Monterey Bay Aquarium
Seafood Watch®

Snow crab, Tanner crab

Chionoecetes opilio, Chionoecetes bairdi

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Alaska

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 covers wild pot fisheries for true snow crab (*Chionoecetes opilio*) and the southern Tanner crab (*C. bairdi,* commonly marketed as "snow crab"). The geographic scope of this report includes the fisheries of Alaska in the eastern Bering Sea (EBS).

Snow crabs have high inherent vulnerability to fishing pressure. Males reach sexual maturity at 4–10 years and can live up to 20 years. Females are highly fecund, producing just over 80,000 eggs on average in their lifetime. Fertilized eggs are brooded by the females outside their bodies under an abdominal flap. Larvae are released to the water column, where they spend several months before settling. Because snow crabs are not broadcast spawners, they may require minimum densities to achieve viable mating aggregations, which raises the potential for depensatory population dynamics at low population sizes.

Tanner crabs have medium inherent vulnerability to fishing pressure. Males reach sexual maturity at 6–8 years and may live for 20 years. Females produce as many as 50,000 eggs in their lifetime, which are brooded under the abdominal flap for up to 12 months and, like snow crabs, are released into the water column until they settle to the bottom. Tanner crabs appear to exhibit decreased spawning at high and low sizes, where Allee effects are possible but haven't been demonstrated.

Stock assessments are performed annually on EBS snow and Tanner crab stocks. The snow crab fishery recovered from an overfished condition in 2011, and from 2011 to 2013, estimates of stock status were above $B_{35\%}$ (the B_{MSY} proxy used in the fishery). However, mature male biomass at spawning (MMB) for 2014/15 was 96% of the value for $B_{35\%}$ that was calculated in the most recent assessment, and MMB was projected to increase to over 100% within the next few years. Fishing effort is below the F_{MSY} proxy of $F_{35\%}$ used in the EBS snow crab fishery and has consistently been so for over a decade. The most recent Tanner crab assessment shows that the fishery recovered from its overfished status in 2011, but it remained closed until the 2013/2014 fishing year when the estimates of stock status were above $B_{35\%}$ and the estimates of fishing effort were below $F_{35\%}$. Tanner crab stock remains in good standing for the 2015/2016 year.

Bycatch in the EBS snow and Tanner crab fishery is limited mostly to female and undersized male snow and Tanner crabs. Other bycatch, such as groundfish, amounts to less than 1% of landings, and no species listed under the U.S. Endangered Species Act (ESA) are caught. The overall discard rate for the EBS snow crab fishery is 30%, while the discard rate in the Tanner crab fishery is 50%.

The EBS snow and Tanner crab fisheries are managed under a federal Fisheries Management Plan (FMP) that establishes joint management between the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADFG), overseen by the North Pacific Fisheries Management Council (NPFMC). The FMP lays out clear goals for the fishery that include ensuring the long-term reproductive viability of snow crab populations, preserving habitat, providing for rigorous scientific backing, and maximizing economic and social benefits over time. Scientific monitoring in the fishery is highly robust, with annual stock assessments conducted using both fishery-dependent and -independent

data. Under the FMP, management decisions are closely tied to the results of completed stock assessments. Compliance with management measures is verified through onboard and dockside observer coverage, along with mandatory electronic logbooks and vessel monitoring systems (VMS). The fisheries have responded well to the challenges of managing snow and Tanner crab populations, which are known to have strong natural fluctuations. Though the fisheries have only been rebuilding for a few years, the outlook is good. Management has been able to successfully rebuild the fisheries from their overfished status. Stakeholder inclusion in this process is strong; reports and minutes are publicly available online, and collaborative partnerships exist between fishing organizations and management.

The EBS snow and Tanner crab industry is a pot fishery, which can affect marine habitats. Because the fisheries are conducted on sandy and/or muddy substrates, the impact of these traps is likely to be limited. In addition, pots are constructed with raised frames that reduce the surface area of the trap that contacts the bottom, although this increases the pressure applied by the trap at its contact points. The FMP mandates identification of essential fish habitat (EFH), so portions of the EBS fishing grounds are closed to snow and Tanner crab traps. But these closures cover a small area and are not present in regions of high crab fishing pressure. Ecosystem-based management is not clearly or directly included in the management of these fisheries, but ecosystem factors are taken into consideration in the overall assessment of the resource conducted by the NPFMC.

Table of Conservation Concerns and Overall Recommendations

Stock / Fishery	Impacts on the Stock	Impacts on other Spp.	Management	Habitat and Ecosystem	Overall Recommendation
Snow crab United States Bering Sea - Pot	Green (4.47)	Green (4.50)	Green (5.00)	Green (3.61)	**Best Choice (4.364)**
Tanner crab United States Bering Sea - Pot	Green (5.00)	Green (4.03)	Green (5.00)	Green (3.61)	**Best Choice (4.364)**

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 covers wild pot fisheries for true snow crab (*Chionoecetes opilio*) and the southern Tanner crab (*C. bairdi,* commonly marketed as "snow crab"). The geographic scope of this report includes the fisheries of Alaska in the eastern Bering Sea (EBS).

Overview of the species and management bodies

Ecology of snow crabs (C. opilio)

Snow crabs are disc-shaped crabs reaching widths of 15 cm and living up to 20 years (Turnock & Rugolo 2011). In the North Pacific, snow crabs are found throughout the continental shelf of the Bering, Chukchi, and Beaufort Seas, as well as the Sea of Okhotsk (the snow crab population in the Sea of Japan is a subspecies, *Chionoecetes opilio elongates*). In the Atlantic, they are found along the eastern seaboard of North America as far south as Maine and as far north as Greenland (NOAA 2012). Snow crabs have four pairs of legs and one pair of large claws that become disproportionally larger in males when they reach their final molt at approximately 14–15 cm, by which time they have also generally developed functional sperm (DFO 2012). Snow crabs grow by molting, undergoing several molts before reaching a terminal molt. After each molt, the crab's new shell is soft (when they are called soft crab), making them vulnerable to handling, predation, or environmental hazards. Snow crabs feed on a variety of material, including fish, crustaceans (including other crabs), algae, and, on occasion, sponges. Snow crab predators include fish, seals, sea otters, and octopus. Smaller-sized crabs are the most frequent target of predation (NOAA 2012).

Snow crabs typically inhabit temperatures from –1 to 5°C (30 to 41°F) (Weston 2011). Adult males generally live along mud or silt bottoms at depths of less than 200 m where they can burrow and feed. Adult females live in habitats apart from the adult males for much of the year (Poulsen 2012). During mating, females are presumed to form large mounds (as has been directly observed for Tanner crabs off Kodiak Island in the Gulf of Alaska), and generally only the largest males participate in mating. After mating, females can brood fertilized eggs on their abdomen outside their body for nearly 1 year (females living in extremely cold water may even brood their embryos for 2 years), eventually releasing larvae to the water column (Choi & Zisserson 2012). The larvae pass through two larval stages, each lasting about 1 month. Then, they go through an intermediate megalops stage, which can last from 1 to 4.5 months, as the young search for suitable seafloor habitats for settlement (Haynes 1973) (Jewett and Haight 1977) (Haynes 1981) (Incze et al. 1987). Juveniles tend to occur in shallower waters, burying themselves in fine sediments in attempts to provide better protection from predators.

Snow crab fisheries are marked by strong boom-bust dynamics, in which periods of high productivity are followed by phases of low recruitment (Sainte-Marie et al. 1996) (Turnock & Rugolo 2011). The drivers and timing of these cycles are not yet well understood, though factors such as compensatory density

dependence, cod predation, and water temperature may all play roles (Boudreau et al. 2011) (Sainte-Marie et al. 1995) (Sainte-Marie et al. 1996).

Ecology of Tanner crabs (C. bairdi)

Tanner crabs are distributed throughout the Northern Pacific Ocean, including the Bering Sea and Gulf of Alaska, where they are found along the Kamchatka peninsula to the west and in Bristol Bay to the east. In the west, they range as far south as Hokkaido, Japan; in the east, as far south as Oregon (Stockhausen 2014). They generally inhabit continental shelf habitat at depths from the subtidal to over 400 m. Tanner crabs have life histories similar to snow crabs. Males reach up to 20 cm in width, with growth occurring through molting. Mating occurs in the spring when females form dense mating aggregations for protection and the attraction of mates (Donaldson et al. 1981) (NPFMC 2011a) (Urban & Hart 1999). In the southern half of Bristol Bay, Tanner and snow crab distributions overlap and the two species hybridize (Fig. 1) (Stockhausen 2015).

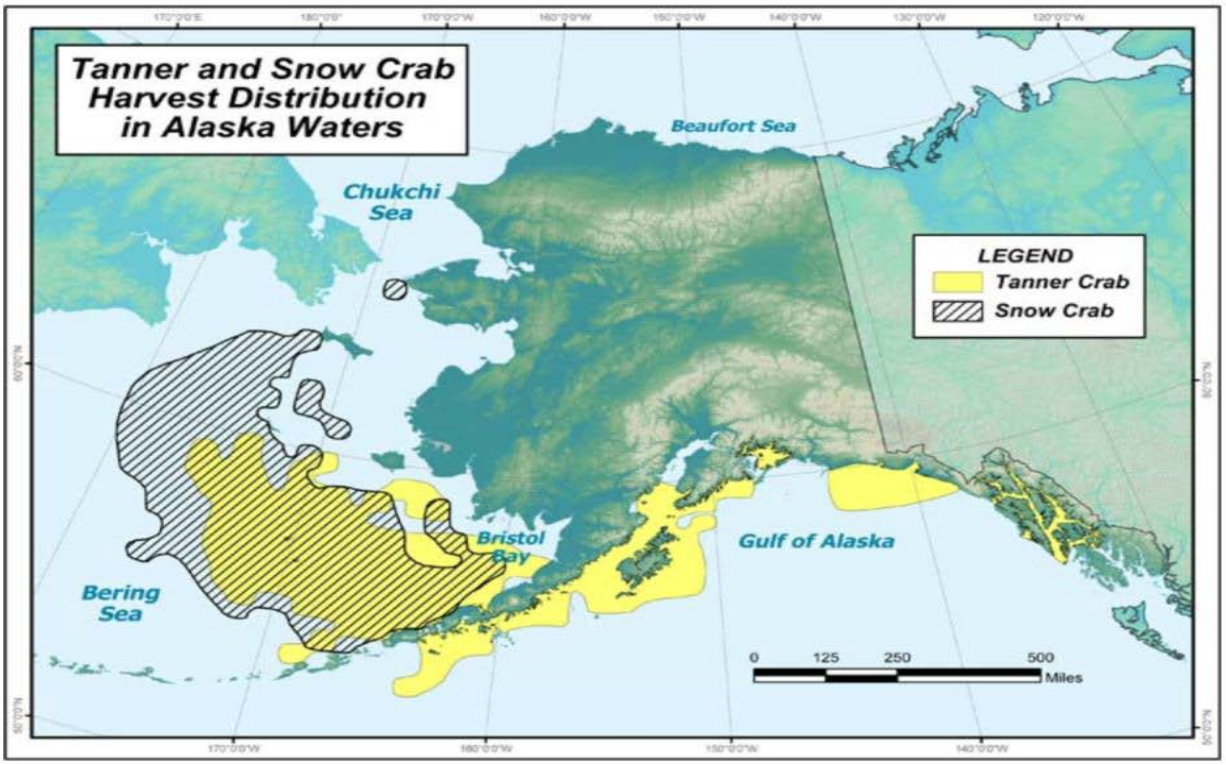
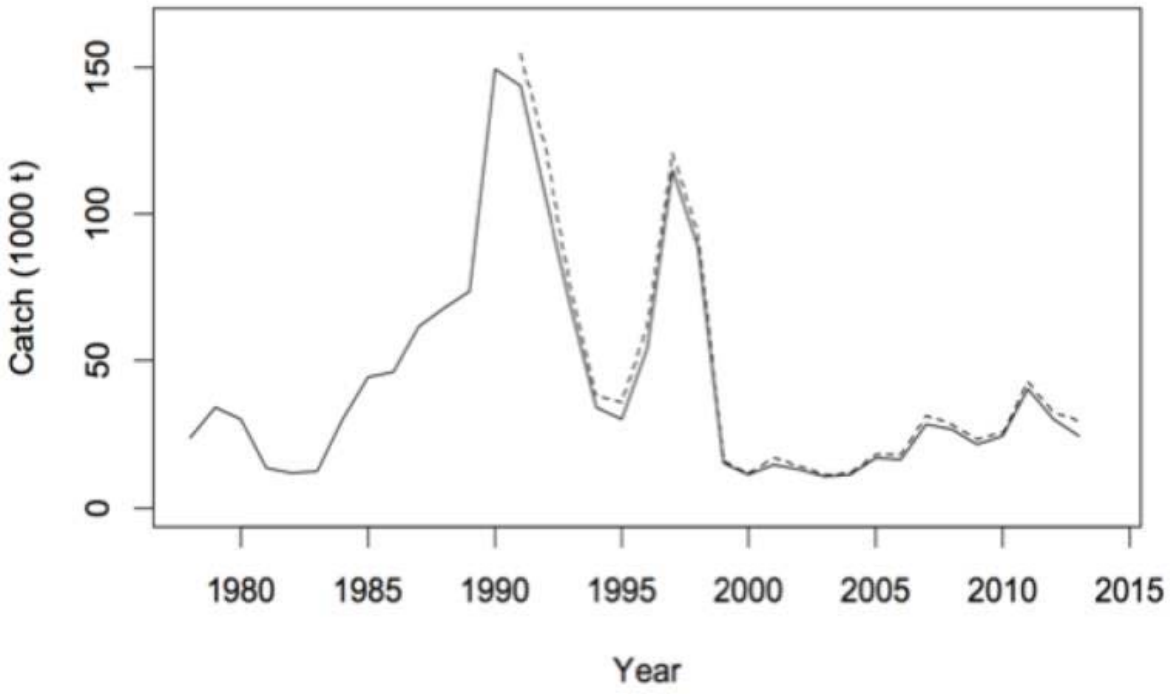


Figure 1:

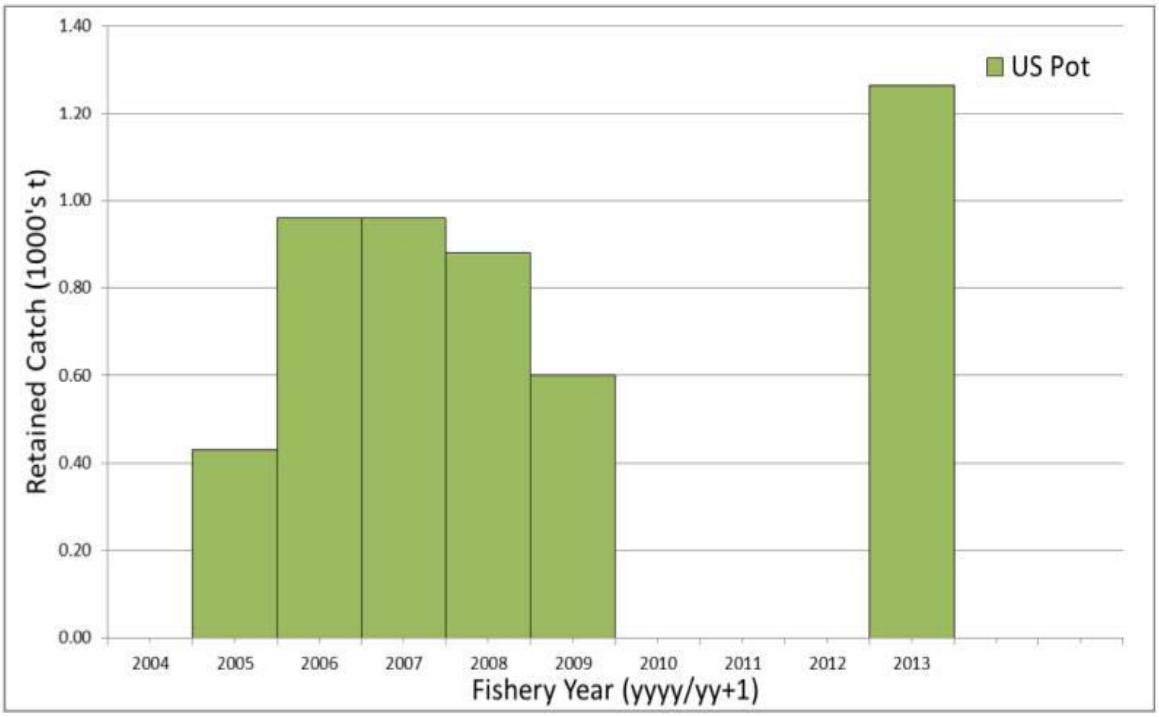
History & management of the fisheries

The snow and Tanner crab fisheries are pot fisheries, targeting crabs along the continental shelf in the Bering Sea (Alaska). The commercial snow crab industry in the EBS began with Japanese fishing from 1960 until 1980, after which the passage of the Fishery Conservation and Management Act of 1976 prohibited the presence of the Japanese fleet within U.S. waters. In the following years, the

domestic industry began to grow, reaching a production peak in 1991. Catches declined thereafter, reaching a low in the early 2000s when the fishery was classified as overfished. The fishery has been recovering in the years leading up to the present (Fig. 2) (Turnock and Rugolo 2015).



Commercial Tanner crab fishing started with the Japanese pot and tangle net and Russian tangle net fisheries from 1965–1978 (ending in 1971 for Russia). The U.S. Tanner crab fishery began in the 1970s, reached peak landings in 1977/78, completely displaced the Japanese and Russian fisheries by 1980, and quickly expanded until the stock collapsed in 1985, resulting in the closure of the fishery. After a rebuilding phase, the fishery reopened in 1987/88 and landings rose to a second peak in 1990/91 until it again collapsed and was closed from 1997 to 2004. The fishery reopened in 2005/06 and averaged a small retained catch, but closed in 2010 due to depressed stock size. In the 2013/2014 season, the fishery opened to targeted commercial capture (Fig. 3) (Daly et al. 2014).



Snow and Tanner crabs are managed under a cooperative partnership between the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADFG). This partnership is formalized by the federal Fishery Management Plan (FMP) for the Commercial King and Tanner Crab Fisheries in the Bering Sea/Aleutian Islands (BSAI), overseen by the North Pacific Fishery Management Council (NPFMC). Under the FMP, responsibilities such as permitting, federal observer programs, and identification of essential Habitat and Areas of Particular Concern (HAPC) are left to the federal government, whereas the majority of the in-season management actions, such as the establishment of total allowable catches (TACs), seasons, and size limits, are left to the ADFG (NPFMC 2011a).

Production Statistics

Global production of snow and Tanner crab has generally increased over time, reaching a peak of over 116 kilotons (kt) in 2002 (FAO 2015). Global production has historically been dominated by Canada, with Russia and the U.S. also providing substantial shares (Pinfold 2006). Snow crab production in the U.S. dropped to historic lows during the early 2000s in response to the overfished condition of the stock. Production has increased since 2005, with the most recent completed season bringing in 34.3 kt (Turnock and Rugolo 2015).

In the 2014/2015 season, the Tanner crab fishery brought in 6,158 t. Over the last several years, the EBS snow crab fishery has been the major source of Tanner crab bycatch, averaging 1,197 t for the 5-year period 2010/11 to 2014/15, and 5,433 t in 2014/15. The groundfish fisheries have been the next major source of Tanner crab bycatch over the last several years, averaging 272 t, and 423 t in 2014/15.

The Bristol Bay Red king crab fishery has typically been the smallest source of Tanner crab bycatch, averaging 51 t over the 5-year period, with 297 t caught and discarded in 2014/15 (Stockhausen 2015).

In 2013, U.S. production totaled 29.7 kt. The U.S. and Japan each account for nearly half of global snow crab consumption (Pinfold 2006). Primary markets are mid-level seafood restaurants, buffets, and casinos in the U.S., and luxury and sushi restaurants in Japan (Pinfold 2006).

Importance to the U.S./North American market

Global production is dominated by Canada and is sold primarily to the U.S. and Japanese markets (Weston 2011) (Fish Choice 2014). Consumption of snow crab in the U.S. was over 101 kt live weight in 2009. The Alaskan EBS snow and Tanner crab fisheries provide approximately 14% of this total. The majority of imports making up the balance of U.S. consumption come from Canada and Russia. Roughly 50% of U.S. snow and Tanner crab landings are exported, primarily to China and Japan (NMFS 2015). Wholesale prices in the U.S. have fluctuated between USD 3.00 and 6.00 per lb (Seafood Market Bulletin 2012).

Common and market names

Snow and Tanner crabs are also marketed as queen and spider crabs. In sushi form, crabs are generically referred to as *kani*.

Primary product forms

The majority of snow and Tanner crabs sold in the U.S. are in section form (four legs and a claw; other forms include live whole, frozen whole, and extracted meat).

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

SNOW CRAB				
Region / Method	**Inherent Vulnerability**	**Stock Status**	**Fishing Mortality**	**Subscore**
United States Bering Sea Pot	1.00:High	4.00:Low Concern	5.00:Very Low Concern	**Green (4.472)**

TANNER CRAB				
Region / Method	**Inherent Vulnerability**	**Stock Status**	**Fishing Mortality**	**Subscore**
United States Bering Sea Pot	2.00:Medium	5.00:Very Low Concern	5.00:Very Low Concern	**Green (5.000)**

Criterion 1 Assessment

SNOW CRAB

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.*

United States Bering Sea, Pot

High

Resilience attribute	Score	Rationale	Source
Average age at maturity	2	Crabs are difficult to age, but estimated values are 5.5–6.5 years	[Orensanz et al. 2007]
Average maximum age	2	Max age estimated as 20 years by stock assessment	[NPFMC 2011b]
Fecundity	N/A	6,000–140,000 eggs produced	[NOAA 2012]
Reproductive strategy	2	Eggs are fertilized and brooded by female; larvae spend several months in water column	[Incze et al 1987]; [NOAA 2012]
Density dependence	1	Weak stock recruitment dynamics evident. However, due to need for physical copulation, mating could be compromised at low population densities	[Orensanz et al. 2007];[Turnock 2012]; [Zheng & Kruse 2003]
Total score	**1.75**	**High vulnerability**	

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.*

United States Bering Sea, Pot

Low Concern

In the September 2015 stock assessment, the estimate of mature male biomass (MMB) at mating was 129,300 t in 2014/15, which was 84% of $B_{35\%}$ (146,357 t); and MMB for 2015/16 (137,600 t) was estimated at 84.4% of the value for $B_{35\%}$ (Turnock and Rugolo 2015). Prior to 2013/2014, estimates of stock status were above $B_{35\%}$ in the assessment (since 2010/11). Base model projections estimate MMB at mating to increase over the next 5 years from 84.4% of $B_{35\%}$ in 2015/16 to 165.5% in 2020/21 while fishing at the overfishing limit (OFL) (Turnock and Rugolo 2015). In addition, fishing at 90% of the OFL also results in increasing MMB over the next few years, from around 87.1% of $B_{35\%}$ in 2015/16 to 179.7% of $B_{35\%}$ in 2020/21. Since current biomass is only 84.4% of $B_{35\%}$ and is projected to increase to over 165% within the next few years, we have rated this factor "low" concern.

Rationale:
The most recent Eastern Bering Sea (EBS) trawl survery (2015) states that legal-sized male snow crab estimated biomass was 71,550 ± 16,480 t and abundance was 183.8 ± 36.2 million crab. This biomass is lower than the 20-year average legal male snow crab biomass of 142,222 ± 32,838 t.

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.*

United States Bering Sea, Pot

Very Low Concern

In 2015/2016 stock assessment, total catch was 34,300 t in 2014/2015 and the ratio of $F/F_{35\%}$ was below 1 (0.78) (Turnock and Rugolo 2015). There is substantial uncertainty in the value of the overfishing limit (OFL) on which $F_{35\%}$ depends, and much of that uncertainty is captured in the acceptable biological catch/annual catch limit (ABC/ACL). The total allowable catch (TAC) set by ADF&G is often set far below the ABC/ACL and has not been exceeded (Turnock and Rugolo 2015). Current fishing for snow crab is likely at a sustainable level, so we have rated this factor "very low" concern.

Rationale:
Estimates of $F_{35\%}$ are based on the OFL (83,100 t for 2015/2016), which is in turn based on estimates of MMB and $MMB_{35\%}$. The value of F is then calculated from landings and estimates of MMB. Results from these model parameters indicate that F is below $F_{35\%}$. However, uncertainty in the underlying parameters makes the true value of the OFL difficult to ascertain, with varied estimates depending on the model used. Thus, substantial uncertainty remains in the determination of the OFL (Turnock and Rugolo 2015), and much of that uncertainty is captured in the ABC/ACL. The TAC set by ADF&G is often set far below the ABC/ACL.

The factors taken into account (with the available information) in developing harvest strategies or setting TACs and guideline harvest limit (GHL) are as follows: (1) whether the ACL for that stock was exceeded in the previous year; (2) stock status relative to the OFL and ACL; (3) estimates of exploitable biomass; (4) estimates of recruitment; (5) estimates of thresholds; (6) market and other economic considerations; (7) additional uncertainty; and (8) any additional factors pertaining to the health and status of the stock or the marine ecosystem. Additional uncertainty includes (1) management uncertainty (i.e., uncertainty in the ability of managers to constrain catch so the ACL is not exceeded, and uncertainty in quantifying the true catch amount) and (2) scientific uncertainty identified and not already accounted for in the ABC (i.e., uncertainty in bycatch mortality, estimates of trends and absolute estimates of size composition, shell condition, molt status, reproductive condition, spatial distribution, bycatch of non-target crab stocks, environmental conditions, fishery performance, fleet behavior, and the quality and amount of data available for these variables) (NPFMC 2011a).

TANNER CRAB

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.

United States Bering Sea, Pot

Medium

Resilience attribute	Score	Rationale	Source
Average age at maturity	2	6–8 years average age at maturity	[Zheng & Kruse 2003]
Average maximum age	2	Max age 12–20 years	[NPFMC 2011a]
Fecundity	N/A	Females carry clutches of 50,000-400,000 eggs	[Somerton and Meyers 1983][Rugolo & Turnock 2011]; [Turnock & Rugolo 2011]
Reproductive strategy	2	Females brood eggs, then release larvae to water column; larval stage 2–7 months	[NPFMC 2011a]
Density dependence	2	Ricker-curve dynamics evident, suggesting decreased spawning at high and low sizes; Allee effects possible but not demonstrated	[Turnock 2012]; [Zheng & Kruse 2003]
Total score	**2**	**Medium**	

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.*

United States Bering Sea, Pot

Very Low Concern

In the September 2015 SAFE stock assessment, MMB was estimated at 71.6 thousand t. B_{MSY} for this stock was calculated to be 26.79 thousand t, so MSST is 13.40 thousand t. Because MMB > MSST (B/B_{MSY} = 1.97), the stock is not overfished (Stockhausen 2015). Thus, we have rated this factor "very low" concern.

Rationale:
The most recent EBS trawl survey (2015) states that the abundance of legal male Tanner crab in the eastern area (east of 166°W) was 30.7 ± 7.8 million crabs and biomass was 22,853 ± 6,247 t, which is substantially above the 20-year average biomass of 12,590 ± 3,204 t (Daly et al. 2015). West of 166°W, legal male Tanner crab abundance was 46.0 ± 14.1 million crabs and biomass was 14,306 ± 5,040 t, which was above the 20-year average biomass of 13,940 ± 4,574 t (Daly et al. 2015).

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.*

United States Bering Sea, Pot

Very Low Concern

In 2015/2016, total catch was 6,158 t and the ratio of $F/F_{35\%}$ was below 1 (F_{OFL} = 0.64) (Stockhausen

2015). There is substantial uncertainty in the value of the overfishing limit (OFL) on which $F_{35\%}$ depends, and much of that uncertainty is captured in the ABC/ACL. The TAC set by ADF&G is often set far below the ABC/ACL (Stockhausen 2015). Current fishing is likely at a sustainable level, so we have rated this factor "very low" concern.

Rationale:
Assessment uncertainty was included in the calculation of OFL, using the same approach that was used for the 2012–2014 assessments (Rugolo and Turnock 2012) (Stockhausen et al. 2013) (Stockhausen 2014). The preferred model OFL value for 2015/16 was 27,190 t (Stockhausen 2015).

Amendment 24 to the NPFMC fishery management plan (NPFMC 2007) revised the definitions for overfishing for EBS crab stocks. The information provided in the 2015 assessment is sufficient to estimate overfishing limits for Tanner crab under Tier 3. The OFL control rule is based on an estimate of "current" spawning biomass at mating (B above, taken as MMB at mating in the assessment year) and spawning biomass per recruit (SBPR)-based proxies for F_{MSY} and B_{MSY} (Stockhausen 2015). For Tanner crab, the proxy for F_{MSY} is $F_{35\%}$, the fishing mortality that reduces the SBPR to 35% of its value for an unfished stock (Stockhausen 2015).

The factors taken into account (with the available information) in developing harvest strategies or setting TACs and GHL are as follows: (1) whether the ACL for that stock was exceeded in the previous year; (2) stock status relative to the OFL and ACL; (3) estimates of exploitable biomass; (4) estimates of recruitment; (5) estimates of thresholds; (6) market and other economic considerations; (7) additional uncertainty; and (8) any additional factors pertaining to the health and status of the stock or the marine ecosystem. Additional uncertainty includes (1) management uncertainty (i.e., uncertainty in the ability of managers to constrain catch so the ACL is not exceeded, and uncertainty in quantifying the true catch amount) and (2) scientific uncertainty identified and not already accounted for in the ABC (i.e., uncertainty in bycatch mortality, estimates of trends and absolute estimates of size composition, shell condition, molt status, reproductive condition, spatial distribution, bycatch of non-target crab stocks, environmental conditions, fishery performance, fleet behavior, and the quality and amount of data available for these variables) (NPFMC 2011a).

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 ghost fishing. 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

Snow crab: United States Bering Sea, Pot

Subscore:: 5.000 **Discard Rate: 0.90** **C2 Rate: 4.500**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
SNOW CRAB	High	4.00: Low Concern	5.00: Very Low Concern	**4.472**
TANNER CRAB	Medium	5.00: Very Low Concern	5.00: Very Low Concern	**5.000**

Tanner crab: United States Bering Sea, Pot

Subscore:: 4.472 **Discard Rate: 0.90** **C2 Rate: 4.025**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
SNOW CRAB	High	4.00: Low Concern	5.00: Very Low Concern	**4.472**
TANNER CRAB	Medium	5.00: Very Low Concern	5.00: Very Low Concern	**5.000**

Bycatch in the EBS snow and Tanner crab fisheries is limited to non-retained females and undersized male snow and Tanner crabs. Other bycatch, such as groundfish, amounts to less than 1% of landings, and no species listed under the U.S. Endangered Species Act (ESA) are caught.

Criterion 2 Assessment

Factor 2.4 - Discard Rate

New York/North Atlantic, Rakes (wild)

40-60%

Estimated discard mortality for Snow crab in the directed pot fishery has averaged about 30% (Turnock and Rugolo 2015), and is assumed to be 32.1% in the Tanner crab fishery (Stockhausen 2015). Reported bait use is 20-30lbs of Pacific cod or 3-5 lbs of chopped herring per pot (Miranda Westphal, ADFG, pers comm.). For the 2014/2015 Tanner season, the average catch was around 58lbs/pot. For snow crab, the average catch was about 235lbs/pot (Miranda Westphal, pers. comm.). The mean bait use/landings was therefore roughly 10% (14.5/146). The discards+bait use/landings ratio was a little over 40%.

Rationale:

The Snow and Tanner crab fisheries occur in winter when crabs could potentially freeze on deck before being returned to the sea, due to low temperatures and wind. In addition to potential short term mortality due to exposure, immature crabs that are discarded may experience mortality during molting later in their life.

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
United States Bering Sea Pot	5.000	All Species Retained	Green(5.000)

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**
United States Bering Sea Pot	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective

The EBS snow and Tanner crab fisheries are managed under a Fishery Management Plan (FMP) established by NMFS and ADFG with oversight by the NPFMC. This FMP lays out clear goals for the fishery that include ensuring the long-term reproductive viability of crab populations, preserving habitat, providing for rigorous scientific backing, and maximizing economic and social benefits over time. Scientific monitoring in the fishery is highly robust, with annual stock assessments conducted using both fishery-dependent and independent data. Under the FMP, management decisions are closely tied to the results of completed stock assessments. Compliance with management measures is verified using onboard and dockside observer coverage, along with mandatory electronic logbooks and vessel monitoring systems (VMS). The fisheries have responded well to the challenges of managing snow and Tanner crab populations, which are known to exhibit strong natural fluctuations. Although the fisheries have only been rebuilding for a few years, the future outlook is good. Management has been able to successfully rebuild the fisheries from their previous overfished status. Stakeholder inclusion in the management process is strong; reports and minutes are publicly available online, and collaborative partnerships exist between fishing organizations and management.

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.

United States Bering Sea, Pot

Highly Effective

The EBS snow and Tanner crab fisheries have clear and detailed management practices and goals in place. The fisheries also have a track record of taking necessary steps to achieve these objectives. The recovery of the stocks and positive outlook for their future suggest that management goals are being successfully implemented, so we have rated this factor “highly effective.”

The EBS snow and Tanner crab fisheries are managed under the Fishery Management Plan (FMP) for the Commercial King and Tanner Crab fisheries in the Bering Sea/Aleutian Islands (BSAI). Under this arrangement, management responsibilities are shared by a partnership between NMFS and ADFG, although the FMP is overseen by the NPFMC. The FMP identifies seven management objectives (NPFMC 2011a): (1) Ensure the long term reproductive viability of crab populations; (2) Maximize economic and social benefits to the nation over time; (3) Minimize gear conflict among fisheries; (4) Preserve the quality and extent of suitable habitat; (5) Ensure the ability of the public to be involved in the development of vessel safety considerations; (6) Ensure that the public has access to due process and redress with respect to the management process; and (7) Provide the research, data, and analysis to ensure that management has sufficient information for decision making.

Three general tiers (categories) of management actions exist within the FMP. Category 1 refers to management measures used in the EBS crab fisheries that are fixed in the FMP and cannot be changed except by an amendment to the Plan. This includes permitting, federal observer programs, and identification of essential Habitat and Areas of Particular Concern (HAPC). In particular, under Category 1, the FMP identifies HAPCs and establishes management practices to prevent their degradation by fishing. Category 2 contains many of the in-season management measures, which may be modified by the state following criteria defined by the FMP. These include size limits, seasons, harvest levels, and areas closed to fishing. Category 3 refers to measures that are not explicitly specified by the FMP and include state observer programs and bycatch limits for the crab fisheries (NPFMC 2011a) (Stockhausen 2015) (Turnock and Rugolo 2015).

Within this overall system, on-the-ground management decisions concerning catch specifications fall under a five-tier system. The goal of this system is to provide a framework for identifying overfishing and overfished conditions, as well as the rules that will be implemented in response to the fishery's condition. Each year, the fishery is assigned to a tier based on the availability of reliable information for that fishery. Tiers 1–4 provide methods for the calculation of F_{OFL} (the fishing pressure that will result in the fishery being classified as overfished) depending on the condition of the stock. The stock condition may be classified as ***a***, ***b***, or ***c***, where ***a*** indicates that the stock status is above B_{MSY}, ***b*** indicates that the stock is below B_{msy} but above the defined critical biomass threshold, and ***c*** indicates that the biomass is below the critical threshold. Under condition ***c***, direct fishing is discontinued and indirect mortality is mitigated to ensure the rebuilding of the species.

As an enforcement measure in setting the ABC, excess catch from the prior season is applied to the total catch estimate used in the stock assessment, thus effectively lowering the maximum ABC for the current season (NPFMC 2011a) (Stockhausen 2015) (Turnock and Rugolo 2015). Once an appropriate rule for determining F_{OFL} has been set, stock assessments are used to find the biological overfishing limit (the amount of catch that would constitute overfishing, OFL). Estimates of the OFL are selected to be risk-neutral and tested under a full range of outcomes and assumptions. Acceptable biological catch (ABC) is the level of annual catch that ensures with greater than 50% probability that the overfishing limit (OFL) will not be exceeded. The ABC is set by the ABC control rule, which is adjusted according to the level of scientific uncertainty present in the fishery. Stock assessments are then reviewed by the Crab Plan Team (CPT), which evaluates the assumptions, probability distributions, and methods for quantifying

uncertainty. The CPT, together with the Scientific and Statistical Committee (SSC), then sets an OFL and an ABC for the year (NPFMC 2011a) (Stockhausen 2015) (Turnock and Rugolo 2015). Overfishing is defined as total capture greater than the OFL for the current year. The fishery also evaluates whether catch levels exceeded the annual catch limit (ACL), where catch includes all direct and indirect estimates of fishing mortality. A stock is classified as overfished if the stock size has fallen below the minimum stock size threshold (MSST), which is determined by the guidelines of the tier program. Per the Magnuson-Stevens Act, if overfishing is occurring or if the stock is overfished, overfishing must end immediately and a plan must be implemented to rebuild the stock. This assessment is repeated annually (NPFMC 2011a) (Stockhausen 2015) (Turnock and Rugolo 2015). To address overcapacity in the crab fishing fleet, an industry-funded vessel buyback program was implemented in 2004 that permanently removed 25 vessels from the fishery. In a further effort to rationalize the fishery, a community quota system was implemented under which 10% of the yearly crab TAC is allocated to cooperatives made up of regional coastal communities (NPFMC 2011a) (Poulsen 2012).

Rationale:
EBS snow crab within U.S. waters is managed as a single stock; however, the distribution of the population may extend into Russian waters to an unknown degree. The minimum legal size limit for snow crab is 3.1 inches (in.) carapace width (CW), but the size for males that are generally accepted by the fishery is 4 in. CW (Turnock and Rugolo 2015). Tanner crab is managed as three separate stocks: EBS, eastern Aleutian Islands, and western Aleutian Islands. An overfishing limit is set for the population as a whole and a TAC is defined for each of the individual stocks (Stockhausen 2015). The minimum legal size for Tanner crab is 4.8 in. CW in the eastern district and 4.4 in. CW in the western district. The TACs for both the eastern and western districts are based on 5 in. CW crab (per the State harvest strategy) (Stockhausen 2015). Season opening dates are set to maximize meat yield and minimize handling of softshell crab. The State of Alaska (SOA) sets pre-season guideline harvest levels for snow and Tanner crab based on a mature male harvest rate of 40%. Only male crabs are harvested. State harvest strategies set minimum thresholds of mature female biomass (Tanner) and spawning biomass (snow) that must be met in order for the fishery to open, and also limit the amount of mature male and/or legal males that can be taken.

Stock assessments are performed annually on the EBS snow and Tanner crab stock using both fishery-dependent and -independent data. Under the crab Fishery Management Plan (FMP), fisheries are classified in one of five available tiers based on the quality of information available (where one is highest and five is lowest). The EBS snow crab stock is classified as Tier 3, meaning that an empirical stock recruitment curve cannot be determined. As a result, the fishery is managed through proxies for B_{MSY} and F_{MSY}. In this case, a 35% control rule is applied, in which $F_{35\%}$ is the fishing effort that would result in egg production equal to 35% of the egg production that would occur in the unexploited population (NPFMC 2011b). Following these metrics, the stock assessment for EBS snow and Tanner crab uses mature male biomass (MMB) to evaluate the state of the stock relative to the $B_{35\%}$ level of MMB ($MMB_{35\%}$). Numerous models are fit to available data (including landings, catch per unit effort, size frequency data, and fishery-independent survey data) to develop estimates of the current and past

status of the EBS snow crab stock. Findings are highly dependent on assumptions underlying the model, such as the selectivity of the fishery-independent survey gear.

The EBS snow crab stock was declared overfished in 1999 due to the survey estimate of total mature biomass (149,900 t) being below the minimum stock size threshold (MSST = 208,710 t). A rebuilding plan was implemented in 2000. During the 10-year rebuilding period, the assessment model structure was changed, and the currency for estimating B_{MSY} was changed from total mature survey biomass to model-estimated mature male biomass at mating (MMB). Using the revised definitions for estimating B_{MSY}, MMB at mating was above $B_{35\%}$ in 2010/11 and the stock was declared rebuilt in 2011 (Rugolo and Turnock 2015). Based on a newly accepted assessment model (Rugolo and Turnock 2012), the NPFMC's Science and Statistical Committee (SSC) moved the Tanner crab stock from Tier 4 to Tier 3 for status determination and OFL setting in October 2012, which resulted in a large reduction in the B_{MSY} used for status determination from 83.33 thousand t in 2011 to 33.45 thousand t in 2012. At the same time, the estimated assessment-year male spawning stock biomass (MMB) increased from 26.73 thousand t in 2011 to 58.59 thousand t in 2012. As a result, Tanner crab status changed from being overfished after the 2011 assessment to not overfished after the 2012 assessment (Stockhausen 2014).

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.

United States Bering Sea, Pot

Highly Effective

Snow and Tanner crab are not currently overfished, and no overfished, depleted, endangered, or threatened species are targeted or retained. However, Tanner crab was overfished and the fishery closed from 1997–2004 and again from 2010–2012. After the 2012 stock assessment, the stock was found to be above MSST (and B_{MSY}) and subsequently considered rebuilt (Turnock and Rugolo 2015). Even though the stock was declared rebuilt in 2012, ADFG kept the fishery closed for another year due to their harvest level algorithms. The most recent trawl assessment in 2015 states that the abundance of legal male Tanner crab is now substantially above the 20-year average biomass (Daly et al. 2015). Due to the above, we have rated this factor "highly effective."

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.

United States Bering Sea, Pot

Highly Effective

Stock assessments are conducted annually for the snow and Tanner crab fisheries. The stock assessment uses a variety of fishery-dependent and -independent data sources to fit its models. Fishery-dependent data include total catch (both retained and discarded crabs), estimates of discard rates, gear selectivity, and sex and size composition of the total catch, as recorded by onboard observers (in place since 1990). Fishery-independent data come from annual bottom trawl surveys conducted by NMFS. Detailed records of the methods of these trawls can be found in Daly et al. (2015). These surveys collect data on densities, sex, and size frequencies at sites throughout the EBS (Daly et al. 2015). The fishery also employs both onboard and dockside observers. However, substantial uncertainty remains in parameters such as individual growth rates, reproductive potential, and natural mortality (Turnock 2012). Data are fit to a sex-specific length-based model using ADModel Builder (ADMB), a robust and highly trusted optimization program. Alternative models are constructed reflecting different assumptions for model parameters and uncertainty. Methods and results for each model are reviewed by an independent Science and Statistical Committee (SSC) of the NPFMC. Following approval of model structures, the Crab Plan Team (CPT) then recommends final control rules for the fishery based on the model results; these are reviewed and finalized by the SSC. Due to the presence of heavily reviewed annual stock assessments that incorporate both fishery-dependent and -independent data, scientific research, and monitoring in the EBS fishery, we have rated this factor "highly effective."

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.

United States Bering Sea, Pot

Highly Effective

The process for setting the annual OFL determined by the CPT is established by the FMP control rules. As such, determination of the OFL is somewhat removed from political processes. ADFG sets the guideline harvest level to be lower than the ABC, providing an additional buffer against exceeding the OFL. However, discretion is left to the CPT in determining an ABC that prevents exceeding the OFL with adequate certainty; this allows for some negotiation in the process of setting catch limits. The OFL

control rule specified in the FMP ensures that the agreed-upon catch remains less than the credible OFL, and that management has a demonstrated record of setting catch limits below the OFL provided by the stock assessment process (Stockhausen 2015) (Turnock and Rugolo 2015). Due to the clear regulations in place for incorporating scientific advice, as well as for management's track record of not exceeding scientific recommendations for capture (not exceeding the TAC), scientific advice in the EBS fishery is rated as "highly effective."

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.

United States Bering Sea, Pot

Highly Effective

The snow crab fishery has not exceeded the TAC since 2005/2006 and the Tanner crab fishery has not exceeded the TAC since the 1995/1996 fishing season. In the prior fishing seasons, TACs were more frequently exceeded but by minimal amounts, and TACs were readjusted in the next year to correct overages when they occurred (Stockhausen 2014) (Turnock and Rugolo 2014). Additionally, there is no evidence that fishing occurs in closed areas. The correction of overages when TACs were exceeded, strong observer coverage, VMS systems, and mandatory electronic logging make enforcement in the EBS snow and Tanner crab fisheries "highly effective."

Rationale:
All crab landings are required to be logged in a confidential electronic fish ticket, which records vessel-specific information together with the number and weight of crabs landed and the date and location of capture. State-mandated onboard observers are required on all catcher/processor and floating processor vessels. EBS snow crab catcher vessel (C/V) observer coverage is 30%, in which 10% coverage is paid for with test fish funds while federal crab rationalization funds pay for 20%. Catcher processor (C/P) observer coverage is 100% pay-as-you-go, and test fish funds are used to reimburse costs for 30% of C/P observer days. EBS Tanner crab C/V observer coverage is 30%–100%, and observer costs are principally paid for with crab rationalization funds. Requirement for EBS Tanner crab C/P observer coverage is 100% pay-as-you-go, and test fish funds are used to reimburse costs for 30% of observer days (ADFG 2014). Registered vessels in the snow crab fishery must have an active VMS approved by NMFS (ADFG 2015a).

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.

United States Bering Sea, Pot

Highly Effective

The EBS snow and Tanner crab fisheries have a strong track record and have proved reasonably responsive and effective in the management of snow and Tanner crabs to date. Using the current definitions provided by the snow crab FMP, the stock was declared overfished in 1999 due to survey estimates of mature biomass being below the MSST. A recovery plan was put into place and the stock was considered rebuilt in 2011 (Turnock and Rugolo 2015). The most recent stock assessment indicates that MMB is slighty below B_{MSY} (Turnock and Rugolo 2015), but it is projected to increase to over 165% of B_{MSY} within the next few years.

The Tanner crab fishery was declared overfished after the 2011 assessment, but subsequently declared not overfished after the 2012 assessment. The stock was considered rebuilt and an OFL of 19.02 thousand t was set for 2012/13, but the directed fishery remained closed by the SOA on the basis of its harvest level algorithms (Stockhausen 2014). In the 2013 assessment (Stockhausen et al. 2013), the Tanner crab stock was again found to be not overfished and was opened for the 2013/14 fishing season.

The fisheries have a strong track record of compliance with catch regulations. Due to the demonstrated ability of management to recover the fisheries from depleted levels, while still taking into account the short duration of the recent recovery, the track record of the EBS snow and Tanner crab fisheries is rated as “highly effective.”

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.

United States Bering Sea, Pot

Highly Effective

Stock assessments and proceedings from relevant meetings are posted online and available to the

public. Stakeholders are able to voice their opinions in both the federal (NPFMC) and state (Alaska Board of Fisheries) management processes. Recently, management entered an agreement with the local crab fishing cooperative, in which the industry self-funded research activities to improve knowledge of the stock (Poulsen 2012). Due to the high level of transparency and opportunity for public comment, stakeholder inclusion in the EBS snow and Tanner crab fisheries is rated as "highly effective."

Bycatch Strategy

Factor 3.2: Management of fishing impacts on bycatch species						
Region / Method	**All Kept**	**Critical**	**Strategy**	**Research**	**Advice**	**Enforce**
United States Bering Sea Pot	Yes	No				

No species other than snow and Tanner crabs are caught in the fisheries, and gear restrictions are in place to minimize the overall impact of undersized crabs. Traps must have a mesh size sufficient to allow the escape of undersized crabs, and they must have escape rings built into the structure (NPFMC 2011b). In addition, biodegradable mesh is used to prevent the risk of ghost fishing. Decreased effort also affords the fleet more time to remove pots under advancing ice conditions, thus reducing the potential for lost pots that would continue ghost fishing. Industry reforms have also helped reduce the extent of bycatch. Due to decreased effort, fewer pots are now soaked for longer, which increases the probability that undersized individuals will escape once the bait runs out. Industry-led efforts have also pushed the snow crab cooperative to avoid regions where high densities of Tanner crab have been observed (Poulsen 2012).

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.
United States Bering Sea Pot	3.00:Low Concern	0.25:Minimal Mitigation	4.00:Low Concern	**Green (3.606)**

The EBS snow and Tanner crab industry is a pot fishery, which can affect marine habitats. Because the fishery is conducted on sandy and/or muddy substrates, the impact of these traps is likely limited. In addition, pots are constructed with raised frames that reduce the surface area of the trap that contacts the bottom, although the pressure applied by the trap is increased in contact areas. The FMP mandates the identification of Essential Fish Habitat (EFH). As a result, portions of the EBS fishing grounds are now closed to snow and Tanner crab traps. However, these closures cover a small area and are not present in regions of high crab fishing pressure. Effort has been reduced in recent years as a result of vessel buy-back programs and active efforts by industry. Ecosystem-based management is not clearly or directly included in the management of the fishery, but ecosystem factors are taken into consideration in the overall assessment of the resource conducted by the NPFMC.

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.

United States Bering Sea, Pot

Low Concern

Chuenpagdee et al. (2003) rank pots and traps as a three out of five on a habitat impacts scale. Most fishing in the EBS region is on silt and mud bottoms, which reduces the potential habitat impacts of the fishing gear because these substrates are more resilient and less vulnerable to the impacts of crab pots (Danner 2007). NMFS (2004) reported that the total portion of the EBS impacted by commercial pot fishing may be less than 1% of the shelf. This was supported by a more recent assessment (Fitch et al. 2012), which concluded that the BSAI crab fisheries have an insignificant effect on benthic habitat. However, no studies have been conducted measuring the number of pots, pot size, or pot weight used in Alaskan waters. Trap mesh is elevated from the substrate by a frame so that the contact area is minimized, but the weight of the trap is concentrated on the frame edges. These frame edges can cause habitat damage, especially if the pot is dragged across the floor during bad weather or during the setting and retrieval of gear. Given the size of the pots and these potential gear effects, pots may have an impact similar to that of a small pelagic trawl that infrequently touches the seafloor, so we have ranked this factor “low” concern.

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.*

United States Bering Sea, Pot

Minimal Mitigation

The FMP mandates the identification of Essential Fish Habitat (EFH). The current FMP has closed coral protection areas (Fig. 8) and seamount habitats (Fig. 9) to pot fishing, but these regions make up a small percentage of habitat fished by the snow and Tanner crab industry (Smith & McConnaughey 1999) (Stockhausen 2015) (Turnock and Rugolo 2015). Fishing effort is effectively controlled through the limited entry program, a well-controlled TAC, a fishery buyback program, and the CDQ system. Therefore, mitigation of fishing gear impacts is ranked as “minimal” (NPFMC 2011a).

Rationale:

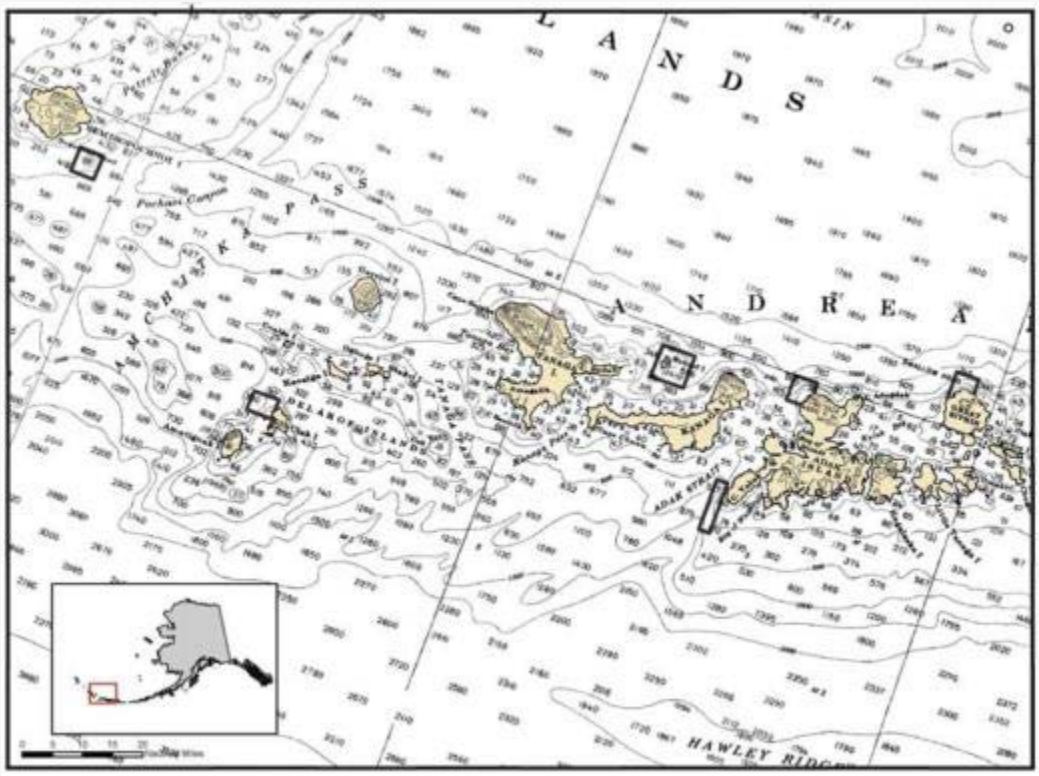


Figure 8. Aleutian Islands Coral Habitat Protection Areas (from NPFMC 2011a).

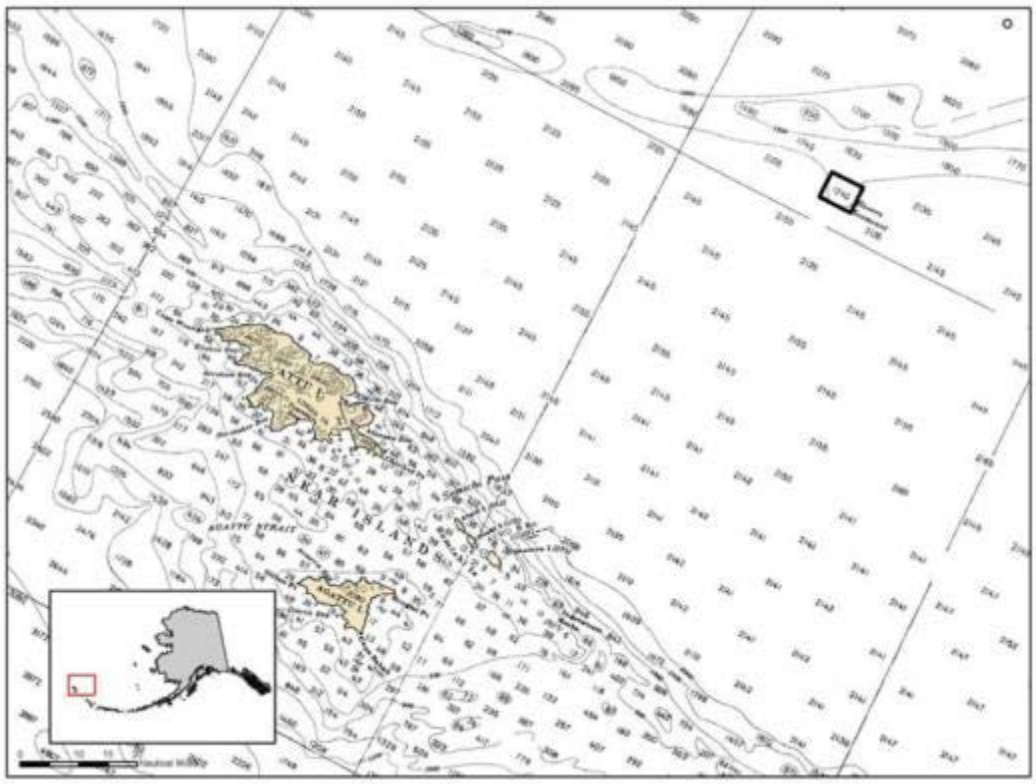


Figure 9. Alaska Seamount Habitat Protection Area in the Aleutian Islands (from NPFMC 2011a)

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.*

United States Bering Sea, Pot

Low Concern

No exceptional species are caught in these fisheries. The snow and Tanner crab FMP does not currently directly manage the fishery from an ecosystem-based perspective. However, the annual assessment report includes assessments of broader ecosystem considerations, such as food webs and habitat availability. Therefore, assessments to account for the ecological role of snow and Tanner crabs are underway (NPFMC 2011a). In Alaska, management regulations already include ecosystem-based fishery management measures such as control of directed and incidental catches; prohibition on fishing of forage species (on which other fish, seabirds, and marine mammals depend); protection of habitat for fish, crabs, and marine mammals; and temporal and spatial controls on fishing (Witherell & Woodby 2005) (Pikitch et al. 2004). As a result, we have rated this factor “low” concern.

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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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