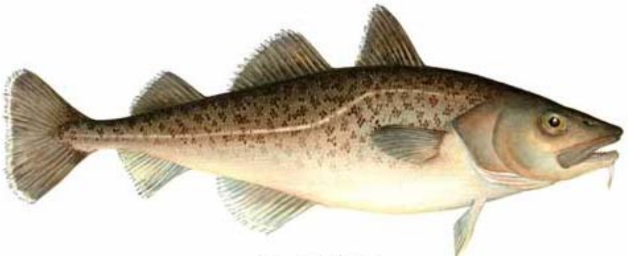
Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Pacific cod
Gadus macrocephalus



(Image courtesy of Robert Donahue)

West Coast Region

Final Report
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Jesse Marsh
Fisheries Research Analyst
Monterey Bay Aquarium

About Seafood Watch® and the Seafood Reports

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 the Internet (seafoodwatch.org) or obtained from the Seafood Watch® program by emailing seafoodwatch@mbayaq.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® Fisheries 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 (831) 647-6873 or emailing seafoodwatch@mbayaq.org.

Disclaimer
Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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Executive Summary

Pacific cod, *Gadus macrocephalus*, is a moderately long-lived species that reaches maturity at an early age and is highly fecund. Pacific cod occurs over the continental shelf and slope primarily in the Bering Sea/Aleutian Islands and Gulf of Alaska. Despite the formation of spawning aggregations, Pacific cod is considered inherently resilient to fishing pressure. Pacific cod is landed primarily in Alaska, with 78.2% of landings from the Bering Sea/Aleutian Islands and 21.8% of landings from the Gulf of Alaska. In the Bering Sea/Aleutian Islands and Gulf of Alaska, Pacific cod is not overfished and not undergoing overfishing. Biomass trends in the Bering Sea/Aleutian Islands are similar for exploitable biomass and spawning stock biomass, showing a general decline over the last 20 years. In the Gulf of Alaska, the spawning stock biomass has remained more stable than the exploitable biomass, although short-term trends are declining overall. However, biomass levels remain above the B_{MSY} proxy, and the stock status of Pacific cod in the Bering Sea/Aleutian Islands and Gulf of Alaska is thus considered healthy. The gear types used to catch Pacific cod include bottom trawls, bottom longlines, pots, and jig gear. Bottom trawls catch other commercially valuable groundfish, while bottom longlines catch seabirds as bycatch, including several albatross species. The number of seabirds caught in the U.S.-based groundfish fisheries of the Bering Sea/Aleutian Islands and Gulf of Alaska is small relative to the global bycatch of seabirds in bottom longline fisheries, and this issue remains a moderate conservation concern. Pots and jig gear are considered to have low bycatch. Bottom trawls damage the seafloor as they catch Pacific cod, and as a result of the diversity and complexity of the habitat types in the Bering Sea/Aleutian Islands and Gulf of Alaska, the habitat effects of bottom trawl gear in these areas are also considered a high conservation concern. Fixed gear such as bottom longlines, pots, and jig gear also affect bottom habitat through entanglement and contact with the seafloor, although to a lesser degree than trawls. Pacific cod is managed by the North Pacific Fishery Management Council under the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish, and the Fishery Management Plan for Groundfish of the Gulf of Alaska. Management of Pacific cod is considered highly effective due to the existence of management measures such as permits and limited entry, quotas, seasonal and area closures, mandatory observer coverage, reporting requirements, and gear restrictions. The habitat concerns associated with trawl gear results in the ranking of Pacific cod as a “Good Alternative”, even though the stock is considered healthy. Pot, jig-caught, and bottom longline-caught Pacific cod is considered a “Best Choice”. For all Pacific cod catch in the Bering Sea/Aleutian Islands and Gulf of Alaska in 2003, 44.9% was caught with longlines, 37.4% with bottom trawls, 16.3% with pots, and 1.4% with “other” gear types[1].

The U.S.-based Bering Sea Aleutian Islands freezer longline fishery targeting Pacific cod is certified by the Marine Stewardship Council (MSC). For more information visit the MSC website at: http://www.msc.org/html/content_1243.htm.

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[1] These percentages are catch including discards.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks	√ (U.S.)			
Nature of Bycatch	√ (Pots, Jigs)	√ (Trawls, longlines)		
Habitat & Ecosystem Effects	√ (Jigs)	√ (Longlines, Pots)	√ (Trawls)	
Management Effectiveness	√			

About the Overall Seafood Recommendation:

- A seafood product is ranked **Avoid** if two or more criteria are of High Conservation Concern (red) OR if one or more criteria are of Critical Conservation Concern (black) in the table above.
- A seafood product is ranked **Good Alternative** if the five criteria "average" to yellow (Moderate Conservation Concern) OR if the "Status of Stocks" and "Management Effectiveness" criteria are both of Moderate Conservation Concern.
- A seafood product is ranked **Best Choice** if three or more criteria are of Low Conservation Concern (green) and the remaining criteria are not of High or Critical Conservation Concern.

Overall Seafood Recommendation:

U.S. pot or jig-caught
U.S. bottom longline-caught:

Best Choice 🟩 Good Alternative 🟨 Avoid 🟥

U.S. trawl-caught:

Best Choice 🟩 **Good Alternative** 🟨 Avoid 🟥

Introduction

Pacific cod is found primarily in the North Pacific from the Yellow Sea to the Bering Strait, and along the Aleutian Islands, and is more rarely found in its more southern range which extends to Los Angeles, California (Figure 1) (Bakkala 1984; NMFS 2004a). Pacific cod is a demersal fish, and is an important member of the groundfish complex. Pacific cod plays an important role in Bering Sea and Gulf of Alaska ecosystems, particularly as a prey item for several marine mammals (e.g., Steller sea lions) and seabirds and also as a predator of pollock, shrimp, and snow crab (Bakkala 1984). After pollock (*Theragra chalcogramma*), Pacific cod is the species most commonly landed in the Bering Sea and Gulf of Alaska. The eastern Pacific cod stock, (Pacific cod from the U.S. and Canada) is not genetically distinct, and there is evidence of significant migrations between the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA) (Grant et al. 1987; Shimada and Kimura 1994). Pacific cod occurring in GOA state waters and federal waters (within the Exclusive Economic Zone) are considered one stock (Thompson et al. 2004). Pacific cod in the BSAI is managed as a second stock.

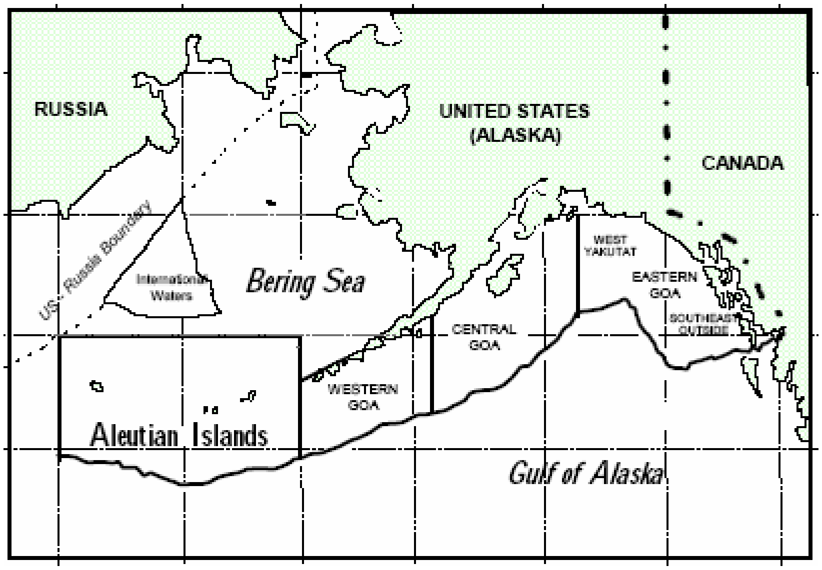

Figure 1. Map of the Bering Sea/Aleutian Islands and Gulf of Alaska (Figure from 50 CFR 679, Figure 14. Available at: http://www.fakr.noaa.gov/rr/figures/fig14.pdf)

A domestic fishery for Pacific cod existed periodically starting in 1864, but did not exist as a large-scale fishery until 1981 (NMFS 2004a). The industrialized fishery for Pacific cod began in the 1960s with the Japanese bottom longline fishery, but as the Japanese trawl fishery for pollock began in the mid-1960s, Pacific cod became an important bycatch species in the trawl fishery (NPFMC 2002). In the late 1960s, a Soviet fishery targeted numerous groundfish, including Pacific cod, until 1971 when pollock became the primary target species (NPFMC 2002). In the eastern Bering Sea, Pacific cod landings by foreign fisheries remained stable near 50,000 metric tons (mt) throughout the 1960s (NPFMC 2002). By the early 1990s, the domestic fishery for Pacific cod had completely displaced the joint-venture and foreign fisheries for Pacific cod (NMFS 2004a).

Landings of Pacific cod by U.S. fisheries increased rapidly throughout the 1980s as fishing by foreign fleets was eliminated in the Bering Sea, and have remained generally stable since the 1990s, averaging approximately 245,000 mt per year from 1990 to 2003 (Figure 2) (NMFS 2004b). In the U.S., Pacific cod was landed predominantly in Alaska in 2003 (99%), with only a fraction landed in California, Oregon, and Washington (NMFS 2004b). There is both a federal and state-managed fishery in Alaska, with the majority of landings coming from the federal fishery that occurs throughout the U.S. Exclusive Economic Zone (EEZ). The Alaska Department of Fish and Game (ADF&G) manages Pacific cod in internal state waters, and ADF&G management of the outer coastal waters of the state reflects NMFS management of the federal fishery (Coonradt 2002). In 2003 the state fishery landed 11,798 mt of Pacific cod in 2003, with 43.8% of the state landings coming from the Alaska Peninsula, 31% from Kodiak, 17% from Chignik, 5.6% from Cook Inlet, 1.5% from Southeast Alaska, and less than 1% from both Prince William Sound and the state waters around the Aleutian Islands (ADF&G 2005). In Southeast Alaska, a large portion of the Pacific cod landed is used as bait in other fisheries and much of this catch goes unreported (Coonradt 2002).

Of the total Pacific cod landed in the EEZ fishery off Alaska, 78.2% is from the BSAI while 21.8% is from the GOA (Thompson and Dorn 2004; Thompson et al. 2004). Different gear types dominate the Pacific cod catch in these two areas. In the BSAI, bottom trawls (42.2%) and bottom longlines (48.8%) accounted for the majority of Pacific cod catch over the last 10 years (Thompson and Dorn 2004). Pots accounted for another 8.8%, and "other" gear types, such as jig gear, accounted for the remaining 0.1% over the same time period in the BSAI (Thompson and Dorn 2004). In GOA federal waters, trawls took the largest portion of Pacific cod (including discards) in 2004 (41.6%), followed by pots (32.8%) (Thompson et al. 2004). In GOA state waters, Pacific cod was caught with pots (78.3%) and "other" gear types (21.7%) (Thompson et al. 2004). The trawls used to target Pacific cod are generally fished in shallow waters; Pacific cod have been observed at depths of 45 – 288 m (130 m average) on submersible transects (Stone 2006).

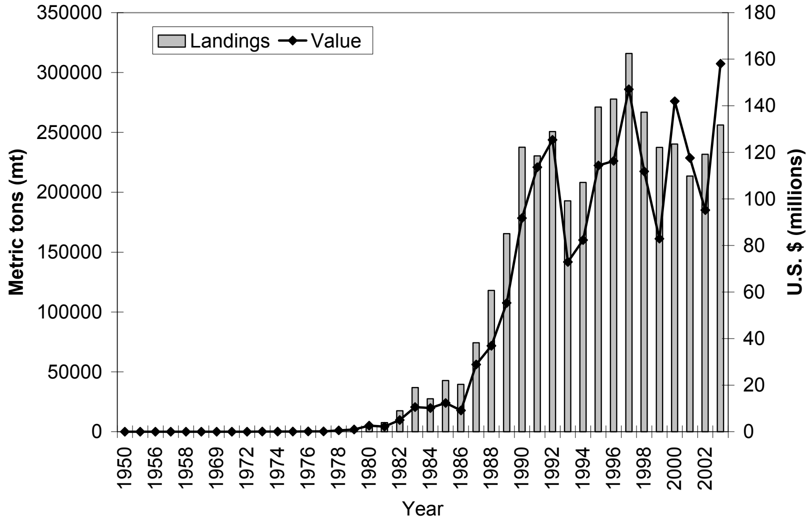

Figure 2. U.S. landings and value of Pacific cod, 1950 – 2003 (NMFS 2004b). Note that prior to the 1980s, Pacific cod was landed by foreign vessels (these data are not shown here); catch in the eastern Bering Sea averaged around 50,000 mt from the mid-1960s to mid 1970s, with a peak of 70,000 mt in 1970 (NPFMC 2002).

The Pacific cod fisheries in the BSAI and GOA are managed by the North Pacific Fishery Management Council (NPFMC) under the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish and the Fishery Management Plan for Groundfish of the Gulf of Alaska, respectively. Management measures include permits and limited entry, quotas, seasonal and area closures, mandatory observer coverage, reporting requirements, and gear restrictions.

The BSAI Pacific cod freezer longline fishery is certified by the Marine Stewardship Council (MSC). The MSC certification program evaluates the sustainability of a fishery before labeling the product, signifying "…environmentally responsible fishery management and practices" (MSC 2004). The majority of Pacific cod caught and processed in the BSAI Pacific cod freezer longline fishery does not end up in the U.S. market; 40% is exported to Europe, 40% to Japan, with only 20% going to the U.S. and China (MSC 2005).

Canada

Pacific cod off the coast of British Columbia is managed as four stocks: Strait of Georgia, west coast of Vancouver Island, Queen Charlotte Sound, and Hecate Strait (DFO 2004). Pacific cod landings by region in Canada exhibit considerable year to year variation (A. Sinclair, pers. comm.). From 2003 to 2004 landings from the west coast of Vancouver Island and Hecate Strait stocks increased, while landings from Queen Charlotte Sound decreased. Landings of Hecate Strait cod since 1994 have been the lowest on record, with the minimum observed in 2001 at 190 mt; in 1966 landings were 9,519 mt (Sinclair et al. 2001). In 2004, Pacific cod landings in Canada were primarily from the west coast of Vancouver Island stock (44%), Hecate Strait (40%), and Queen Charlotte Sound (16%) (A. Sinclair, pers. comm.). Trawls are the primary gear used to target Hecate Strait cod (DFO 2000). Pacific cod landings are highly variable, and reflect changes in recruitment (Sinclair et al. 2001). The Pacific cod fishery in Canada is managed by the Department of Fisheries and Oceans Canada (DFO).

Russian Federation

The Russian Federation also fishes for Pacific cod, primarily in the Sea of Okhotsk and the Bering Sea. Pacific and Arcto-Norwegian cod combined are the second highest marine catch in the Russian Federation each year (FAO 2004). However, stock status data for Pacific cod stocks in the Russian EEZ are not available to the public (Vaisman 2001). In the Russian Federation fishery for Pacific cod, the most common gear type used is bottom longlines, while bottom trawls, bottom nets, and bottom seines are less commonly used (FAO 2004). In the western Bering Sea overall, Pacific cod catch increased from 1980 – 1986, declined until 1989, and was variable until 1993, which is the most recent year that these catch data are available. From 1984 – 1999 there was a general decline in Pacific cod catches by the Russian Federation (Vaisman 2001). Management of this fishery falls under the jurisdiction of the federal State Committee of Fisheries, as well as scientific advisory bodies and management bodies at the regional level (Vaisman 2001). The Russian Federation exports the majority of its seafood products to China, Japan, and South Korea (FAO 2004).

Scope of the analysis and the ensuing recommendation:

This analysis encompasses Pacific cod caught in the U.S.-based Bering Sea/Aleutian Islands and Gulf of Alaska commercial fisheries. Information on the Pacific cod fishery in Alaska state waters, as well as information on the Canadian and Russian fisheries for Pacific cod is also included, although not specifically evaluated due to the relatively small contributions of these fisheries to the U.S. market. Although there is also a Chinese fishery for Pacific cod, there is no readily available information on this fishery. South Korean and Japanese catches of Pacific cod do not likely end up in the U.S. market (Vaisman 2001).

Availability of Science

There are limited length-at-age data for Pacific cod in both the BSAI and the GOA (Thompson and Dorn 2004; Thompson et al. 2004). Future research needs identified in the 2004 BSAI and GOA Pacific cod Stock Assessment and Fishery Evaluation (SAFE) report include: spatial dynamics, trophic, and other interspecific relationships of the Pacific cod stock; spatial dynamics of the Pacific cod fishery; and biomass estimates, carrying capacity, and resilience of bycatch species and species that interact with Pacific cod (Thompson and Dorn 2004; Thompson et al. 2004).

Market Availability

Common and market names:

Pacific cod is also known as Alaska cod, grey cod, P-cod, and true cod (Witherell 2000; Froese and Pauly 2004; Pacific Seafood Group 2004).

Seasonal availability:

Pacific cod is available year-round.

Product forms:

Pacific cod is marketed fresh, frozen, and smoked (Froese and Pauly 2004). Headed and gutted Pacific cod, as well as fillets, are the primary product forms (Witherell 2000). Less common products include salted, whole fish, roe, and minced cod used for surimi (Witherell 2000).

Import and export sources and statistics:

The National Marine Fisheries Service Foreign Trade Database does not distinguish between cod species for its import and export data; cod is either listed as “Atlantic” or “Not Specifically Provided For”. However, 81,450 mt of cod was exported from the Pacific U.S. Customs District in 2003, and it is likely that this cod is Pacific cod although it is not specified as such (R. Ranta, pers. comm.). Of the cod exported from the Pacific U.S. Customs District in 2003, the majority was exported to Japan (36%), China (14%), South Korea (13%), Norway (9%), Canada (7%), and Portugal (6%) (NMFS 2004c). Of the total cod (“Atlantic” and “Not Specifically Provided For”) imported into the U.S. in 2003, 84.5% came from only four countries: China, Canada, Iceland, and the Russian Federation (Figure 3) (NMFS 2004c). Average U.S. imports of Pacific cod from the Russian Federation from 1995 – 1998 were approximately 270 mt per year (Vaisman 2001). In 2003, the amount of all cod imported into the U.S. (after re-exports are considered) remained small relative to U.S. landings of all cod (after exports are considered). Of all cod available on the U.S. market, approximately 34% is imported while the remaining 66% is U.S.-caught. However, these figures may be misleading, as the majority of cod landed in the U.S. is Pacific cod (> 95%), and it is likely that the majority of cod imports from countries such as China and Iceland are Atlantic cod.

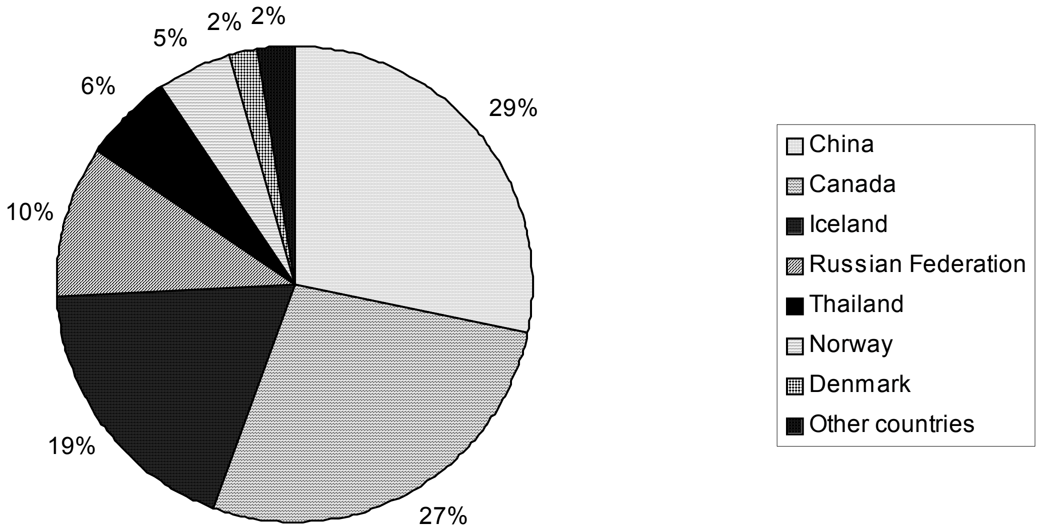

Figure 3. Imports of all cod ("Atlantic" and "Not Specifically Provided For") into the U.S., 2003 (NMFS 2004c).

Analysis of Seafood Watch® Sustainability Criteria for Wild-caught Species

Criterion 1: Inherent Vulnerability to Fishing Pressure

Pacific cod has a limited distribution, as it is found primarily in the North Pacific from the Yellow Sea to the Bering Strait, and along the Aleutian Islands, and is more rarely found in its southern range which extends to Los Angeles, California (Table 1) (Bakkala 1993; Froese and Pauly 2004). Pacific cod is primarily demersal, although the species does forage in the water column. The maximum length recorded for Pacific cod is 119 cm total length (TL), and the published maximum weight recorded is 22.7 kilograms (kg) (Froese and Pauly 2004). Pacific cod is moderately long-lived, with a maximum reported age of 25 years (Munk 2001). The intrinsic rate of increase for Pacific cod is unknown. Pacific cod reaches maturity at a relatively early age. In the BSAI 50% of Pacific cod reaches maturity by a length of 67 centimeters (cm) and an age of five years (Witherell 2000), while in the GOA this length corresponds to an age of seven years (Witherell 2000).

Pacific cod aggregates over small areas to spawn, making the species easier to catch. Data on spawning locations and behavior is sparse, although it is known that large spawning aggregations occur between Unalaska and Unimak Islands, southwest of the Pribilof Islands, and near the Shumagin group. Spawning occurs from 40 to 290 meters (m) deep (Shimada and Kimura 1994; NMFS 2004a). Pacific cod is highly fecund, with a 67 cm female capable of producing more than one million eggs (DiCosimo and Kimball 2001). The reproductive success of Pacific cod may be affected if prey availability is modified as a result of climate change or regime shifts (NMFS 2004a).

Pacific cod feeds both in the water column and in the benthic environment, with juvenile Pacific cod primarily consuming invertebrates and adults primarily consuming other fish (Yang 1990). Pacific cod is an important predator, particularly for pollock, shrimp, and snow crab (Bakkala 1984). Pacific cod also serves as an important prey item for Pacific halibut, salmon shark, and several marine mammal species, including Steller sea lions (*Eumetopias jubatus*) (Westrheim 1996).

Table 1. Life history characteristics of Pacific cod.

Intrinsic Rate of Increase (r)	Age at Maturity	Growth Rate	Max Age	Max Size	Fecundity	Species Range	Special Behaviors	Sources
Unknown	50% maturity at 5 – 7 yrs	vBgf[2]: L_∞ = 105.0 cm, k = 0.157 – 0.670	25 yrs	119 cm TL	> 1 million eggs for a 67 cm female	North Pacific	Spawning aggregations	Witherell 2000; Froese and Pauly 2004; NMFS 2004a

Synthesis

Pacific cod reaches maturity at a relatively early age, and is a fast-growing, moderately long-lived species with a maximum age of 25 years. As a species with high reproductive potential and a high growth coefficient, Pacific cod is considered inherently resilient to fishing pressure, despite the formation of spawning aggregations which may increase its ease of capture.

Inherent Vulnerability Rank:

Resilient 🟩 Neutral 🟨 Vulnerable 🟥

Criterion 2: Status of Wild Stocks

Canada

The four Pacific cod stocks managed in British Columbia, Canada are the Strait of Georgia, west coast of Vancouver Island, Queen Charlotte Sound, and Hecate Strait stocks. The Hecate Strait stock was most recently assessed in 2001, the west coast of Vancouver Island stock in 2002, and the Strait of Georgia stock in 1987. The Queen Charlotte Sound stock has never been assessed (Sinclair et al. 2001). Stock assessment information for Pacific cod is summarized in a report

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[2] vBgf = a commonly used growth function in fisheries science to determine length as a function of age. L_∞ is asymptotic length, and k is body growth coefficient. Note that maximum size may be larger than L_∞ due to individual variation around L_∞.

card by the DFO; primary ratings include biomass indicators, recruitment, recruits per spawner, mortality, and fishery/production/industry input (Sinclair et al. 2001). Secondary factors include size structure, maturity, growth, spatial distribution, predators, prey abundance, and oceanography (Sinclair et al. 2001). According to the report card for Pacific cod in Hecate Strait, biomass status is ranked as "low" and "danger" (Sinclair et al. 2001). Due to the low total allowable catch (TAC) implemented in 2001, both fishing effort and mortality have declined. Both the current stock biomass and recruitment are below target (Sinclair et al. 2001). Fishing mortality is below F_{MSY} due to the decrease in TAC in 2001 (Sinclair et al. 2001). The production model estimates that current biomass is 6 – 9% of the unfished population biomass (Sinclair et al. 2001). The model estimates of biomass are below $1/2B_{MSY}$, and both catch per unit effort (CPUE) and swept area biomass estimates have been declining since the late 1980s (Sinclair et al. 2001). The status of the Hecate Strait stock remains an issue of concern for Seafood Watch® due to the extremely low biomass levels and long-term declining trend. The west coast of Vancouver Island stock of Pacific cod is highly uncertain; while one assessment model that included shrimp trawl data estimated biomass at 104% of B_{MSY}, an alternative assessment model that did not include the shrimp indices estimated biomass at 39% of B_{MSY} (Starr et al. 2002). According to the stock assessment authors, the model that included the shrimp trawl indices is the preferred model, and both models suggested an increase from the previous year's assessment (Starr et al. 2002). Despite different biomass estimates, both assessment models indicate that the biomass of Pacific cod increased from 1999 until 2002, which is the most recent year for which data are available (Starr et al. 2002).

Russian Federation

There are no data available on the stock status of Pacific cod being fished by vessels from the Russian Federation, and there is also a great deal of uncertainty associated with the accuracy of the catch data that are available. Catch quotas for the Russian waters of the Bering Sea declined from 61,430 mt in 1996 to 43,455 mt in 1999 (Vaisman 2001). Although Japan and South Korea also fish for Pacific cod in the Russian waters of the Bering Sea, the majority of this catch remains in Japan or South Korea or is exported to China (Vaisman 2001). According to the limited data evaluated by Vaisman (2001), Pacific cod stocks in Russian waters of the Bering Sea have remained stable from 1978 – 1998.

Bering Sea/Aleutian Islands

In the BSAI, Pacific cod is not overfished, and is not undergoing overfishing (Table 2) (NMFS 2004d). Although B_{MSY} and F_{MSY} are not defined for Pacific cod in the BSAI, $B_{35\%}$ and $F_{35\%}$ serve as proxies[3]. The most recent Stock Assessment and Fishery Evaluation (SAFE) report estimates that the 2005 spawning stock biomass (295,000 mt) is 11% above the B_{MSY} proxy of $B_{35\%}$ (266,000 mt) (Thompson and Dorn 2004). B_{MSY} is the biomass at which maximum sustainable yield is produced. The fishing mortality rate in 2004 was estimated at $F = 0.29$ for the BSAI, which is below $F_{35\%} = 0.43$ (Thompson and Dorn 2004). Scientific model estimates of exploitable (age 3+) biomass and spawning stock biomass are lower than last year's estimate due to the addition of age, growth, and length data in the model (Thompson and Dorn 2004). In addition, fishery independent survey results show a recent decrease in biomass in the eastern Bering Sea (Thompson and Dorn 2004). From 1978 to 1983, fishery independent surveys show

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[3] $B_{35\%}$ refers to the level of spawning that is 35% of what the level of spawning would be in the absence of fishing. The $F_{35\%}$ level is then the level of fishing that produces $B_{35\%}$.

that biomass increased, and then remained stable throughout the remainder of the 1980s (Thompson and Dorn 2004). A biomass peak of approximately 1.4 million mt was observed in 1994, followed by a steady decline until the late 1990s (Thompson and Dorn 2004). From 1997 to 2004, survey biomass estimates have generally ranged from 525,000 – 625,000 mt; the 2004 estimate was 596,988 mt (Figure 4) (Thompson and Dorn 2004).

The estimate of age 3+ biomass decreased from 1.68 million mt in 2003 to 1.29 million mt in 2005 (Thompson and Dorn 2004). The projected spawning stock biomass estimate for 2005 is approximately 32% lower than the projected spawning stock biomass in 2004 (Thompson and Dorn 2004). This reduction in the biomass estimate is due in part to the inclusion of more data in the 2005 model. The scientific model used in the stock assessment estimates that both age 3+ and spawning stock biomass have been continually declining since 1987, and the biomass estimates in each year from 2000 to 2004 were the lowest points seen since 1981 (Thompson and Dorn 2004). Although Pacific cod in the BSAI exhibits a long-term and short-term decline, biomass estimates are above the proxy for B_{MSY}, or $B_{35\%}$. There is little uncertainty associated with the stock status of Pacific cod in the BSAI, as the current stock assessment is considered robust. It is unknown whether the current age, size, or sex distribution of the stock is skewed, relative to the unfished condition.

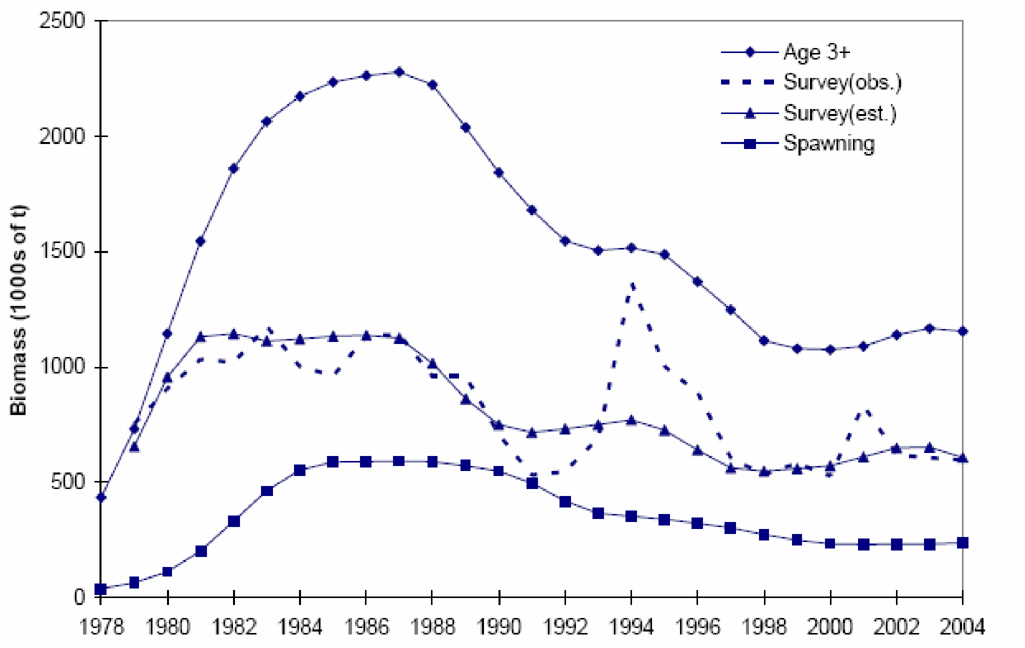

Figure 4. Biomass estimates for Pacific cod in the BSAI, 1978 – 2004 (Figure from Thompson and Dorn 2004).

Gulf of Alaska

In the GOA, Pacific cod is not overfished, and not undergoing overfishing (NMFS 2004d). Although B_{MSY} is not defined for the Pacific cod stock in the GOA, $B_{35\%}$ serves as a proxy. The most recent SAFE report estimates that the 2005 spawning stock biomass (91,700 mt) is 24% above $B_{35\%}$ (73,900 mt). Although the spawning stock biomass is above $B_{35\%}$, short-term trends in age 3+ and spawning stock biomass are declining (Figure 5) (Thompson et al. 2004). The 2005 estimates of both spawning stock biomass and age 3+ biomass declined from 2004 estimates; spawning stock biomass declined by 11% and the age 3+ biomass declined by 2% (Thompson et al. 2004). The model trends in age 3+ biomass are similar to the spawning stock biomass and survey biomass trends; since 1990 there has been a general decline in these biomass estimates (Thompson et al. 2004). The model estimates of age 3+ and spawning stock biomass for 2004 were the lowest since the 1970s (Thompson et al. 2004). Despite long-term declines in biomass, biomass estimates are above B_{MSY}. The proxy for F_{MSY} is $F_{35\%}$, which was 0.43 in the most recent stock assessment. The fishing mortality rate in 2004 was F = 0.23, which is below $F_{35\%}$ (Thompson et al. 2004). There is little uncertainty associated with the stock status of Pacific cod in the GOA, as the current stock assessment is considered robust. It is unknown whether the current age, size, or sex distribution of the stock is skewed, relative to the natural condition.

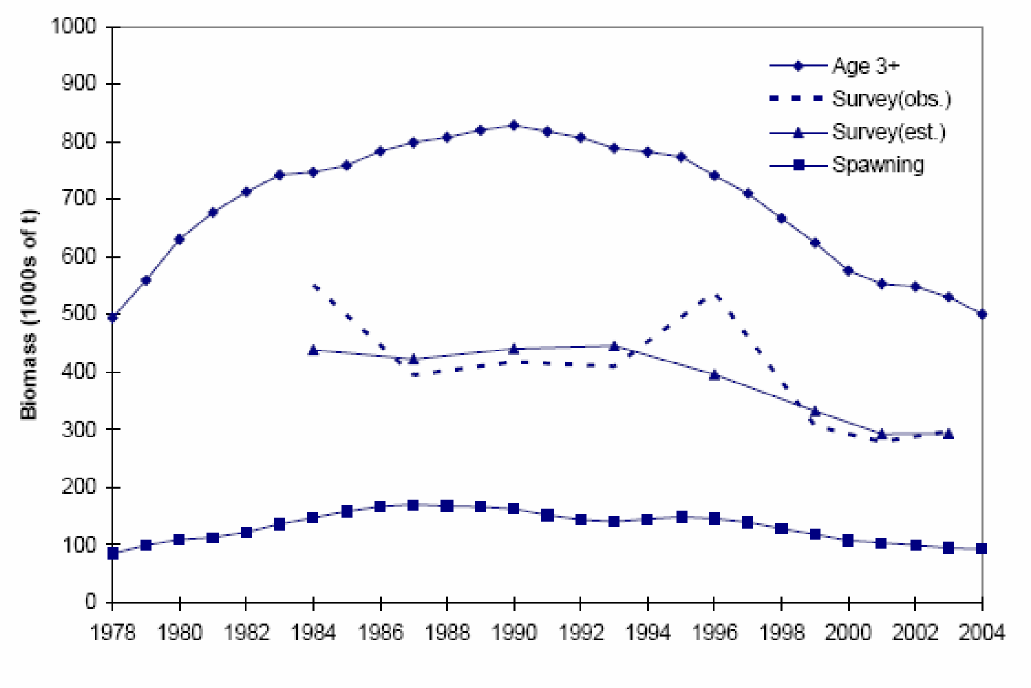

Figure 5. Biomass estimates for Pacific cod in the GOA, 1978 – 2004 (Figure from Thompson et al. 2004).

Table 2. Stock status of Pacific cod.

Region	Classification Status	B/B_{MSY}	Occurrence of Overfishing	F/F_{MSY}	Abundance Trends/CPUE	Age/Size/Sex Distribution	Degree of Uncertainty in Stock Status	Sources
Bering Sea/Aleutian Islands	Not overfished	$B_{2005}/B_{35\%} = 1.11$	Overfishing not occurring	$F_{2004}/F_{35\%} = 0.67$	Long-term and short-term declining biomass trends	Unknown whether distributions are skewed	Low	NMFS 2004d; Thompson and Dorn 2004
Gulf of Alaska	Not overfished	$B_{2005}/B_{35\%} = 1.24$	Overfishing not occurring	$F_{2004}/F_{35\%} = 0.64$	Long-term and short-term declining biomass trends	Unknown whether distributions are skewed	Low	NMFS 2004d; Thompson et al. 2004

Synthesis

Spawning stock biomass in both the BSAI and GOA is above $B_{35\%}$. In addition, the fishing mortality rate is below $F_{35\%}$. Although biomass levels are high, both spawning stock biomass and age 3+ biomass have exhibited long-term declines over the last 20 years. The decline of spawning stock biomass has been more pronounced in the BSAI, with a more stable trend observed in the GOA. The Pacific cod stock in both the BSAI and GOA is considered "healthy" until biomass trends fall below the B_{MSY} proxies or until overfishing occurs.

Status of Wild Stocks Rank:

BSAI/GOA:

[✓ **Healthy** 🟩] Moderate/Rebuilding 🟨 Poor 🟥 Critical ⬛

Criterion 3: Nature and Extent of Bycatch

Seafood Watch® defines sustainable wild-caught seafood as marine life captured using fishing techniques that successfully minimize the catch of unwanted and/or unmarketable species (i.e., bycatch). Bycatch is defined as species that are caught but subsequently discarded (injured or dead) for any reason. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, accounted for and/or managed in some way.

Pacific cod is caught with bottom trawls, bottom longlines, pots, and jig gear. There are different bycatch concerns associated with each of these gear types. Finfish and invertebrate bycatch is a concern in the trawl fishery, while seabird bycatch is the predominant concern in the Pacific cod longline fishery. Jig and pot fisheries are considered to have "very low to negligible discard rates" (Kelleher 2004). The global average discard rate for finfish jig fisheries is low, at 1.1%, and the global average weighted discard rate is 3.5%[4] (Kelleher 2004). In 2001, there was no bycatch in the BSAI and GOA shoreside jig fisheries for Pacific cod (FIS 2003). There is some concern over Tanner crab bycatch in the Pacific cod fishery, as the pots used to catch Pacific cod are modified crab pots (Zhou and Kruse 2000); Tanner crabs are a prohibited species and must be discarded. In 2001, the BSAI shoreside pot fishery for Pacific cod discarded 123,764 Tanner and king crabs, the BSAI catcher/processor pot fishery for Pacific cod discarded 70,513 Tanner and king crabs, the GOA shoreside pot fishery for Pacific cod discarded 50,362 Tanner and king crabs, and the GOA catcher/processor pot fishery for Pacific cod discarded 19,220 Tanner and king crabs (FIS 2003). The mortality of these discards is unknown.

Discards of other groundfish species in the directed Pacific cod trawl fishery does occur (Table 3), although prohibited species such as halibut, herring, some crab species, and some salmon species must be discarded. In the BSAI, bycatch of nontarget and "other" species differs

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[4] The average discard rate is the average of the individual discard rates for a set of fisheries. The weighted discard rate is derived from the set of complete records for the type of fishery and is the summed discards as a percentage of summed landings plus summed discards (Kelleher 2004).

according to gear type. Some examples of species caught as bycatch in the bottom longline and bottom trawl fisheries include sculpin, skates, sleeper sharks, and salmon sharks (Thompson and Dorn 2004). Although the incidental catch of sharks in the BSAI and GOA fisheries is generally low relative to the targeted catch (Courtney et al. 2004), salmon sharks are listed as data deficient on the IUCN Red List and there are little data concerning the population status of this species (Goldman and Human 2000). The bycatch of sharks and skates was recognized as a priority research area by the MSC (MSC 2006). In addition, formal stock assessments have not been conducted for grenadiers, which are common species incidentally caught in the Pacific cod longline fishery (MSC 2006).

Table 3. Groundfish discards in the directed Pacific cod trawl fishery in the BSAI (FIS 2003).

Species	Caught (mt)	Discarded (mt)	Discard Rate
Atka mackerel	896	305	34.1%
Pollock	3,885	2,004	51.6%
Pacific cod	12,628	168	1.3%
Yellowfin sole	432	305	70.5%
Rock sole	4,797	2,273	47.4%
Flathead sole	657	431	34.5%
Other flatfish	524	430	81.9%
Greenland turbot	78	22	27.6%
Arrowtooth flounder	1,828	1,287	70.4%
Pacific ocean perch	102	80	78.4%
Sharpchin/northern rockfish	180	179	99.3%
Shortraker/rougheye rockfish	4	4	100%
Other rockfish	34	24	71.4%
Sablefish	30	2	7.8%
Other species	962	923	96%

Seabird Bycatch

Pot and trawl gear

Seabirds are caught as bycatch in longline, trawl, and pot gear although longlines are the most serious threat. In trawl fisheries, seabirds may interact with the "third wire" gear on the trawl vessels, as well as the net and the warps (Wilson et al. 2004). "Third wires" are used to monitor the performance of the trawl gear, and consist of a wire or cable coming from the center of the vessel into the water (Wilson et al. 2004). There are documented mortalities of northern fulmars, shearwaters, and Laysan albatrosses in Alaskan trawl fisheries (Wilson et al. 2004). There is currently a ban on the use of such "third wire" gear in several southern hemisphere trawl fisheries (Wilson et al. 2004). Estimates of seabird bycatch in the Pacific cod trawl fishery does not account for seabird interactions with the "third wire", as observer data consists of seabirds that are brought onboard in the trawl net. Due to the way that observer data are collected in the trawl fishery, there is considerable uncertainty associated with the estimates of seabird bycatch in this fishery (NMFS 2005). From 1999 – 2003, the average annual estimate of seabirds taken in this fishery ranged from a minimum of 1,343 to a maximum of 15,343 seabirds per year (NMFS 2005). In 2003, bycatch of albatross species in the trawl fishery was similar to that in the bottom longline fishery, although there is considerable inter-annual variability. Seafood Watch® will continue to monitor this situation as more data become available. Pot gear takes very few seabirds; in the BSAI and GOA combined, seabird bycatch in the pot fisheries was estimated at 55 birds per year, on average from 1993 to 2003 (NMFS 2005). Most of these takes were a result of seabirds colliding with the gear while it was on deck, rather than during fishing (NMFS 2004a).

Longline gear
In the longline fishery, seabirds are hooked on the gear when they dive for the bait as the lines are being deployed. The most common seabird species that occur on longline fishing grounds are black-footed albatrosses (*Phoebastria nigripes*), northern fulmars (*Fulmarus glacialis*), and shearwaters (Melvin et al. 2004). Laysan albatrosses (*Phoebastria immutabilis*) are taken in the BSAI and GOA longline fisheries, while short-tailed albatrosses (*Phoebastria albatrus*) have been observed as takes only in the BSAI longline fishery (NMFS 2004a). The most common seabird caught as bycatch in both the BSAI and the GOA is the northern fulmar (Livingston 2002). The short-tailed albatross is the only seabird species caught as bycatch in these fisheries that is listed as endangered by the U.S. Endangered Species Act (ESA). However, several of the seabird species are listed on the IUCN Red List of Threatened Species, including the Laysan albatross (vulnerable), short-tailed albatross (vulnerable), and black-footed albatross (endangered) (IUCN 2004). Because the short-tailed albatross is protected under the ESA, several Biological Opinions (BiOps) have been issued to determine whether any federally managed fisheries have an adverse effect on this species. The 1989 Biological Opinion set the incidental take limit for short-tailed albatross at four every two years in the hook and line groundfish fishery, and two every five years in the trawl fishery (NMFS 2004a). If the take limit is exceeded, the fishery faces possible modifications or closure (NMFS 2004a). The most recent BiOp, published in 2003, found that BSAI and GOA groundfish fisheries are not likely to jeopardize the continued existence or recovery of the short-tailed albatross (USFWS 2003). The recent comprehensive assessment conducted by the MSC concluded that the Pacific cod longline fishery is "…unlikely to be creating a major problem" (MSC 2006, p. 78).

Seabird bycatch in the Bering Sea/Aleutian Islands
While seabird bycatch in the U.S.-based North Pacific longline fisheries[5] is not as high as international seabird bycatch, there is still cause for concern. From 1993 – 2003, seabird bycatch in all of the groundfish longline fisheries in the BSAI averaged 12,619 birds per year, with a low of 4,000 birds in 2002 (Fitzgerald et al. 2004). The bycatch rate over this time period was 0.71 birds per 1,000 hooks (NMFS 2005). The bycatch rate for all seabird species in the BSAI was variable from 1993 – 2003, although it has declined dramatically, despite a concomitant increase in fishing effort, since 1998 due to the implementation of management measures requiring seabird mitigation devices (Figure 6) (NMFS 2005). In 2003 in the BSAI, the bycatch rate for all seabird species was 0.019 birds per 1,000 hooks and the estimate of the number of birds caught was 5,351 birds (NMFS 2005). From 1993 – 2003, seabirds caught in the BSAI included fulmars (59%), gulls (20%), unidentified seabirds (12%), albatrosses (4%), shearwaters (3%), and all other species (2%) (NMFS 2005).

Seabird bycatch in the Gulf of Alaska
In the GOA, the species distribution differs from that in the BSAI, and fewer birds are taken. From 1993 – 2003, an average of 932 seabirds were taken each year with the most common species being fulmars (46%), albatrosses (34%), gulls (12%), unidentified species (5%), shearwaters (2%), and all other species (< 1%) (NMFS 2005). The bycatch rate in the GOA was

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[5] Note that these data refer to all bottom longline fisheries.

0.24 birds per 1,000 hooks over this time period (NMFS 2005). Similar to the BSAI, the bycatch rate for all seabird species in the GOA was variable from 1993 – 2003, and has declined since 1998, although fishing effort has increased since then (NMFS 2005). In 2003 in the GOA, the bycatch rate for all seabird species was 0.012 birds per 1,000 hooks and the estimate of the number of birds caught was 632 birds (NMFS 2005). Although black-footed albatrosses are taken in the groundfish longline fisheries in the BSAI and GOA, these numbers are small compared to the number of black-footed albatrosses taken in foreign longline fisheries (NMFS 2004a).

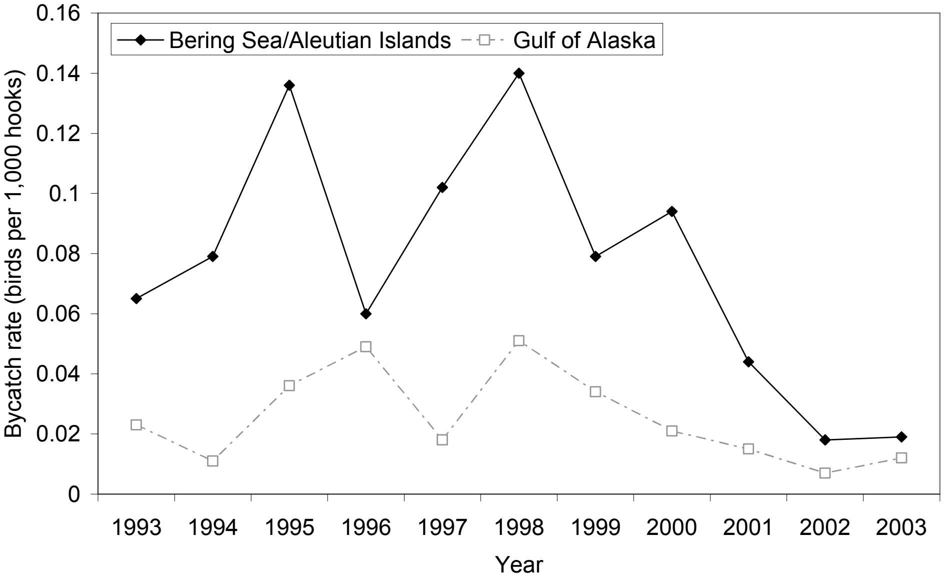

Figure 6. Bycatch rates of all seabird species in the BSAI and GOA, 1993 – 2003 (NMFS 2005).

On average, from 1993 – 2002, the BSAI bottom longline fishery has accounted for 93% of the seabird bycatch in the Pacific cod fishery, and bycatch rates for seabirds have been three times higher in the BSAI than in the GOA (NMFS 2005). In 2003, however, bycatch rates for seabirds in the bottom longline fisheries were similar in the two areas (NMFS 2005). Albatross bycatch in the GOA in 2003 was equivalent to that in the BSAI (178 birds and 177 birds, respectively). The differences in the level of bycatch between the BSAI and GOA may be attributed to a number of factors, such as differences between the vessel types or bird distribution in these two areas (NMFS 2004a). For instance, catcher-processor vessels operating in the BSAI are larger, can spend up to 30 days at sea, and set up to 55,000 hooks per day (Melvin et al. 2001). Catcher vessels in the GOA have shorter trip lengths and set up to 10,500 hooks per day (Melvin et al. 2001). Longline fisheries occurring in state waters may be a relatively small contribution to albatross bycatch in the U.S.-based fishery, although with no observer coverage this is difficult to quantify (NMFS 2004a). Overall, bycatch of seabirds in the BSAI and GOA longline fisheries has declined over the last 10 years. The bycatch levels of certain albatross species have declined since 1998, except for a slight increase observed in 2003 for bycatch of Laysan albatross in the BSAI and black-footed albatross in the GOA (Figures 7 and 8) (NMFS 2005).

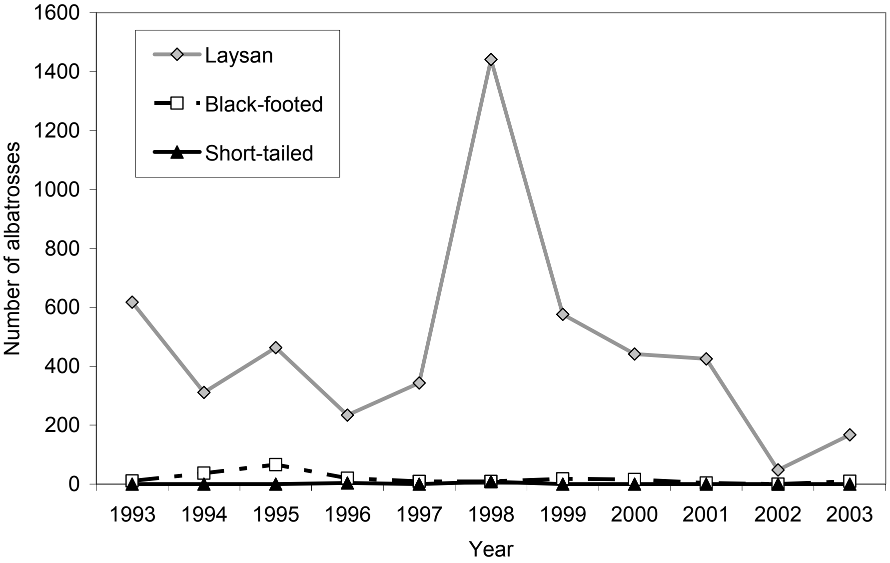

Figure 7. Bycatch of albatross species in the BSAI longline fisheries, 1993 – 2003 (NMFS 2005).

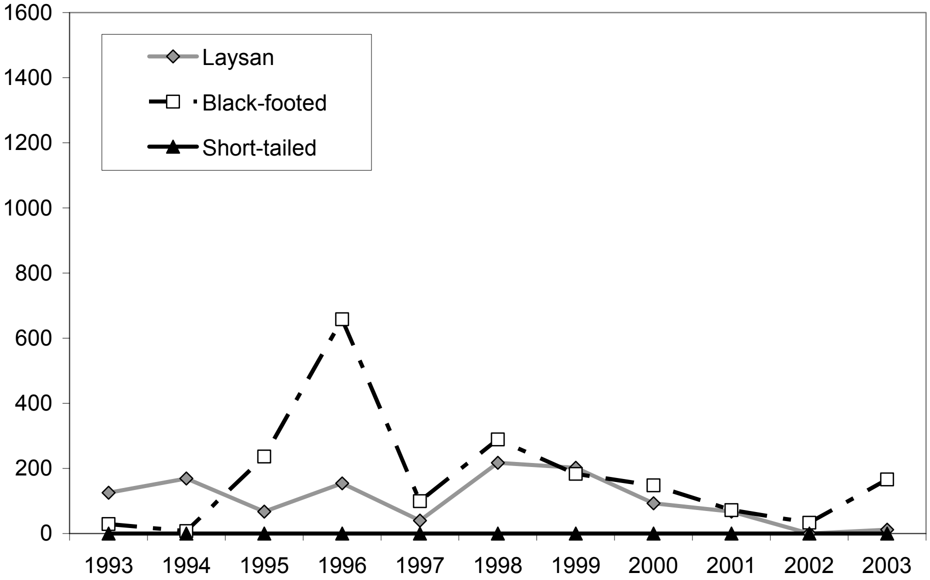

Figure 8. Bycatch of albatross species in the GOA longline fisheries, 1993 – 2003 (NMFS 2005).

The seabird avoidance measures implemented in 1997 (see Criterion 5: Effectiveness of the Management Regime) were successful at reducing the seabird bycatch rates in the BSAI and the GOA, as well as the number of albatrosses caught as bycatch, although the number of albatrosses caught in 2003 was higher than in 2002.

Population effects

Seabirds exhibit life history characteristics that make them vulnerable to increased adult mortality, such as a long life span, late age at maturity, and low reproductive rates (Russell et al. 1999; Saether and Bakke 2000). Due to these life history characteristics, it may take years for a population decline to be detected, and subsequently for the population to show signs of recovery (Moloney et al. 1994). Globally, longline fishing is considered the most serious threat to certain seabird species such as albatrosses (Brothers et al. 1999). Due to a lack of published population data, there is some uncertainty associated with the population consequences of seabird bycatch in the bottom longline fisheries of the BSAI and GOA. Population assessments are currently underway by the U.S. Fish and Wildlife Service (USFWS) for several albatross species, and when these data are available they will be included in an updated version of this report. The population of short-tailed albatross is thought to be increasing (Fitzgerald et al. 2004); the current population is estimated at 2,150 birds with an annual growth rate of 7.5% per year (P. Sievert, pers. comm.). Laysan and black-footed albatross bycatch in the Alaskan bottom longline fisheries is estimated to be 0.06% and 0.07% of the most recent population estimates, respectively (Fitzgerald et al. 2004). For northern fulmars, the current bycatch levels are estimated to be 1.4% of the population estimate (Fitzgerald et al. 2004). The impacts of northern fulmar bycatch are not regularly reviewed, and one condition of the MSC certification is that acceptable bycatch levels should be established for this species (MSC 2006). The number of breeding pairs of Laysan albatross on Midway Atoll, Laysan Island, and the French Frigate Shoals declined dramatically from 1997 to 2002 (Flint 2005). Estimates of breeding pairs have generally increased since 2002, although 2005 estimates were lower than 2004 estimates (Flint 2005). The number of breeding pairs of black-footed albatross exhibited a similar, but less variable trend over the same time period (Flint 2005). Since 1992, the number of breeding pairs of black-footed albatross at Midway Atoll, Laysan Island, and French Frigate Shoals has generally been stable, particularly since 2000, and has been increasing since 2003 (Flint 2005).

Despite the trends observed at these nesting locations, recent population declines for both the Laysan albatross and black-footed albatross have been attributed to the bycatch of these species in the longline fisheries of the North Pacific (BirdLife International 2004). In October 2004, several conservation groups filed a petition with the USFWS to list the black-footed albatross as endangered or threatened under the ESA. The endangered short-tailed albatross has a global population of only 1,600 – 1,700 birds, and is considered “one of the rarest species on earth” (NMFS 2004a), although this species has not been observed taken in this fishery since 1997. Fulmars are the species most commonly caught in the groundfish longline fisheries, and although they are abundant, with an estimated population of 2 million birds in the BSAI and GOA, the continued bycatch of these species has uncertain population impacts (NMFS 2004a). In general, population trends for seabird colonies in Alaska show a predominantly negative trend in the southeast Bering Sea and Gulf of Alaska (Figure 9) (Dragoo et al. 2003).

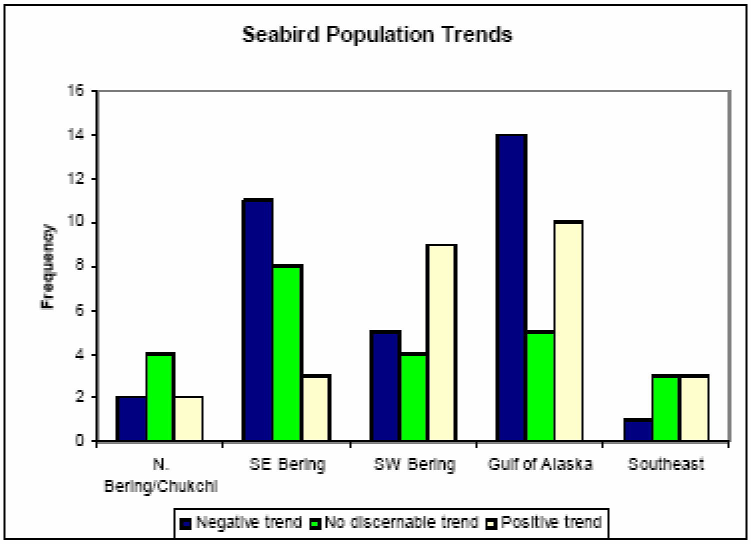

Figure 9. Seabird population trends for some colonies in Alaska, 2001 (Figure from Fitzgerald et al. 2004, data from Dragoo et al. 2003).

Synthesis

The different gear used to catch Pacific cod in the BSAI and GOA results in different levels of bycatch. Pot and jig gear are generally considered to have low bycatch levels. The Pacific cod trawl fishery catches several commercially important groundfish species in addition to structure forming organisms such as corals and sponges; bycatch in the trawl fishery therefore rates as a moderate conservation concern. In the Pacific cod longline fishery, bycatch regularly includes protected species such as seabirds (particularly black-footed and Laysan albatross) in addition to finfish bycatch. Management measures have been successful at reducing seabird bycatch, and this issue is considered a moderate conservation concern.

Nature of Bycatch Rank:

Pots and jigs:

[✓ **Low** 🟩]   Moderate 🟨   High 🟥   Critical ⬛

Longlines and trawls:

Low 🟩   [✓ **Moderate** 🟨]   High 🟥   Critical ⬛

Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Due to the large extent of the Pacific cod fishery in the BSAI and GOA, the fishery occurs over many different habitats. For instance, in the Aleutian Islands, the catcher-vessel longline fishery occurs predominantly over mud bottoms, while longline catcher-processors fish more frequently over rocky bottoms (Thompson and Dorn 2004). In the GOA, the Pacific cod longline fishery occurs over gravel, cobble, mud, sand, and rocky bottoms from depths of 48 to 256 m (Thompson and Dorn 2004). Bottom longlines in the waters off Alaska may be set with weights attached to the lines over rough bottoms, and the average set length for Pacific cod in 1996 was 10 miles (NMFS 2004a). The pots used to catch Pacific cod in these waters are modified crab pots, and are approximately 1.8 m x 1.8 m x 1 m (6 ft x 6 ft x 3 ft), and weigh between 227 and 318 kg (500 – 700 pounds) (NMFS 2004a).

Habitat Effects

Bottom trawls, bottom longlines, pots, and jigs all affect the seafloor habitat to some degree. The trawls used to catch Pacific cod in the BSAI and GOA are otter trawls, which consist of a large net that is dragged along the seafloor, and doors attached at either side to keep the mouth of the net open. The trawl doors create large grooves in the seafloor, and damage coral and other substrate in their path (Roberts et al. 2000). Bottom trawls are often equipped with rock-hopper gear, designed to allow the net to be dragged through complex habitat areas without snagging on rocks and other obstacles (Enticknap 2002). Trawl vessels targeting Pacific cod in the Gulf of Alaska often use such rock-hopper gear (Enticknap 2002). Bottom trawling has both biogenic and physical effects on the seafloor. Bottom trawls damage benthic organisms such as corals and sponges, and disturb complex habitat that provides shelter for juvenile commercially important fish species (Chuenpagdee et al. 2003). In general, organisms in stable sediments such as gravel and mud suffer more adverse effects than those in unconsolidated sediments (Collie et al. 2000). One indirect effect of bottom trawling on corals is the resuspension of bottom sediments (Piskaln et al. 1998). Emergent epifauna may be destroyed by mobile gear such as trawls, as well as fixed gear such as longlines and pots (Hall 1999).

Although trawls are the gear most often cited as negatively impacting cold-water corals off Alaska, longlines, pots, and jigs also affect this sensitive bottom habitat (NMFS 2004a). Groundlines and hooks on bottom longlines snag large branches of corals, and also cause portions of hard corals to be broken off (Breeze et al. 1997; High 1998). Although bottom longlines have limited contact with the seafloor, both the hooks and lines may snag on bottom structure as the gear is set and retrieved (Chuenpagdee et al. 2003). For rougher habitats such as boulders with corals, fixed gear may have an impact, particularly because it is easier to fish fixed gear over rough habitat (NMFS 2004a). Jigging is a type of hook and line gear, and the hooks do not generally contact the seafloor unless they are set on the bottom, in which case the lines and sinkers may damage organisms such as corals (Chuenpagdee et al. 2003). A panel of fishery experts concluded that bottom trawls (all types) have “very high” physical and biological habitat impacts, bottom longlines have “low” physical and biological habitat impacts, and hook and line gear have “very low” physical and biological habitat impacts (Chuenpagdee et al. 2003).

Trawling in the North Pacific

From 1998 to 2000, a total of 53,931 km^2 were swept by bottom trawl gear in the Bering Sea, 10,201 km^2 in the Aleutian Islands, and 17,562 km^2 in the Gulf of Alaska (NRC 2002). There are habitat differences between the BSAI and the GOA, as well as local variability of sediment types within these areas (Enticknap 2002). In the Bering Sea, bottom sediments include sand and gravel, as well as organisms such as soft corals, hydroids, sea pens, tubeworms, tunicates, and sponges (Enticknap 2002); these organisms create structure and habitat (McConnaughey et al. 2000). The GOA is a more open system with weaker currents, and is predominantly gravely-sand, silty-mud, and areas of hard bedrock (NMFS 2001b).

In the North Pacific, corals have been designated as essential fish habitat (EFH) (Witherell and Coon 2000), as they provide shelter, prey, and habitat for commercial fish such as rockfish (Mortensen et al. 1995). In addition sponges, corals, anemones, sea pens, and sea whips have been designated Habitat Areas of Particular Concern (HAPC) in Alaska (Heifetz 2002). HAPCs are habitat types that may require additional protection (NMFS 2004a). Other HAPCs may also include substrate such as boulders and cobble (NMFS 2004a). Corals provide shelter for commercial fish species, and are particularly vulnerable to the impacts of fishing gear because they are long-lived and easily damaged by fishing gear (Witherell and Coon 2000). Like other stable environments composed of long-lived species, corals recover slowly from damage (Auster and Langton 1999; Witherell and Coon 2000). The largest deep-sea corals occurring in Alaskan waters are *Primnoa*, which can grow up to 3 m high and 7 m wide (Witherell and Coon 2000). These corals also grow slowly and can live longer than 500 years (Risk et al. 1998).

In the waters off Alaska, gorgonians are found along the continental shelf and slope along the Gulf of Alaska and the Aleutian Islands (Witherell and Coon 2000). Soft corals are most common in the Bering Sea, gorgonians are most common in the Aleutian Islands, and gorgonians and cup corals are most common in the Gulf of Alaska (Heifetz 2002). Heifetz (2002) found that rockfish and Atka mackerel (*Pleurogrammus monopterygius*) were associated with gorgonian, cup, and hydrocorals, while flatfish and gadids were most often associated with soft corals. Ten megafaunal groups have been shown to associate with *Primnoa*, and rockfish, shrimp, and crabs were observed utilizing *Primnoa* for shelter (Krieger and Wing 2002). In particular, rockfish were commonly affiliated with corals; although less than 1% of the boulders in the study area contained coral, 85% of the large rockfish were observed next to boulders with corals (Krieger and Wing 2002).

There is less known about fishing gear impacts on cold-water corals than there is on sponges and tropical corals (Witherell and Coon 2000); however, cold-water corals have been observed to be vulnerable to damage by fishing gear (Krieger 1998). The removal of deepwater corals may have long-term effects on the species that associate with the coral (Krieger and Wing 2002). It may take as long as 100 years for gorgonians to recover from fishing impacts (Andrews et al. 2002). According to Krieger and Wing (2002), "Removal or damage of *Primnoa* may affect the populations of associated species, especially at depths > 300 m, where species were using *Primnoa* almost exclusively." The exact amount of coral removed as bycatch in commercial fisheries is unknown.

In Norway, fishermen have reported that catches are lower in areas were deepwater corals have been damaged; in addition, these same fishermen were concerned about the reduced ability of reefs to function as nursery habitat for commercial fish species (Fosså et al. 2002). Research conducted in Norway also found that more fish were caught in coral reef habitat than in non-coral reef habitat (Husebo et al. 2002). Fishermen using hook and line gear and gillnets have been known to set their gear close to reefs, as these areas are known to be good fishing areas (Fosså et al. 2002). Deepwater corals in Norwegian waters have been observed with trawl scars as a result of otter trawl doors, rockhopper gear, and nets damaging the sensitive habitat (Hall-Spencer et al. 2002).

A recent study in the Bering Sea found that heavily fished areas had a patchier distribution of structure-forming organisms such as sponges, anemones, soft corals, and stalked tunicates (McConnaughey et al. 2000). Overall, habitat complexity and diversity were reduced after bottom trawling, accompanied by physical changes to the seafloor habitat itself, which was a sandy, shallow benthic environment (McConnaughey et al. 2000). Research in a different habitat type, dominated by find sand and mud, found that bottom trawling had very little effect on the seafloor habitat (Brown 2001). In the GOA, bottom trawling has also been shown to have negative effects. In one case, an area that was trawled in 1990 had still not recovered by 1997; despite the seven-year time lapse, the coral colonies remained damaged with some missing up to 99% of their branches (Krieger 2001). On hard-bottom habitat in the Gulf of Alaska, bottom trawling has been shown to damage 67% of the epifaunal sponges, and 55% of the sea whips in trawl transects ranging from 0.29 – 0.56 km in length (Freese et al. 1999). Emergent epifauna were removed or damaged, and boulders were displaced after the single pass of a trawl (Freese et al. 1999). It is expected that areas subject to long-term trawling would have a decreased density of such epifauna (Freese et al. 1999). Trawling may also indirectly impact coral habitat by removing fish that consume coral grazers, thereby causing an increase in the abundance of coral grazers (Rogers 1999).

Freese et al. (1999) also found that a year after bottom trawling occurred at the study site, none of the damaged sponges had recovered, and it was possible to identify the tracks left by the trawl doors. Organisms such as corals are likely to show a measured population decline in areas that are repeatedly bottom trawled, as they are slow-growing and physically vulnerable to damage by the trawl gear (Kaiser 1998). On seamounts in Tasmania, the biomass and diversity of species was higher on unfished seamounts than on heavily fished seamounts (Koslow et al. 2001).

In the Aleutian Islands, corals are found throughout the depths at which the commercial fisheries operate, and in one study, 39% of the total seafloor observed with submersibles had been disturbed by fishing gear (Stone 2006).

Ecosystem Effects

Trawling in the waters off Alaska has had documented effects on both the physical and biogenic habitats associated with the seafloor, including changes to community structure and potential effects on prey (NMFS 2004a). The large amount of biomass removed from the Bering Sea may have an impact on community structure and be a contributing factor in the recent shift to a pelagic system dominated by pollock (NRC 1996). Fixed gear such as longlines and pots has also been shown to affect the benthos, but it is unlikely that these fisheries have resulted in widespread ecosystem effects (NMFS 2004a). Other potential ecosystem effects include the removal of species that are prey for seabirds (NMFS 2004a).

Steller sea lions[6]

Groundfish fisheries in the BSAI and GOA remove large quantities of fish from the ecosystem, thereby reducing the amount of prey available to Steller sea lions (*Eumetopias jubatus*). Pollock, Atka mackerel, salmonids, and Pacific cod have been shown to be the most common prey items of Steller sea lions (Sinclair and Zeppelin 2002). More importantly, there may be population effects as a result of local depletion, particularly due to the small available biomass in certain locations (NMFS 2003). Steller sea lions are protected under the Marine Mammal Protection Act (MMPA), as well as the ESA. In Alaska, the western population of Steller sea lions is listed as endangered under the ESA, while the eastern population is listed as threatened.

Since the 1960s, the western population of Steller sea lions has declined by greater than 80% (Sease and Loughlin 1999). From 1991 – 2002, the decline slowed to a rate of about 5% per year (Loughlin and York 2002). While the 2002 numbers of non-pup Steller sea lions were an increase of 5.5% over numbers in 2000, numbers of pups have continued to decline (Sease and Gudmundson 2002). Although the increases in non-pup Steller sea lions were the first increases observed region-wide for more than 20 years, it is premature to conclude that this increase signifies an end to the long-term population decline (Sease and Gudmundson 2002). While the fishery most often cited as having an impact on Steller sea lions is the pollock fishery, the Pacific cod and Atka mackerel fisheries have also been included in BiOps to determine if these fisheries have adverse impacts on Steller sea lions. The most recent BiOp concluded that these fisheries do not adversely affect Steller sea lions or their habitat (NMFS 2001c).

In the BSAI, Pacific cod is caught primarily in the winter months (NMFS 2001d), when Steller sea lion prey availability is most important for foraging females (NMFS 2001c). In the Bering Sea, 42 – 46% of the catch occurs in Steller sea lion critical habitat, with 35 – 36% of this catch occurring during the winter months (NMFS 2001d). Critical habitat for Steller sea lions includes 20 nautical miles (nm) around all major rookeries and haulouts, and three offshore foraging areas (50 CFR 226.202). In the Aleutian Islands, 80 – 95% of the Pacific cod catch occurs in critical habitat, with 60 – 75% of this catch occurring in critical habitat during the winter months (NMFS 2001d). In the GOA, 40 – 70% of the Pacific cod catch occurs in critical habitat, with 47 – 68% of this catch occurring during the winter months (NMFS 2001d). Since 1998, annual Pacific cod catch and catch from critical habitat areas have remained stable in the BSAI and declined in the GOA (Figures 10 and 11) (NMFS 2003).

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[6] For a more detailed discussion of the Steller sea lion decline, please see the Seafood Watch Pollock Report.

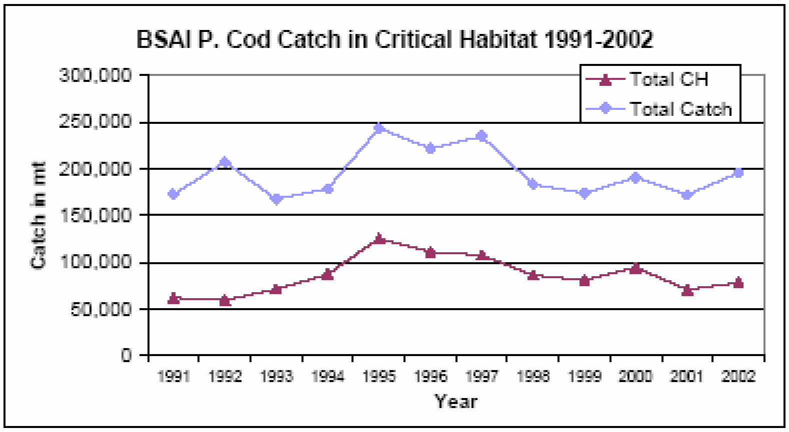

Figure 10. BSAI Pacific cod catch in Steller sea lion critical habitat, 1991 – 2002 (Figure from NMFS 2003).

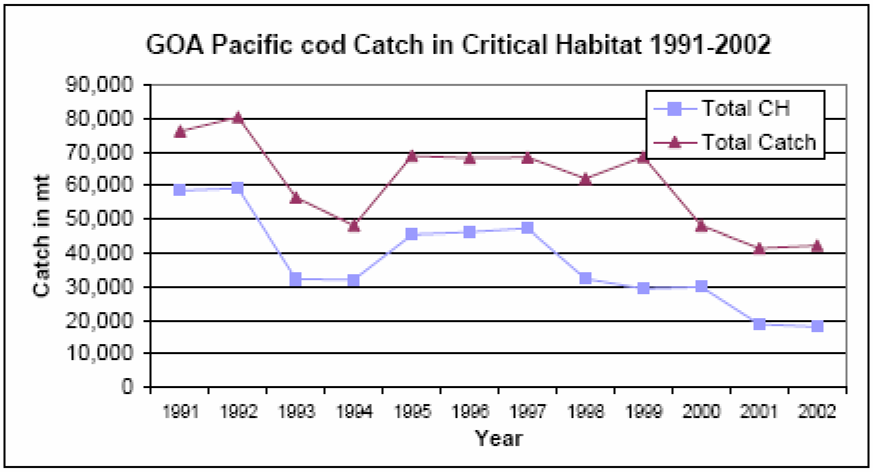

Figure 11. GOA Pacific cod catch in Steller sea lion critical habitat, 1991 – 2002 (Figure from NMFS 2003).

Both top-down (e.g., increased predation by killer whales) and bottom-up (e.g., nutritional stress) factors have been hypothesized as playing a role in the decline of Steller sea lions. A comprehensive report published by the National Research Council in 2003 concluded that nutritional stress hypotheses are "…unlikely to represent the primary threat to recovery", but that "…there is insufficient evidence to fully exclude fisheries as a contributing factor to the continuing decline" (NRC 2003).

Synthesis

Bottom trawling in the BSAI and GOA damages the seafloor habitat, in particular emergent epifauna such as corals, sponges, and anemones. Damage to sensitive habitats such as these has been shown to reduce the diversity and abundance of associated species, including commercially valuable fishes. Although fixed gear such as bottom longlines and pots have less of an impact on the bottom habitat, they do come into contact with the seafloor. In an environment such as the BSAI and GOA, these gear types may still have a moderate impact on the habitat. The ecosystem effects of removing large quantities of Pacific cod from the BSAI and GOA have been explored, although there is not sufficient evidence that this factor alone has resulted in the decline of Steller sea lions. Overall, trawls are considered to have “severe” habitat and ecosystem effects, bottom longlines and pots are considered to have “moderate” habitat and ecosystem effects, and jigs are considered to have “benign” habitat effects.

Effect of Fishing Practices Rank:

Jigs:	[✓ **Benign** 🟩]	Moderate 🟨	Severe 🟥	Critical ⬛
Pots/ longlines:	Benign 🟩	[✓ **Moderate** 🟨]	Severe 🟥	Critical ⬛
Trawls:	Benign 🟩	Moderate 🟨	[✓ **Severe** 🟥]	Critical ⬛

Criterion 5: Effectiveness of the Management Regime

Canada

The Pacific cod fishery in Hecate Strait has been managed by a total allowable catch (TAC) rule since 1992. In 2002, there was a major reduction in the TAC due to the low biomass estimated in the 2000 stock assessment (Sinclair et al. 2001). Both fishery independent and fishery dependent data were used in the most recent stock assessment, including commercial CPUE data, swept area biomass index, size composition data, research vessel surveys, and sea level data (Sinclair et al. 2001). In the British Columbia trawl fishery, there is 90% observer coverage (Starr et al. 2002).

Russian Federation

Management of the Russian fishery falls under the jurisdiction of the federal State Committee of Fisheries, as well as scientific advisory bodies and management bodies at the regional level (Vaisman 2001). Vaisman (2001) found that violations of fisheries management measures occurred on a regular basis. The most common types of violations were fraudulent documents, exceeding catch quotas, unauthorized sale of over-quota catch, and undocumented exports of this over-quota catch. The prevalence of illegal activities in the Russian Federation fishery in the Bering Sea has in part been attributed to inappropriate legislation, ineffective enforcement, and organized crime (Vaisman 2001). Despite uncertainty in stock status and uncontrolled catches, exports of many species are increasing (Vaisman 2001). For all species combined the value of illegal catch in the Russian Federation ranges from US$1 – 5 billion annually (Vaisman 2001). For the Pacific cod fishery, annual quotas have been variable since 1999, at an average of 97,667 mt per year although the 2003 quota was exceptionally low at 9,850 mt (PRFP undated). Based on the available data, it does not appear as if Pacific cod catch in the Far East exceeds the allotted quota. From 1999 – 2003, reported catch exceeded the quota only once (PRFP undated).

Fishery in the state waters of Alaska

The Pacific cod fishery occurring in the state waters of Alaska is managed by the Alaska Department of Fish and Game (ADF&G). There are a number of management areas within the state waters of Alaska, and some regulations vary by region. The three areas managed by ADF&G are the Southeast Region (Eastern GOA/Southeast Alaska), Central Region (Cook Inlet/Prince William Sound/Central GOA), and the Westward Region (Alaska Peninsula/Kodiak/Western GOA). Management measures implemented in state waters (not specific to management area) include a guideline harvest of 750,000 – 1.25 million pounds round weight in the Southern and Northern Southeast Inside Subdistricts, and gear restrictions depending on the management region and logbook requirements.

U.S. fisheries in federal waters

In the BSAI, Pacific cod is managed by the North Pacific Fishery Management Council (NPFMC) under the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish. The BSAI Groundfish Plan Team recommends the acceptable biological catch (ABC) and overfishing level (OFL) levels, which the Science and Statistical Committee may agree with, or make its own recommendations. The Science and Statistical Committee is part of the NPFMC. The NPFMC then determines the TAC based on these recommendations (NPFMC 2004). In the BSAI, overall catch of all species cannot exceed 2 million mt. Over the past 25 years, TAC has been set equal to ABC eight times (32%). Catch has exceeded TAC five times (20%) over the same time period, and on average, catch only exceeded TAC by 4% for those five years (Thompson and Dorn 2004). The BSAI TAC is allocated by gear type, with the fixed gear fishery (longlines and pots), trawl fishery, and jig fishery receiving 51%, 47%, and 2% of the TAC, respectively (Thompson and Dorn 2004). The TAC may be reallocated at the end of the year if a particular gear type is unlikely to catch their specified share (Thompson and Dorn 2004).

Pacific cod in the GOA is managed by the North Pacific Fishery Management Council under the Fishery Management Plan for Groundfish of the Gulf of Alaska. Over the 19 years for which ABC has been determined for Pacific cod in the GOA, catch has exceeded TAC 37% of the time (7 years), and has exceeded ABC twice (Thompson et al. 2004). However, catch includes catch from the state-managed fishery while TAC applies only to vessels operating in federal waters. The GOA TAC is allocated by area, processor component (90% to the inshore component and 10% to the offshore component), and season (Thompson et al. 2004). State management of the Pacific cod fishery also affects the TAC, as some of these overages in the past have been due to take in the state fishery, with the quota being adjusted accordingly.

The BSAI and GOA longline fleets have been required to use some form of bird deterrent device since 1997 (62 FR 23176, April 29, 1997). Recently, management has implemented additional mandatory bycatch reduction measures, such as towing a buoy, and use of single or paired streamers depending on the size of the longline fishing vessel (69 FR 1930, January 13, 2004). Paired streamers have been shown to be the most effective seabird bycatch reduction device for the Alaskan longline fleet, while single streamers do not eliminate the risk of hooking albatrosses (Melvin et al. 2001). Since 1997, the observed takes of all seabird species has declined, suggesting that management's bycatch reduction measures are effective.

The NPFMC has implemented numerous closed areas to protect both EFH and HAPCs; a total area of 310,500 km^2 has been closed to bottom trawls in the federal waters off Alaska (NRC 2002). These closures have been implemented to protect diverse habitat and species from trawling (DiCosimo 1999). Management measures to protect corals include areas closed to trawls and a prohibition on commercial harvest of corals (Witherell and Coon 2000). In February 2005 the NPFMC voted to prohibit bottom trawling in approximately 280,000 nm^2 in the the U.S. EEZ around the Aleutian Islands, while allowing bottom trawling to continue in areas where high catches have been taken in the past (NPFMC 2005). The NPFMC also voted to prohibit bottom trawling in 10 designated areas in the GOA (NPFMC 2005).

Numerous Steller sea lion conservation measures have been implemented in the Pacific cod fishery; some are described below, but for a full description see the supplement to the 2001 BiOp (NMFS 2003). Directed fishing for Pacific cod would be prohibited if Steller sea lion biomass fell below $B_{20\%}$ (NMFS 2003). The Pacific cod TAC is also allocated by both gear type and season in the BSAI and GOA, although there are regulatory differences between these two areas. There are also area restrictions for the different gear types (NMFS 2003). In addition, there are five haulouts in the Bering Sea for which no fishing is permitted within the 0 – 20 nm zone (NMFS 2003). In the Bering Sea, there is also no trawling permitted within 0 –10 nm of all rookeries and haulouts, and no fishing with any gear type permitted within 0 – 3 nm of all rookeries and haulouts (with the exception of jig gear, which is permitted in the 0 – 3 nm closures around haulouts) (NMFS 2003).

The Pacific cod fishery in the BSAI and GOA is regulated by a permitting system, limited entry, quotas, mandatory observer coverage (100% on large vessels), and reporting requirements (Table 5). These measures have helped to ensure that the productivity of the Pacific cod stock is maintained. In addition, the Community Development Quota (CDQ) in western Alaska allocates 7.5% of the Pacific cod catch to coastal Alaskan communities. The NPFMC is currently considering a groundfish rationalization program which would assign individual transferable quotas (ITQs) to individuals, similar to the Alaskan halibut fishery.

Table 5. Commercial harvest management measures for the Pacific cod fishery, 2004.

Region	Management Jurisdictions & Agencies	Overfishing Level (OFL)	Acceptable Biological Catch (ABC)	Total Allowable Catch (TAC)	Gear Restrictions & Area Closures	Sources
Bering Sea/Aleutian Islands	National Marine Fisheries Service, North Pacific Fishery Management Council	350,000 mt	223,000 mt	215,500 mt	Numerous areas have been closed to trawling to protect EFH and HAPCs	DiCosimo 1999; Thompson and Dorn 2004
Gulf of Alaska	National Marine Fisheries Service, North Pacific Fishery Management Council	102,000 mt	62,810 mt	41,076 mt	Numerous areas have been closed to trawling to protect EFH and HAPCs	DiCosimo 1999; Thompson et al. 2004

Synthesis

Management of Pacific cod in the BSAI and GOA includes measures to limit effort and the amount of Pacific cod caught. Mandatory observer coverage in the federal fisheries ensures that bycatch of other commercially valuable species, as well as protected species, is monitored. In addition, management has attempted to protect the diversity and abundance of species by closing sensitive areas to damaging fishing practices such as trawling. Overall, management of Pacific cod in the BSAI and GOA is considered "highly effective".

Effectiveness of Management Rank:

Highly Effective 🟩	Moderately Effective 🟨	Ineffective 🟥	Critical ⬛

Overall Evaluation and Seafood Recommendation

Due to life history characteristics such as a fast growth rate, an early age at sexual maturity, and a moderate geographic distribution, this highly fecund species is considered inherently resilient to fishing pressure. Biomass estimates are above $B_{35\%}$, and despite declining trends in spawning stock and age 3+ biomass, Pacific cod stocks are considered healthy. Several different gear types are used to catch Pacific cod, including bottom trawls, bottom longlines, pots, and jig gear. There is little bycatch in the pot and jig fisheries, while the trawl fishery catches a number of commercially valuable groundfish species as bycatch. Bycatch in the bottom longline fishery rates as a moderate conservation concern, primarily due to seabird bycatch. Trawls impact the seafloor habitat when the trawl doors and net are dragged along the bottom, causing severe damage to the physical and biological habitat. Bottom longlines and pots have only moderate habitat effects due to their limited contact with the benthos. In addition, ecosystem effects include the conflicting evidence surrounding the role of the Pacific cod fishery in the decline of Steller sea lions. Management of the Pacific cod fishery in both the Bering Sea/Aleutian Islands and Gulf of Alaska is considered highly effective as a result of numerous measures that have been implemented to maintain the productivity of the Pacific cod stock. These measures include a permitting system, limited entry, quotas, mandatory observer coverage, reporting requirements, a bycatch reduction plan, and closed areas. The habitat concerns associated with trawls results in the ranking of Pacific cod caught with this gear as a "Good Alternative", even though the stock is considered healthy. Pot, jig, and bottom longline-caught Pacific cod is considered a "Best Choice".

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks	√ (U.S.)			
Nature of Bycatch	√ (Pots, Jigs)	√ (Longlines, Trawls)		
Habitat & Ecosystem Effects	√ (Jigs)	√ (Longlines, Pots)	√ (Trawls)	
Management Effectiveness	√			

Overall Seafood Recommendation:

U.S. pot or jig-caught
U.S. bottom longline-caught:

Best Choice 🟩 Good Alternative 🟨 Avoid 🟥

U.S. trawl-caught: Best Choice 🟩 **Good Alternative** 🟨 Avoid 🟥

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