates of historical catch.

3. Risk aversion and buffering against uncertainty
The differences between OFL, ABC, and TAC offer a buffer against scientific and management uncertainty, and help fisheries managers to avoid the risk of accidental over-exploitation. The first degree of buffering occurs when ABCs are set at less than OFLs; when the 2013 ABCs and OFLs for important retained species are summed, the sum of the ABCs is 83.6% and 86.4% of the sum of the OFLs for the GOA and BSAI, respectively. Management uncertainty may be buffered further by reducing the TAC below the ABC: for the same stocks in the GOA and BSAI, the sums of TACs are 52.4% and 54.1%, respectively, of the sums of OFLs. See the Seafood Watch Alaska Groundfish Report for additional details.

Management of the fishery's impacts on octopus: As of 2011, to comply with the re-authorized 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; 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, Conners et al. (2013) determined the OFL for octopus in the BSAI in 2015 to be 3,450 t with an associated ABC (.75*OFL) of 2,590 t. It is important to note that this estimate is derived independently of the current BSAI biomass estimate (1,810 t), 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.

Alaska Gulf of Alaska: Pacific cod pot, Pot

Highly Effective

Management strategy and implementation is scored ’highly effective’ for all fisheries in this assessment. The standards for “management strategy and implementation,” and the degree to which the management of Criterion 1 species meets them, are summarized below.

Rationale

1. Appropriate reference points
Each managed stock is placed into one of six tiers based upon the information available for the stock. Stocks in Tiers 1-3 have biomass reference points (BMSY for Tiers 1 and 2, and B35% for Tier 3). There are no estimates of BMSY or B35% for Tiers 4-6.

2. Harvest control rules that adjust for declining biomass
The harvest control rules for stocks managed under Tiers 1-3 incorporate measures that automatically reduce fishing mortality when the stock’s biomass passes beneath a threshold, and which set fishing mortality to zero if the biomass falls below a minimum threshold. Stocks in Tiers 4 and 5 lack biomass reference points, and as such the fishing mortality rates used to calculate OFL are not affected by stock status (NPFMC 2012). The OFL for Tier 6 stocks is generated from estimates of historical catch.

3. Risk aversion and buffering against uncertainty
The differences between OFL, ABC, and TAC offer a buffer against scientific and management uncertainty, and help fisheries managers to avoid the risk of accidental over-exploitation. The first degree of buffering occurs when ABCs are set at less than OFLs; when the 2013 ABCs and OFLs for important retained species are summed, the sum of the ABCs is 83.6% and 86.4% of the sum of the OFLs for the GOA and BSAI, respectively. Management uncertainty may be buffered further by reducing the TAC below the ABC: for the same stocks in the GOA and BSAI, the sums of TACs are 52.4% and 54.1%, respectively, of the sums of OFLs. See the Seafood Watch Alaska Groundfish Report for additional details.

Management of the fishery’s impacts on octopus: As of 2011, to comply with the re-authorized 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; however, the catch history for this species is of incidental take only and is not considered very reliable. Thus, in the GOA, current catch limits were determined by the Plan Team and SSC. These recommendations are based on the average of the last three surveys as a minimum biomass estimate and the mortality rate estimated from age at maturity. Currently, this results in an overfishing limit (OFL) of 2,009 t and an allowable biological catch (ABC) of 1,507 t (Conners and Conrath 2013).

British Columbia North Pacific, Pot

Moderately Effective

Management is ranked 'moderately effective' due to lack of biological reference points for precautionary population monitoring.

Rationale

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 2013a). 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 of the fishery's impacts on octopus: 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). However, there is no information to suggest the effectiveness of these spatial closures.

British Columbia Northeast Pacific, Pot

Highly Effective

The current strategy is based on the precautionary approach.

Rationale

A fixed escapement model, the Spawner Index Model, is used to assess and manage the harvest in-season. Using catch per unit effort data, the model indicates the minimum number of female spawners required during the hatch period and harvest reference points are set. When the minimum monthly index is reached in a particular PFMA sub-area, the fishery is immediately closed. In recent years, the fishing season for spot prawns has been about 60 days. Since 2000, the fisheries have been managed more conservatively, with closures occurring when the number of spawning females falls to 10% above the spawner index, which provides a buffer to ensure spawner indexes are met. Landings data indicate a general, but steady, increase over time (DFO 2012b). Additional management measures to manage effort in the trap fishery include a limitation on license number, limitations on numbers of traps allowed per license, harvest log requirements, restrictions on mesh size and trap volume, single haul per day limits, and vessel length restrictions (DFO 2013c).

Management of the fishery's impacts on octopus: 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). However, there is no information to suggest the effectiveness of these spatial closures.

Subfactor 3.1.2 – Recovery of Species of Concern

Considerations: When needed, are recovery strategies/management measures in place to rebuild overfished/threatened/ endangered species or to limit fishery's impact on these species and what is their likelihood of success? To achieve a rating of 'highly effective,' rebuilding strategies that have a high likelihood of success in an appropriate timeframe must be in place when needed, as well as measures to minimize mortality for any overfished/threatened/endangered species.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

N/A

There are no overfished, depleted, endangered, or threatened stocks targeted or retained in the fisheries addressed in this assessment.

Rationale
One species (spiny dogfish) is an IUCN 'vulnerable' species, but the IUCN's assessment justification specifically states that the Alaska stock of spiny dogfish 'appears stable' (Fordham et al. 2006). All fisheries in this assessment, therefore, receive scores of 'NA' for this aspect of management.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

N/A

There are no overfished, depleted, endangered, or threatened stocks targeted or retained in the fisheries addressed in this assessment.

Rationale
One species (spiny dogfish) is an IUCN 'vulnerable' species, but the IUCN's assessment justification specifically states that the Alaska stock of spiny dogfish 'appears stable' (Fordham et al. 2006). All

fisheries in this assessment, therefore, receive scores of 'NA' for this aspect of management.

British Columbia North Pacific, Pot

N/A

There are currently no overfished, depleted, endangered or threatened species targeted or retained in the fishery.

British Columbia Northeast Pacific, Pot

N/A

There are currently no overfished, depleted, endangered or threatened species targeted or retained in the fishery.

Subfactor 3.1.3 – Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the health of the population and the fishery's impact on the species? To achieve a 'highly effective' rating, population assessments must be conducted regularly and they must be robust enough to reliably determine the population status.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

All of the major retained species (see Appendix B in Seafood Watch Alaska Groundfish Report) have up-to-date stock assessments.

Rationale

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 (Conners and Conrath 2013). 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. 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).

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Highly Effective

All of the major retained species (see Appendix B in Seafood Watch Alaska Groundfish Report) have up-to-date stock assessments.

Rationale

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 (Conners and Conrath 2013). 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. 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).

British Columbia North Pacific, Pot

Moderately Effective

The DFO acknowledges that existing biological information is insufficient for implementing future ecosystem-based management and has plans underway to begin monthly fishery-independent surveys in additional fishing areas (DFO 2013a).

Rationale

Fishery-independent stock assessments are conducted twice annually in two of seven designated fishing areas (Areas I & J, (DFO 2013a)). 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.

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.

British Columbia Northeast Pacific, Pot

Highly Effective

Rationale

Parameters related to growth and fishing mortality are derived from semi-annual independent fishery surveys. Fisheries dependent data are also collected in-season by observers to monitor stock status relative to the established reference points. Overall stock abundance is determined by annual commercial landings and is considered a reasonable proxy. As this is not a year-round fishery, robust monitoring efforts to aid in-season management decisions are integral (DFO 2012b).

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.

Subfactor 3.1.4 – Management Record of Following Scientific Advice

Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g., do they set catch limits at recommended levels)? A Highly Effective rating is given if managers nearly always follow scientific advice.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

One of the primary avenues through which science informs management of Alaska groundfish is through the determination of the OFL and ABC. A prescriptive process is followed to determine the OFL and maximum ABC for each stock or complex. This process takes into consideration the information available for the productivity of the stock and the stock's status (if known), and then specifies the mortality rate (or, in the case of Tier 6 stocks, the historical catch data) to be used to determine OFL and maximum ABC. While a final ABC may be reduced from the maximum ABC for various reasons, it cannot be greater than the calculated maximum ABC, and it will always be less than the OFL due to the process that is followed to calculate both (NPFMC 2012a). In addition, reductions in ABC that are recommended by the science body cannot be overruled by the Council; the ABCs recommended by the NPFMC to the secretary cannot exceed the SSC's recommended ABC (NPFMC 2012a). In essence, the process that exists for the determination of OFLs and maximum ABCs, and the recommendation of ABCs, ensures that the maximum acceptable mortality is determined by science and scientists and cannot be overruled, exceeded, or otherwise ignored.

Rationale

Management record of following scientific advice related to octopus: Giant Pacific octopus fall under Tier 6 and thus catch limits are based on historical catches or an alternative method approved by the plan teams and the Scientific and Statistical Committee (SSC). There is no evidence to suggest managers have not adhered to these recommendations in the past or that they do not currently follow this advice.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Highly Effective

One of the primary avenues through which science informs management of Alaska groundfish is through the determination of the OFL and ABC. A prescriptive process is followed to determine the OFL and maximum ABC for each stock or complex. This process takes into consideration the information available for the productivity of the stock and the stock's status (if known), and then specifies the mortality rate (or, in the case of Tier 6 stocks, the historical catch data) to be used to determine OFL and maximum ABC. While a final ABC may be reduced from the maximum ABC for various reasons, it cannot be greater than the calculated maximum ABC, and it will always be less than the OFL due to the process that is followed to calculate both (NPFMC 2012b). In addition, reductions in ABC that are recommended by the science body cannot be overruled by the Council; the ABCs recommended by the NPFMC to the secretary cannot exceed the SSC's recommended ABC (NPFMC 2012b). In essence, the process that exists for the determination of OFLs and maximum ABCs, and the recommendation of ABCs, ensures that the maximum acceptable mortality is determined by science and scientists and cannot be overruled, exceeded, or otherwise ignored.

Rationale

Management record of following scientific advice related to octopus: Giant Pacific octopus fall under Tier 6 and thus catch limits are based on historical catches or an alternative method approved by the plan teams and the Scientific and Statistical Committee (SSC). There is no evidence to suggest managers have not adhered to these recommendations in the past or that they do not currently follow this advice.

British Columbia North Pacific, Pot

Highly Effective

Management follows scientific advice, modifying and implementing regulations in response to research findings, however, research on stock abundance is extremely limited.

Rationale
A move toward precautionary management of crab populations through development of biological reference points to indicate stock status has been recommended (Zhang & Dunham 2013). Fisheries and Oceans Canada intends to base future management of the crab fishery on biological information (DFO 2013a).

Management record of following scientific advice related to octopus: While there are no scientifically deduced catch or effort recommendations for the giant Pacific stock, there is no evidence to suggest that scientific advice is not followed for bycatch species.

British Columbia Northeast Pacific, Pot

Highly Effective

Management does follow scientific advice and does not have a track record of disregarding it.

Rationale
DFO is currently reviewing the 2013 season and results indicate that scientific advice was nearly always followed. Over 80% of the in-season fisheries management decisions were based on area-specific scientific advice relative to the adopted (science peer-reviewed) reference points (i.e., fishery closures). The remainder, i.e., <20% of in-season decisions made by fisheries managers, were based on scientific advice in an adjacent area. In the latter, the management action was always precautionary to implement fishing closures based on scientific advice from the adjacent area (L. Convey, DFO, pers. comm.).

Management record of following scientific advice related to octopus: While there are no scientifically deduced catch or effort recommendations for the giant Pacific stock, there is no evidence to suggest that scientific advice is not followed for bycatch species.

Subfactor 3.1.5 – 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.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

Methods to ensure compliance with regulations include mandatory use of vessel monitoring systems (VMS) and record-keeping requirements such as mandatory logbooks and the submission of product, discard, and disposition information via eLandings. These measures meet the standard for 'highly effective' enforcement for those fisheries in which they are in place.

Rationale

The GOA sablefish and GOA and BSAI groundfish jig fisheries are essentially the only fisheries without full VMS coverage (VMS Discussion Paper 2012). Many sablefish and jig vessels do have VMS equipped, however (Table 3 in VMS Discussion Paper 2012).

Enforcement related the catch of octopus: When octopus were included as part of the 'other species' complex, landings were always well below the recommended TAC (Conners et al. 2013). In recent years, landings continue to be below the octopus-specific catch quota. In 2011, the BSAI cod pot fishery was closed pre-maturely once the quota for Pacific giant octopus had been reached.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Highly Effective

Methods to ensure compliance with regulations include mandatory use of vessel monitoring systems (VMS) and record-keeping requirements, including mandatory logbooks and the submission of product, discard, and disposition information via eLandings. These measures meet the standard for 'highly effective' enforcement for those fisheries in which they are in place. The GOA sablefish and GOA and BSAI groundfish jig fisheries are essentially the only fisheries without full VMS coverage (VMS Discussion Paper 2012). Many sablefish and jig vessels do have VMS equipped, however (Table 3 in VMS Discussion Paper 2012).

Rationale

Enforcement related the catch of octopus: When octopus were included as part of the 'other species' complex, landings were always well below the recommended TAC (Conners et al. 2013). In recent years, landings continue to be below the octopus-specific catch quota.

British Columbia North Pacific, Pot

Highly Effective

The DFO conducts enforcement activities to survey closed areas for illegal activity, check gear requirement compliance, and investigate landings of undersize, female and soft shell crab and fraudulent crab landing reporting (DFO 2013a). The enforcement program includes dockside monitoring, vessel inspection, electronic vessel monitoring and fishery patrol via vessel and air surveillance.

Rationale
Enforcement related the catch of octopus: There are currently no concerns pertaining to the recording or reporting of octopus catch data or the landing of octopus in no-take and restricted zones.

British Columbia Northeast Pacific, Pot

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). Overall, regulations are regularly enforced and independently verified, including logbook reports, dedicated enforcement, and independent verification by Fisheries Act certified Observers (DFO 2013c).

Rationale
Enforcement related the catch of octopus: There are currently no concerns pertaining to the recording or reporting of octopus catch data or the landing of octopus in no-take and restricted zones.

Subfactor 3.1.6 – Management Track Record

Considerations: Does management have a history of successfully maintaining populations at sustainable levels or a history of failing to maintain populations at sustainable levels? A 'highly effective' rating is given if measures enacted by management have been shown to result in the long-term maintenance of species overtime.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

The Alaska groundfish fisheries have a solid record of sustained catch levels and healthy stocks. In the GOA, landings have stayed relatively steady since 1990, ranging from a low of approximately 171,734 t in 2004 to 261,694 t in 1992 (Table 5 in GOA Groundfish Plan Team 2012). In the BSAI, catches, TACs, ABCs, OFLs, and total groundfish biomass have stayed relatively steady since the early 1980s (see Figure 33 in Seafood Watch Alaska Groundfish Report). Retention rates for many species have steadily increased over the past two decades as well; this is especially true for species, such as arrowtooth flounder, that traditionally had been retained at very low rates. Finally, there are no stocks that are currently listed as overfished or as experiencing overfishing (NMFS 2012). For these reasons, the track record for the management of the non-pollock groundfish fisheries in Alaska warrants a score of 'highly effective.'

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Highly Effective

The Alaska groundfish fisheries have a solid record of sustained catch levels and healthy stocks.

Rationale

In the GOA, landings have stayed relatively steady since 1990, ranging from a low of approximately 171,734 t in 2004 to 261,694 t in 1992 (Table 5 in GOA Groundfish Plan Team 2012). In the BSAI, catches, TACs, ABCs, OFLs, and total groundfish biomass have stayed relatively steady since the early 1980s (see Figure 33 in Seafood Watch Alaska Groundfish Report). Retention rates for many species have steadily increased over the past two decades, as well; this is especially true for species, such as arrowtooth flounder, that traditionally had been retained at very low rates. Finally, there are no stocks that are currently listed as overfished or as experiencing overfishing (NMFS 2012). For these reasons, the track record for the management of the non-pollock groundfish fisheries in Alaska warrants a score of 'highly effective.'

British Columbia North Pacific, Pot

Highly Effective

Based on annual landings data, management of the crab fishery has resulted in long-term maintenance of average stock abundance and ecosystem integrity (DFO 2013a).

British Columbia Northeast Pacific, Pot

Highly Effective

Over the last 20 years, and within the backdrop of fluctuations that are typical for forage species, landings have generally increased. License limitations began in 1990 and landings have risen from about 1.6M pounds to 4.8M pounds in 2010. Over this same time period, management has been consistent and became precautionary in 2000. This is evidence of long-term maintenance of stock abundance and productivity, and ecosystem integrity (DFO 2012b).

Subfactor 3.1.7 – 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 and includes stakeholder input.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

There are several avenues through which stakeholder input may considered and integrated into fisheries management decisions.

Rationale

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.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Highly Effective

There are several avenues through which stakeholder input may be considered and integrated into fisheries management decisions.

Rationale

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 2012b). 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.

British Columbia North Pacific, Pot

Highly Effective

The crab fishery management process is inclusive of stakeholder groups (DFO 2013a). Fishery planning involves an annual consultative process through a crab sectoral committee comprised of representatives from DFO, commercial license holders, and processors.

British Columbia Northeast Pacific, Pot

Highly Effective

The management process is transparent, with notifications and invitations to the public to participate year-round in meetings (DFO 2012b).

Bycatch Strategy

Factor 3.2: Management Of Fishing Impacts On Bycatch Species						
Region / Method	All Kept	Critical	Strategy	Research	Advice	Enforce
Alaska Bering Sea Aleutian Islands: Pacific Cod Pot **Pot**	No	No	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective
Alaska Gulf of Alaska: Pacific Cod Pot **Pot**	No	No	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective
British Columbia North Pacific **Pot**	No	No	Highly Effective	Moderately Effective	Highly Effective	Moderately Effective
British Columbia Northeast Pacific **Pot**	No	No	Highly Effective	Moderately Effective	Highly Effective	Highly Effective

As noted above, octopus is not a main species in any of the fisheries assessed in this report, the scores for 3.1 and 3.2 in this report are unchanged from the parent report. However, text specific to the management of the fisheries' impacts on octopus has been added to the relevant sections in this criterion.

As discussed throughout this report, a small number of octopus is landed incidentally rather than targeted. Over the last fifteen years, available data suggest that about 40%–80% of this species 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).

Subfactor 3.2.1 – Management Strategy and Implementation

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and how successful are these management measures? To achieve a 'highly effective' rating, the primary bycatch species must be known and there must be clear goals and measures in place to minimize the impacts on bycatch species (e.g., catch limits, use of proven mitigation measures, etc.).

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Moderately Effective

The management of bycatch species is generally sound. Concerns include the halibut prohibited species catch (PSC) limits' very slow response to declining halibut abundance, a lack of limits on grenadier bycatch, and the apparently minimal limits on dark rockfish bycatch in the Gulf. Several other common bycatch species lack biomass reference points (e.g., sleeper shark, harlequin rockfish). In the BSAI, sharks are managed as Tier 6 species, but instead of the overfishing limit being set at the typical level for Tier 6 species (average historical catch) it is set at a less precautionary level (maximum average catch). Fisheries in this assessment receive a score of 'moderately effective' for management strategy and implementation for bycatch species (Fissel et al. 2012).

Rationale

The groundfish fisheries are prohibited from retaining certain species. Prohibited Species Catch (PSC) refers to the catch of a group of species/species groups that may not be retained for sale by Alaska groundfish vessels. PSC species consist of Pacific halibut, Pacific herring, Pacific salmon and steelhead species, and king, tanner (*Chionoecetes bairdi*), and snow (*C. opilio*) crabs (NPFMC 2012a). Limits on PSC are in place for certain PSC stock/fishery combinations, and the relevant fishery is closed when a PSC limit is reached. Catch of PSC species is not equally distributed among the groundfish fisheries. In 2011, the Alaskan pollock trawl fisheries were responsible for the vast majority of the groundfish fisheries' catch of Pacific herring (95% of all Pacific herring caught in all groundfish fisheries), Chinook salmon (84%), and all other salmon (99%) (Tables 12 and 13 in Fissel et al. 2012). The PSC limits generally represent strong management of the fisheries' catches of this set of species; however, the slowness of the management regime to reduce halibut PSC limits in the face of declining halibut abundance is a concern (see Pacific halibut fishing mortality summary in this report). The management of non-PSC fish species that are caught as bycatch generally meets the standard for ’moderately effective’ management. Some common bycatch species do not have biomass reference points (e.g., harlequin rockfish, sharpchin rockfish, sleeper shark). Measures to improve the management of grenadier bycatch were recently adopted by the NPFMC (NPFMC 2014), but these measures do not place limits on grenadier bycatch (see giant grenadier fishing mortality summary). Another bycatch species for which bycatch management is a concern is the GOA dark rockfish. This species was removed from the FMP and is managed by the state of Alaska; currently, there is no assessment for the stock, and it is caught in nontrivial amounts in the GOA rockfish trawl fishery where the only limit on its catch is that it cannot be more than 5% of the total weight of retained rockfish for a trip (see dark rockfish summary in Criterion 2). Seabird bycatch in Alaskan groundfish demersal longline fisheries sharply declined after the introduction of streamer lines in 2002 (Zador 2012). All longline vessels >55’ length must use paired streamer lines, while vessels from 26’ to 55’ have to use single streamer lines or a buoy bag (NPFMC 2012a). Bycatch of short-tailed albatross in demersal longline fisheries is a matter of particular concern, and it should be noted that there were no observed mortalities of short-tailed albatross during the period 1998-2010 (AFSC 2011).

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Moderately Effective

The management of bycatch species is generally sound. Concerns include the very slow response to declining halibut abundance, a lack of limits on grenadier bycatch, and the apparently minimal limits on dark rockfish bycatch in the Gulf. Several other common bycatch species lack biomass reference points (e.g., sleeper shark, harlequin rockfish). In the BSAI, sharks are managed as Tier 6 species, but instead of the overfishing limit being set at the typical level for Tier 6 species (average historical catch) it is set at a less precautionary level (maximum average catch). Fisheries in this assessment receive a score of ’moderately effective’ for management strategy and implementation for bycatch species.

Rationale

The groundfish fisheries are prohibited from retaining certain species. Prohibited species catch (PSC) refers to the catch of a group of species/species groups that may not be retained for sale by Alaska groundfish vessels. PSC species consist of Pacific halibut, Pacific herring, Pacific salmon and steelhead species, and king, tanner (*Chionoecetes bairdi*), and snow (*C. opilio*) crabs (NPFMC 2012b). Limits on PSC are in place for certain PSC stock/fishery combinations, and the relevant fishery is closed when a PSC limit is reached. Catch of PSC species is not equally distributed among the groundfish fisheries. In 2011, the Alaskan pollock trawl fisheries were responsible for the vast majority of the groundfish fisheries’ catch of Pacific herring (95% of all Pacific herring caught in all groundfish fisheries), Chinook salmon (84%), and all other salmon (99%) (see Tables 12 and 13 in Fissel et al. 2012). The PSC limits generally represent strong management of the fisheries' catches of this set of species; however, the slowness of the management regime to reduce halibut PSC limits in the face of declining halibut abundance is a concern (see Pacific halibut fishing mortality summary in this report). The management of non-PSC fish species that are caught as bycatch generally meets the standard for 'moderately effective' management. Some common bycatch species do not have biomass reference points (e.g., harlequin rockfish, sharpchin rockfish, sleeper shark). Measures to improve the management of grenadier bycatch were recently adopted by the NPFMC (NPFMC 2014), but these measures do not place limits on grenadier bycatch (see giant grenadier fishing mortality summary). Another bycatch species for which bycatch management is a concern is the GOA dark rockfish. This species was removed from the FMP and is managed by the state of Alaska; currently, there is no assessment for the stock, and it is caught in nontrivial amounts in the GOA rockfish trawl fishery, where the only limit on its catch is that it cannot be more than 5% of the total weight of retained rockfish for a trip (see dark rockfish summary in Criterion 2). Seabird bycatch in Alaskan groundfish demersal longline fisheries sharply declined after the introduction of streamer lines in 2002 (Zador 2012). All longline vessels >55' length must use paired streamer lines, while vessels from 26' to 55' have to use single streamer lines or a buoy bag (NPFMC 2012b). Bycatch of short-tailed albatross in demersal longline fisheries is a matter of particular concern, and it should be noted that there were no observed mortalities of short-tailed albatross during the period 1998-2010 (AFSC 2011).

British Columbia North Pacific, Pot

Highly Effective

Management mitigates impacts of the fishery on bycatch through gear requirements.

Rationale

Traps must have two 105 mm diameter escape rings to allow for escape of undersize crab and females (DFO 2013a). To reduce handling mortality, hanging bait and bait cups have been banned and managers may implement in-season closures if a great frequency of soft shell is observed. The gear must be equipped with rot cord that serves as a biodegradable escape mechanism to reduce effects of ghostfishing when pots are lost at sea. The use of single trap gear and pot limits minimizes whale entanglement through reduction of gear in the water.

Discarding of octopus: Discard rates for octopus in BC were unavailable. However, as is the case in AK, a high rate of survivorship is likely.

British Columbia Northeast Pacific, Pot

Highly Effective

Similar to the trawl fishery, action to address overall bycatch concerns was taken years before COSEWIC declared quillback rockfish "threatened" in 2009 (quillback rockfish is currently under consideration for SARA listing). A rockfish conservation strategy was first proposed in 1998, and rockfish bycatch in the shrimp/prawn trap fishery has been monitored since 2002 (DFO 2013c). DFO deems rockfish encounters in the shrimp/prawn trap fishery as rare events (0.000 to 0.045 rockfish/trap), so allows shrimp/prawn trap fishing to occur in rockfish conservationaAreas (RCAs) (RCAs were first established in 2002) (DFO 2013c). 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).

Rationale

Discarding of octopus: Discard rates for octopus in BC were unavailable. However, as is the case in AK, a high rate of survivorship is likely.

Subfactor 3.2.2 – Scientific Research and Monitoring

Considerations: Is bycatch in the fishery recorded/documented and is there adequate monitoring of bycatch to measure fishery's impact on bycatch species? To achieve a 'highly effective' rating, assessments must be conducted to determine the impact of the fishery on species of concern, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are being met.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Moderately Effective

The GOA and BSAI Pacific cod pot and jig fisheries, the GOA sablefish longline fishery, and the BSAI sablefish longline and pot fisheries are scored 'moderately effective' for scientific research and monitoring, because substantial proportions of these fisheries' fleets have been exempt from observer coverage in recent years. Recent changes to the observer program address this issue and will warrant a review of this score once coverage rates under the new regime are available. All other fisheries are scored 'highly effective' for scientific research and monitoring, due to sufficient observer coverage.

Rationale

The at-sea observer program has long been in place for Alaska groundfish fisheries, but coverage varied greatly from fishery to fishery due to the criteria used to determine observer coverage rates. For example, 82% of total observer at-sea days in 2008 were spent on larger catcher-processors and motherships, or BSAI pollock catcher vessels and processors; conversely, 18% of at-sea days in 2008 were spent on vessels between the lengths of 60 feet and 125 feet (Northern Economics, Inc. 2011). Furthermore, vessels under 60 feet in length were exempt from observer coverage at this time. In 2009, vessels that were exempt from observer coverage due to the 60' length threshold included 464 hook and line vessels (out of 527 total hook and line vessels), 106 pot vessels (out of 159 pot vessels), and 27 trawl vessels (out of 148 trawl vessels) (summing these values results in double-counting of vessels that used more than gear in 2009; Table 19 in Northern Economics, Inc. 2011). The GOA and BSAI Pacific cod pot and jig fisheries, the GOA sablefish longline fishery, and the BSAI sablefish longline and pot fisheries are largely or entirely composed of vessels <60' LOA (NPFMC 2012a). In previous years, observer coverage requirements were determined by vessel length and processing volume, but a recent overhaul to the program replaces predetermined coverage levels with an approach meant to confer more flexibility to NMFS in observer deployment (NOAA Fisheries 2012a). This overhaul will also increase substantially the number of vessels covered by the observer program, because the hundreds of vessels under 60' in length are now subject to observer coverage (Northern Economics, Inc. 2011). All vessels (including both catcher vessels and processors) engaged in any federally managed groundfish and halibut fishery in Alaska are now placed into one of two categories: full observer coverage, or partial observer coverage. Vessels in the full observer coverage category must carry an observer on 100% of trips and have 100% of hauls sampled (Northern Economics, Inc. 2011), while those placed into the partial coverage group will carry observers based on random assignment from NMFS (NOAA Fisheries 2012a). The partial coverage category includes smaller vessels (<60' length) that previously had not received observer coverage (Northern Economics, Inc. 2011). The changes to the program were implemented in January 2013, and as such there is not yet information available regarding observer coverage rates for vessels in the partial coverage category.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Moderately Effective

The at-sea observer program has long been in place for Alaska groundfish fisheries, but coverage varied greatly from fishery to fishery due to the criteria used to determine observer coverage rates.

Rationale

In 2008, 82% of total observer at-sea days were spent on larger catcher-processors and motherships, or BSAI pollock catcher vessels and processors; conversely, 18% of at-sea days in 2008 were spent on vessels between the lengths of 60 feet and 125 feet (Northern Economics Inc. 2011). Furthermore, vessels under 60 feet in length were exempt from observer coverage at this time. In 2009, vessels that were exempt from observer coverage due to the 60' length threshold included 464 hook and line vessels (out of 527 total hook and line vessels), 106 pot vessels (out of 159 pot vessels), and 27 trawl vessels (out of 148 trawl vessels) (summing these values results in double-counting of vessels that used more than gear in 2009; Table 19 in Northern Economics, Inc. 2011). The GOA and BSAI Pacific cod pot and jig fisheries, the GOA sablefish longline fishery, and the BSAI sablefish longline and pot fisheries are largely or entirely composed of vessels <60' LOA (NPFMC 2012b). In previous years, observer coverage requirements were determined by vessel length and processing volume, but a recent overhaul to the program replaces predetermined coverage levels with an approach meant to confer more flexibility to NMFS in observer deployment (NOAA 2012). This overhaul will also increase substantially the number of vessels covered by the observer program, because the hundreds of vessels under 60' in length are now subject to observer coverage (Northern Economics Inc. 2011). All vessels (including both catcher vessels and processors) engaged in any federally managed groundfish and halibut fishery in Alaska are now placed into one of two categories: full observer coverage, or partial observer coverage. Vessels in the full observer coverage category must carry an observer on 100% of trips and have 100% of hauls sampled (Northern Economics Inc. 2011), while those placed into the partial coverage group will carry observers based on random assignment from NMFS (NOAA 2012). The partial coverage category includes smaller vessels (<60’ length) that previously had not received observer coverage (Northern Economics Inc. 2011). The changes to the program were implemented in January 2013, and as such there is not yet information available regarding observer coverage rates for vessels in the partial coverage category.

British Columbia North Pacific, Pot

Moderately Effective

Scientific research exists on the fishery’s impacts on sublegal and female crab, but data are extremely limited and more information is necessary regarding the magnitude of bycatch collected, handling effects and mortality.

Rationale

Much is unknown about the fishery’s effect on whales, including frequency of entanglement and mortality (Neilson et al. 2009). In southeast Alaska, the majority of humpback whales have been non-lethally entangled as determined from scarring, however, more research is necessary to determine prevalence in other regions and the magnitude attributed specifically to the Dungeness crab fishery. Some research is available on the effects of bycatch due to lost gear, however, the impact of lost traps is still poorly understood. It is estimated that 10%–20% of traps are lost at sea annually, with 32.5% of lost pots actively ghostfishing, resulting in bycatch mortality (Breen 1990). Ghostfishing presents a serious concern as derelict pots can fish effectively for at least 7 years (Maselko et al. 2013). More information is needed to identify and quantify species impacted by lost Dungeness crab pots.

British Columbia Northeast Pacific, Pot

Moderately Effective

Scientific monitoring of rockfish bycatch occurrences and estimates of coast-wide catch are produced (Rutherford et al. 2010), although species specific bycatch estimates are not available. However, no new research efforts are underway to further reduce their incidence of capture.

Subfactor 3.2.3 – Management Record of Following Scientific Advice

Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g., do they set catch limits at recommended levels)? A Highly Effective rating is given if managers nearly always follow scientific advice.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

See 'Scientific Advice' under Factor 3.1.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Highly Effective

See 'Scientific Advice' under Factor 3.1.

British Columbia North Pacific, Pot

Highly Effective

There is no evidence that advice is followed differently for bycatch species.

British Columbia Northeast Pacific, Pot

Highly Effective

See 3.1 above.

Subfactor 3.2.4 – Enforcement of Management Regulations

Considerations: Is there a monitoring/enforcement system in place to ensure fishermen follow management regulations and what is the level of fishermen's compliance with regulations? To achieve a 'highly effective' rating, there must be consistent enforcement of regulations and verification of compliance.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Highly Effective

See 'Enforcement' under Factor 3.1.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Highly Effective

See 'Enforcement' under Factor 3.1.

British Columbia North Pacific, Pot

Moderately Effective

Pots without proper rot cord have been observed ghostfishing, suggesting further enforcement of gear requirements is necessary (NRC 2006)(NSF & NRC 2011)(Maselko et al. 2013).

British Columbia Northeast Pacific, Pot

Highly Effective

As indicated above in 3.1, nearly all of the vessels underwent vessel monitoring (DFO 2012b).

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 (plus the mitigation of gear impacts score) and the ecosystem-based fishery management 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 cannot be Critical for Criterion 4.

Criterion 4 Summary

Region / Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Overall Recomm.
Alaska Bering Sea Aleutian Islands: Pacific Cod Pot **Pot**	3.00:Low Concern	0.50:Moderate Mitigation	4.00:Low Concern	**Green (3.742)**
Alaska Gulf of Alaska: Pacific Cod Pot **Pot**	3.00:Low Concern	0.50:Moderate Mitigation	4.00:Low Concern	**Green (3.742)**
British Columbia North Pacific **Pot**	3.00:Low Concern	0.25:Minimal Mitigation	3.00:Moderate Concern	**Yellow (3.123)**
British Columbia Northeast Pacific **Pot**	2.00:Moderate Concern	0.50:Moderate Mitigation	3.00:Moderate Concern	**Yellow (2.739)**

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. Both Alaskan fisheries scored 3.74 overall for Criterion 4, with the BC Dungeness crab trap fishery scoring 3.12 and the BC spot prawn trap fishery scoring 2.74. 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.*

Justification of Ranking

Factor 4.1 – Impact of Fishing Gear on the Habitat/Substrate

Scoring Guidelines

- *5 (None)—Fishing gear does not contact the bottom*
- *4 (Very Low)—Vertical line gear*
- *3 (Low)—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. Bottom seine on resilient mud/sand habitats. Midwater trawl that is known to contact bottom occasionally)(*
- *2 (Moderate)—Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Bottom seine except on mud/sand*
- *1 (High)—Hydraulic clam dredge. Dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 (Very High)—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.

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Low Concern

The EFH for BSAI Pacific cod has been identified as sand, mud, combinations of the two, and gravel (NPFMC 2012a).

Rationale

The BSAI Pacific cod pot fishery takes place on mud, sand, cobble, and hard substrates with low relief (NOAA 2005). Bycatch of corals/bryozoans, sea pens/whips, and unidentified sponges are relatively minimal in BSAI Pacific cod fisheries (Table 2.38 in Thompson and Lauth 2012). Gear impacts on substrate are therefore scored 'low concern' for the BSAI Pacific cod pot fishery.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Low Concern

Identified EFH for adult GOA Pacific cod includes sand, mud, sandy mud, and gravel (NPFMC 2012b).

Rationale

The GOA Pacific cod pot fishery takes place over sand, mud, gravel, cobble, and rock substrates (NOAA 2005). Catches of corals/bryozoans, sea pens/whips, and sponges are minimal across the GOA Pacific cod fisheries (including the trawl and longline fisheries; Table 2.5 in A'mar et al. 2012). The impact of the fishing gear on substrate is therefore scored ’low concern’ for the GOA Pacific cod longline fishery.

British Columbia North Pacific, Pot

Low Concern

The fishery uses pot/trap gear that contacts the bottom via a vertical line, primarily in mud and sand habitats. Traps have potential to crush and scour biogenic structures (DFO 2013a), but result in minimal impact to benthic habitats in relation to other types of fishing gear.

British Columbia Northeast Pacific, Pot

Moderate Concern

This fishery occurs on rocky, hard substrate (DFO 2012b).

Factor 4.2 – Mitigation of Gear Impacts

Scoring Guidelines

- *+1 (Strong Mitigation)—Examples include large proportion of habitat protected from fishing (>50%) with gear, fishing intensity low/limited, gear specifically modified to reduce damage to seafloor and modifications shown to be effective at reducing damage, or an effective combination of ‘moderate’ mitigation measures.*
- *+0.5 (Moderate Mitigation)—20% of habitat protected from fishing with gear or other measures in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing.*
- *+0.25 (Low Mitigation)—A few measures are in place (e.g., vulnerable habitats protected but other habitats not protected); there are some limits on fishing effort/intensity, but not actively being reduced.*
- *0 (No Mitigation)—No effective measures are in place to limit gear impacts on habitats.*

Alaska Bering Sea Aleutian Islands: Pacific Cod pot, Pot

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Moderate Mitigation

Approximately 51% of Alaskan EEZ waters south of the Bering Strait are in closed areas. In addition, approximately 1% of Alaska's EEZ waters are in areas designated as HAPCs, which generally offer protection from a wider suite of fishing gears than other closures. Due to the large cumulative area of the habitat-related closures, it could be easy to assume that habitat is adequately protected in Alaskan waters. However, such an assumption would overlook the critical question of habitat representation: if a closure is composed primarily of one group of habitats, and does little or nothing to protect another group of habitats that are affected by fisheries, then the size of the closure is moot as far as the protection of the second group is concerned. Habitat representation in closed areas is an important consideration in the Seafood Watch assessment criteria and, to date, there is insufficient information regarding habitat representation in EFH closed areas vs. the areas that are open to bottom-contact gears in Alaskan groundfish fisheries. HAPC areas provide strong protection for the important habitat features within them, but cover only approximately 1% of Alaska's waters. For these reasons, the existing suite of closed areas, by itself, meets the Seafood Watch guidelines for 'moderate' mitigation of fishing gear impacts for the bottom trawl, longline, and pot fisheries assessed in this report; this is the score that is assigned to all fisheries except for the BSAI and GOA flatfish trawl fisheries. Modified trawl sweeps are required for all vessels fishing in the Bering Sea and Gulf of Alaska flatfish trawl fisheries. Field tests have found that modifications of the sort used in these fisheries result in less visible disturbance of sediment, significantly less damage to sea pens, and significantly less mortality of crabs. Mitigation of fishing gear impacts is scored 'moderate' for the BSAI and GOA flatfish trawl fisheries, due primarily to the gear modifications that are mandatory in the two fisheries, and due secondarily to existing trawl closed areas.

Rationale:
See Appendix E in the Seafood Watch Alaska Groundfish Report for details.

British Columbia North Pacific, Pot

Minimal Mitigation

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 2013a). Fishery effort is regulated with pot limits, however, some fisherman have compensated for this limitation by increasing frequency of haul, effectively increasing spatial footprint. In the 2013 season, new regulations have been implemented in some regions, restricting haul frequency to once per day. Spatial footprint is further reduced through limits on maximum trap size.

British Columbia Northeast Pacific, Pot

Moderate Mitigation

Rationale
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. For example, the number of licenses decreased from 900 in 1989 to 260 by the following year due to license limitation regulations implemented in 1990. And an additional 10 licenses have been retired that were grandfathered in, leaving a total of 250 licenses in 2013. The number of traps has decreased by 5,000 since 1994 and in-season stacking (where two trap allotments are fished from a single vessel) further reduces this number. And regulations reducing the number of times traps may be set and hauled per day to just one, constitute an effective gear modification that is enforced by industry funding (Harbo and Wylie 2006). Lastly, the season is now the shortest it has ever been (less than 50 days in 2012 and 2013) due to a more intensive spawner index management regime (L. Convey, pers. comm.). The Strait of Georgia ecological risk assessment (see trawl above) is also being applied to the trap fishery (DFO 2013c). Together, these provisions provide moderate mitigation of the traps' impacts to the seafloor.

Factor 4.3 – Ecosystem-Based Fisheries Management

Scoring Guidelines

- *5 (Very Low Concern)—Substantial efforts have been made to protect species' ecological roles and ensure fishing practices do not have negative ecological effects (e.g., large proportion of fishery area is protected with marine reserves, and abundance is maintained at sufficient levels to provide food to predators).*
- *4 (Low Concern)—Studies are underway to assess the ecological role of species and measures are in place to protect the ecological role of any species that plays an exceptionally large role in the ecosystem. Measures are in place to minimize potentially negative ecological effect if hatchery supplementation or fish aggregating devices (FADs) are used.*
- *3 (Moderate Concern)—Fishery does not catch species that play an exceptionally large role in the ecosystem, or if it does, studies are underway to determine how to protect the ecological role of these species, OR negative ecological effects from hatchery supplementation or FADs are possible and management is not place to mitigate these impacts.*

- *2 (High Concern)—Fishery catches species that play an exceptionally large role in the ecosystem and no efforts are being made to incorporate their ecological role into management.*
- *1 (Very High Concern)—Use of hatchery supplementation or fish aggregating devices (FADs) in the fishery is having serious negative ecological or genetic consequences, OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.*

Alaska Bering Sea Aleutian Islands: Pacific Cod Pot, Pot

Low Concern

There is a good deal of scientific information available regarding the ecosystem roles of some, but not all, species that are caught by fisheries in substantial amounts. A thorough 'ecosystem considerations' report accompanies the SAFE reports, and each SAFE report contains a summary of relevant ecosystem information, and often a qualitative assessment of the risk posed by fisheries activities. A pilot fishery ecosystem plan (FEP) exists for the Aleutian Islands (AI); this document summarizes key relationships within the AI ecosystem and offers guidance for the integration of ecosystem considerations into fisheries management. Despite the relative wealth of information and research available to support ecosystem-based management efforts, there is no evidence that ecosystem or food web concerns are regularly integrated into the determination of harvest limits (with the exception of the AI Atka mackerel and Pacific cod fisheries mentioned below). For this reason, the Factor 4.3 score is 'low concern' for all fisheries except BSAI Atka mackerel.

Rationale

See Appendix E in the Seafood Watch Alaska Groundfish Report for detailed rationale.

Alaska Gulf of Alaska: Pacific Cod Pot, Pot

Low Concern

There is a good deal of scientific information available regarding the ecosystem roles of some, but not all, species that are caught by fisheries in substantial amounts. A thorough 'ecosystem considerations' report accompanies the SAFE reports, and each SAFE report contains a summary of relevant ecosystem information, and often a qualitative assessment of the risk posed by fisheries activities. A pilot fishery ecosystem plan (FEP) exists for the Aleutian Islands; this document summarizes key relationships within the AI ecosystem and offers guidance for the integration of ecosystem considerations into fisheries management. Despite the relative wealth of information and research available to support ecosystem-based management efforts, there is no evidence that ecosystem or food web concerns are regularly integrated into the determination of harvest limits (with the exception of the AI Atka mackerel and Pacific cod fisheries mentioned below). For this reason, the Factor 4.3 score is 'low concern' for all fisheries except BSAI Atka mackerel.

Rationale
See Appendix E in Alaska Groundfish Report for detailed rationale.

British Columbia North Pacific, Pot

Moderate 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.

British Columbia Northeast Pacific, Pot

Moderate Concern

No species of exceptional importance to the ecosystem are caught in this fishery. DFO has extensive general policies related to harvesting of forage species and ecosystem-based management. However, the ecological role of shrimp has not yet been studied, nor specifically addressed within these policies (DFO 2009).

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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