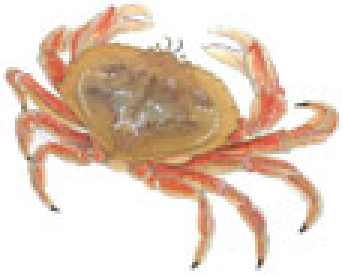
Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Dungeness crab
Cancer magister



(Image © Monterey Bay Aquarium)

West Coast

Final Report
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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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I. Executive Summary

The commercial Dungeness crab fishery ranges along the west coast of North America from Alaska to Point Conception, California. Dungeness crabs (*Cancer magister*) exhibit life history characteristics that make them inherently resilient to fishing pressure, as they have a low age at first maturity, a short lifespan, and high fecundity. As with other crab species, Dungeness crab populations undergo cyclic fluctuations due to varying oceanic conditions, including wind-driven currents, ocean temperature, and food availability (Higgins et al. 1997; WDFW 2006; Hankin and Warner 2001). As a result, landings within the Dungeness crab fishery have periods of highs and lows. While Dungeness crab stocks in Oregon, California, and Washington have never collapsed[1], several stocks in Alaska have. In the Alaskan fishery, Dungeness crab stocks have historically occurred in Southeast Alaska, Yakutat, Prince William Sound, Cook Inlet, and Kodiak; however, only the Southeast Alaska and Kodiak fisheries remain open. The other fisheries were closed due to collapses of the Dungeness crab stocks during the 1980s and 1990s. Possible causes of these collapses include sea otter predation, overfishing, and climatic changes (ADF&G 2006a; Orensanz et al. 1998).

The Oregon Department of Fish and Wildlife (ODF&W), California Department of Fish and Game (CA DFG), Washington Department of Fish and Wildlife (WDFW), and Alaska Department of Fish and Game (ADF&G) do not conduct routine stock assessments for their Dungeness crab fisheries. As a result, population abundance and occurrence of overfishing for the U.S. Dungeness crab fisheries are unknown. In addition, catch per unit effort (CPUE) is unknown. Instead, the state management agencies examine annual landings to determine stock status. Given these unknown parameters, Seafood Watch® considers the status U.S. Dungeness crab stocks to be a moderate conservation concern.

Dungeness crabs are captured with pots, which are known to have moderate impacts on habitats and ecosystems. The pots are set primarily in shallow, sandy, or mud bottom areas. These areas are moderately resilient to fishing activities. Bycatch data in the Dungeness crab fisheries are not collected, but bycatch is reportedly very low due to the high selectivity of the fishery (Michelle Grooms, pers. comm.; Heather Reed, pers. comm.; Ed Roberts, pers. comm.; and Joe Stratman, pers. comm.). The mortality rate of Dungeness crabs is low (2-4% for hard-shell and 22-25% for soft-shell) (Alverson et al. 1996). Assuming a similar bycatch rate as that observed in the snow crab fishery, and then applying the Dungeness crab mortality rates, the percentage of Dungeness crab bycatch that dies relative to landings is less than 5%. It is likely that this low amount of bycatch has little impact on Dungeness crab population levels; thus bycatch in the Dungeness crab fisheries is considered to be a low conservation concern.

The Dungeness crab fisheries are managed using a male-only harvest, strict minimum size limits that protect the reproductive ability of the population, and fishing seasons that protect sensitive molting periods. In California, Oregon and Washington, this high selectivity, commonly referred to as '3-S management', has effectively maintained stock productivity over the past 50 years. Management in these fisheries is thus considered to be highly effective. Alaskan Dungeness crab fisheries are also managed by size, sex, and season; however, several stocks have collapsed, most

[1] Throughout this report "collapse" is defined as a stock having declined by 90%. 10% of the stock remains.

likely as a result of spatial expansion and overfishing. Due to their inability to maintain stock productivity, Alaskan management is considered to be moderately effective.

The low inherent vulnerability of Dungeness crabs to fishing pressure, low amounts of bycatch, and the fisheries' highly effective management regime result in a recommendation of **Best Choice** for the California, Oregon, and Washington Dungeness crab fisheries. The moderate stock status, fishery's moderate impacts to habitats and the ecosystem, and fishery's moderately effective management regime result in a recommendation of **Good Alternative** for the Alaskan Dungeness crab fishery. The British Columbia Dungeness crab fishery was evaluated by SeaChoice and is also listed as a **Best Choice**[2].

The Oregon Dungeness crab fishery is certified by the Marine Stewardship Council (MSC). For more information visit the MSC website at: http://www.msc.org.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√		
Nature of Bycatch	√			
Habitat & Ecosystem Effects		√		
Management Effectiveness	√ **California, Oregon, and Washington**	√ **Alaska**		

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.

[2] Visit http://www.seachoice.org/profile/15/view for the SeaChoice report on British Columbia Dungeness crab.

Overall Seafood Recommendation:

California, Oregon, & Washington Dungeness crab:

Best Choice  Good Alternative  Avoid 

Alaska Dungeness crab:

Best Choice  **Good Alternative**  Avoid 

II. Introduction

Dungeness crab (*Cancer magister*) is a member of the family Cancridae and is named after the Dungeness spit along the Strait of Juan de Fuca in Washington State (ODCC 2007). It is characterized by a light reddish-brown, broad carapace with white-tipped pincers on its claws. The top claws and upper pincers are sawtoothed (CA DFG 1986). Dungeness crabs have been commercially fished since the late 1800s (ODCC 2007), and the current commercial Dungeness crab fishery ranges along the west coast of North America from Alaska to Point Conception, California (Pauley et al. 1989).

Dungeness crabs grow by shedding their hard outer shell in a process called molting. During this process, the crab sheds its old, hard shell revealing a new, soft shell. Mating occurs between hard-shelled males and freshly molted, soft-shelled females from spring through fall. The female carries the eggs under her abdomen for several months until they are hatched; large females can carry up to 2.5 million eggs. After hatching, the larvae are planktonic, and from 4 months to a year the larvae undergo five zoeal and one megalops stage before molting into the first juvenile stage. The juveniles then settle on the bottom of shallow intertidal areas and estuaries. Dungeness crabs molt about seven times during their second year, twice during their third year, and then approximately once per year thereafter. As they grow, they move into deeper waters. Adults prefer eelgrass beds and sandy or muddy bottom areas. Dungeness crabs mature at 2 to 3 years of age and live up to 8 to 13 years of age (PSWQAT 2006; ADF&G 2004; CA DF&G 2001; Pauley et al. 1989).

Dungeness crab populations undergo cyclic fluctuations due to varying oceanic conditions, including wind-driven currents, ocean temperature, and food availability (Higgins et al. 1997; WDFW 2006; Hankin and Warner 2001). As a result, landings within the Dungeness crab fishery have experienced periods of highs and lows. Oregon and California landings are currently at historically high levels, while Washington and Alaska landings are at moderate levels. The Dungeness crab stocks in Oregon, California, and Washington have never collapsed, but several stocks in Alaska have (ADF&G 2006a). Dungeness crab fisheries in Alaska have historically occurred throughout the Alaskan coast. The cumulative catch in Alaska from 1969 to 1994 came from Southeast Alaska/Yakutat (47%), Kodiak (35%), Prince William Sound (10%), and Cook Inlet (7%). Currently, however, only the Southeast Alaska and Kodiak fisheries remain open; the other Alaskan Dungeness crab fisheries closed due to stock collapses in the 1980s and 1990s.

Causes of Dungeness crab depletion in Alaska are uncertain, with the exception of the Orca Inlet stock, which is known to have collapsed as a result of the reintroduction of sea otters in 1979. Possible causes of the depletion of the other Alaskan stocks include overfishing and climatic change. Overfishing in the Alaskan Dungeness crab fisheries is likely to have resulted from two factors. First, fisheries may have developed based on exceptional year classes. For example, the Southeast Alaska Dungeness crab fishery changed dramatically in 1978 in response to strong recruitment. Second, overfishing could have resulted from expansion of the fishing area and serial depletion (Orensanz et al. 1998). Orensanz et al. (1998) believe this to be the most probable reason for depletion of Alaskan Dungeness crab stocks. Alaskan Dungeness crab management has paid little attention to spatial stock structure and in 1962 large vessels that were able to operate offshore entered the Kodiak Dungeness crab fishery, expanding the area fished.

The spatial expansion of the fishery deprived crabs of reproductive refugia, allowing for recruitment overfishing. Southeast Alaskan Dungeness crab landings were sustained throughout the 1980s only because the vessels moved to new areas after local depletion occurred (Orensanz et al. 1998).

The Dungeness crab fisheries are managed under the '3-S' principle: size, sex, and season. In Oregon, California, and Washington, only mature males of at least 6-1/4 inches in size are allowed to be harvested. In Alaska, the minimum size limit is 6-1/2 inches. The size limits provide adequate opportunity for sexually mature male crabs to mate with female crabs for one to two years before reaching legal fishery size (SCMRAC 2003; Joe Stratman, pers. comm.; Heather Reed, pers. comm.). Fishermen may not harvest female or soft-shelled crabs in any of the Dungeness crab fisheries and fishing seasons are scheduled to avoid the primary molt period (Balsiger 2006; Heather Reed, pers. comm.). The '3-S' management approach is effective because it protects the reproductive ability of the Dungeness crab population by allowing for healthy female populations and adequate opportunities for males to mate before being harvested.

The Oregon and California Dungeness crab fisheries (~70% of the U.S. supply) are currently undergoing certification assessments by the Marine Stewardship Council (MSC). The Washington and Alaskan Dungeness crab fisheries have not applied for MSC certification. The MSC is an independent non-profit organization, which has developed an environmental standard for sustainable and well-managed fisheries. It uses a product label to reward environmentally responsible fishery management and practices[3].

Scope of the analysis and the ensuing recommendation:
This report focuses on the United States Dungeness crab fisheries, which occur off the coasts of Oregon, California, Washington, and Alaska. This report does not include a recommendation on Dungeness crab from South Korea because it makes up only 0.003% of the U.S. supply. Dungeness crab from British Columbia (~3% of the U.S. supply) has been evaluated by SeaChoice and listed as a **Best Choice**.

Availability of Science

ODF&W, CA DFG, WDFW, and ADF&G do not conduct routine stock assessments; therefore, population abundance and occurrence of overfishing in the Dungeness crab fisheries are unknown. In addition, these agencies do not collect CPUE or bycatch data.

Market Availability

Common and market names:
Dungeness crab is also known as Pacific edible crab, edible crab, market crab, and commercial crab (Hankin et al. 2001; Pauley et al. 1989; and PSMFC 1996).

[3] http://www.msc.org/

Seasonal availability:
Dungeness crab is available fresh during the fishing season, which varies by location. The central California season is open from November 15 through June 30, and the northern California season is open from December 1 through July 15 (MSC 2005). The Oregon season is open from December 1 to August 15 (ODCC 2007); however, the opening of the season can be delayed in an area until soft-shell preseason testing indicates the appropriate meat recovery rate has been achieved (Michelle Grooms, pers. comm.). In 2005, approximately 75% of the harvest was landed in the first 60 days of the season, and 85% was landed within the first 90 days of the season (data provided by Michelle Grooms). The Washington coastal commercial Dungeness crab fishery is open from December 1 through September 15 (WDFW 2006); the Washington Puget Sound Dungeness crab fishery is open from October 1 through April 15 (WAC 220-52-046); and the Alaskan Kodiak season is open from May through December (ADF&G 2006b). The Southeast Alaskan fishing seasons vary by area, but are generally open from June 15 through August 15 and October 1 through November 30 (ADF&G 2004).

Product forms:
Dungeness crab is available fresh or frozen as whole fully-cooked crabs and cooked and cleaned frozen sections ("clusters"), picked meat, and whole legs ("frylegs") (ODCC 2007). Dungeness crabs are also sold live (ADF&G 2006a).

Import and export sources and statistics:
Approximately 97% of the Dungeness crab in the U.S. market in 2004 was harvested in the United States. Canada provided approximately 3% and South Korea provided a mere 0.003% of the Dungeness crab sold in the United States in 2004 (NMFS 2004a) (Figure 1).

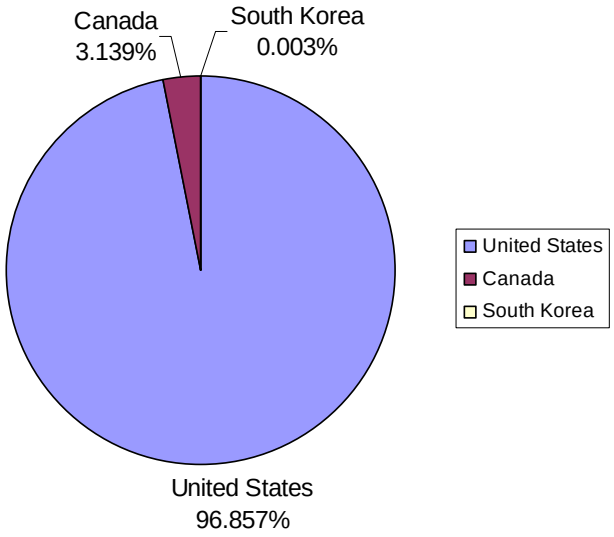


Figure 1. Sources of Dungeness crab sold in the United States, 2004 (Data from NMFS 2004a).

Within the United States, the Dungeness crab fisheries occur off the coasts of Oregon, California, Washington, and Alaska. In 2004, Oregon provided 38% of the Dungeness crab sold

in the U.S., California provided 34%, Washington provided 21%, and Alaska provided 7% (Figure 2).

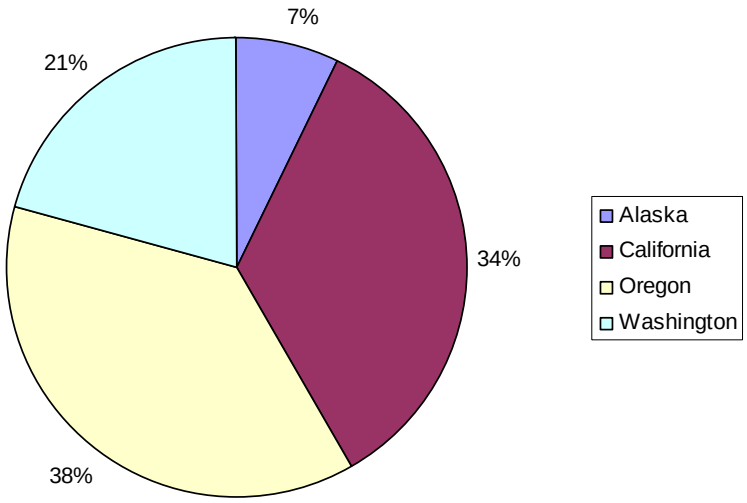


Figure 2. United States producers of Dungeness crab (Data from NMFS 2004b).

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

Criterion 1: Inherent Vulnerability to Fishing Pressure

Dungeness crabs are distributed along the Pacific coast of the United States from the Aleutian Islands to Point Conception. They occur at depths from the intertidal to 230m (Snohomish County Marine Resources Advisory Committee 2003). The intrinsic rate of increase and growth rate for these crabs are unknown. Dungeness crabs reach sexual maturity at approximately 2 to 3 years of age and live up to 8 to 13 years of age (ADF&G 2004; Hankin et al. 2001). Male crabs reach a maximum size of 218mm carapace width (CW) and females reach a maximum size of 160mm CW. Female Dungeness crabs are highly fecund, producing 0.5 million to 2 million eggs per brood and three or four broods during their lifetime (Hankin et al. 2001; Pauley et al. 1989; ADF&G 2004). Dungeness crabs do not exhibit any special behaviors that increase ease of their capture.

Table 1. Life history characteristics of Dungeness crab.

Intrinsic Rate of Increase (r)	Age at Maturity	Growth Rate	Max Age	Max Size	Fecundity	Species Range	Special Behaviors	Sources
Unknown	2-3 years	Unknown	8-13 years	Males: 218 mm CW Females: 160mm CW	0.5-2 million eggs per brood	Aleutian Islands to Point Conception	None	Hankin et al. 2001; Pauley et al. 1989; ADF&G 2004

Synthesis

The Dungeness crab's low age at first maturity, low maximum age, and high fecundity make it inherently resilient to fishing pressure.

Inherent Vulnerability Rank:

Resilient Moderately Vulnerable Highly Vulnerable

Criterion 2: Status of Wild Stocks

ODF&W, CA DFG, WDFW, and ADF&G do not conduct routine stock assessments for Dungeness crab stocks due to lack of methods or difficulties of surveying the numerous areas of Dungeness crab habitat (Heather Reed, pers. comm.; WDFW 2006; ADF&G 2002). As a result, current population abundance and occurrence of overfishing in Dungeness crab fisheries are unknown. It is believed that all of the stocks are fully fished, meaning they are currently at maximum sustainable yield (MSY) (Dewees et al. 2004; Hankin and Warner 2001; FAO 2004). The state management agencies examine annual landings to determine stock status.

U.S. Dungeness crab landings have fluctuated widely, almost cyclically in 10-year cycles, over the past 50 years (Figures 3, 4, 5, & 6) (Higgins et al. 1997; Dewees et al. 2004; Pauley et al. 1989). These fluctuations could be caused by a variety of environmental factors that affect population abundance. Natural variations in oceanic conditions, such as wind-driven currents, ocean temperature, and food availability often lead to changes in abundance of Dungeness crabs (Higgins et al. 1997; WDFW 2006; Hankin and Warner 2001), as some of these environmental factors can cause increased mortality of eggs and larvae, which result in reduced populations. High amounts of cannibalism and interspecific competition can also lead to a decline in crab abundance within 3 to 4 years and disease caused by bacteria, protozoa, or fungi may lead to mass mortalities of adult crabs. Finally, predation can greatly impact Dungeness crab abundance in some areas. For example, predation by hatchery-released coho salmon from the Columbia River has limited the Washington Dungeness crab population in the past (Pauley et al. 1989).

Currently, landings in Oregon and California are at historically high levels, while landings in Washington and Alaska are at moderate levels. Oregon and California Dungeness crab landings

have increased dramatically since 2001 (Figures 3 and 4); Washington Dungeness crab landings decreased by about 20,000 pounds from 2003 to 2004, but remain at a relatively high level (Figure 5); and Alaskan Dungeness crab landings decreased from 2002 to 2004, but remain at a moderate level (Figure 6).

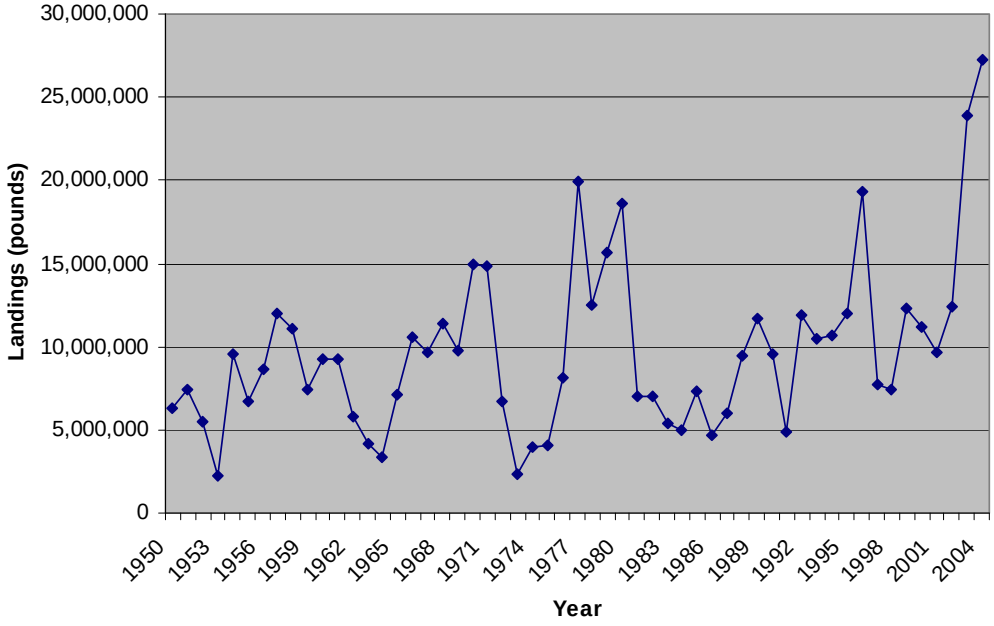


Figure 3. Oregon landings of Dungeness crabs from 1950-2004. Note the increase in landings since 2001 to the historically high level in 2004 (Data from NMFS 2004b).

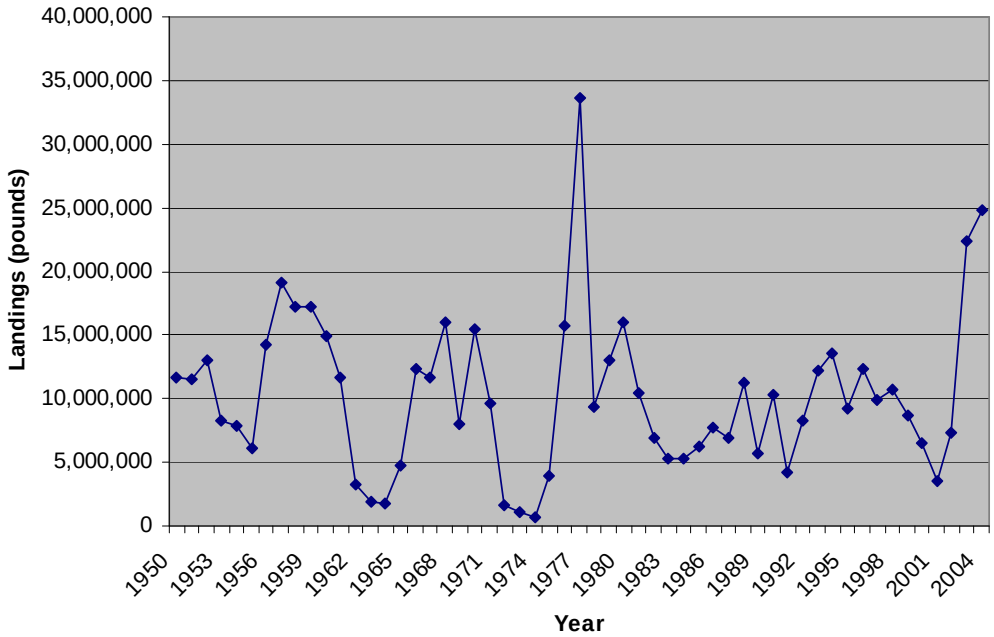


Figure 4. California landings of Dungeness crabs from 1950-2004. Note the increase in landings since 2001 to one of the historically highest levels in 2004 (Data from NMFS 2004b).

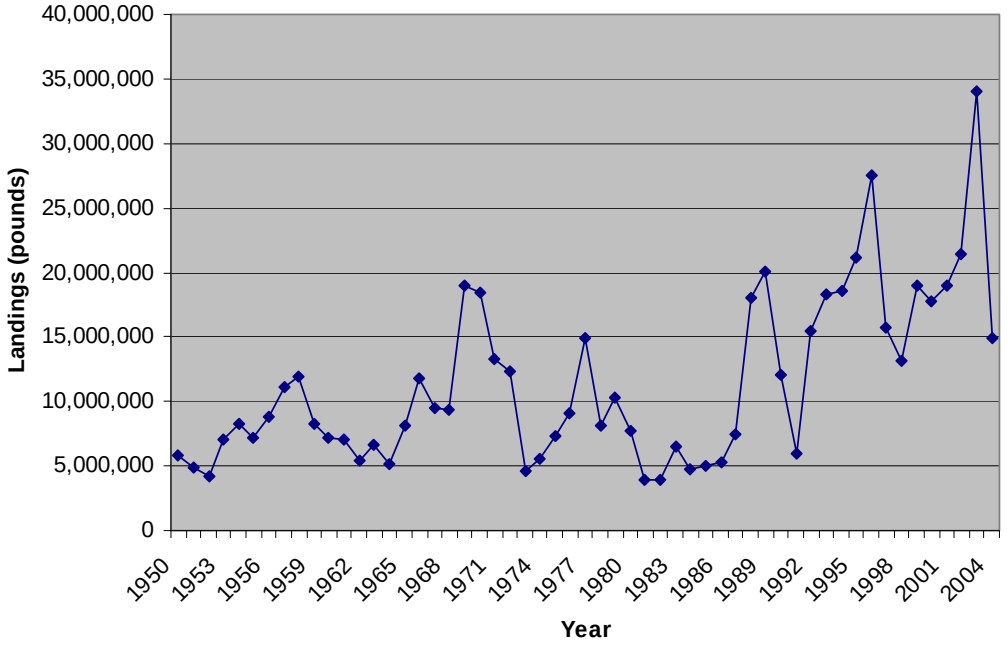


Figure 5. Washington landings of Dungeness crabs from 1950-2004. Note that landings decreased in 2004, but remain at a moderate level (Data from NMFS 2004b).

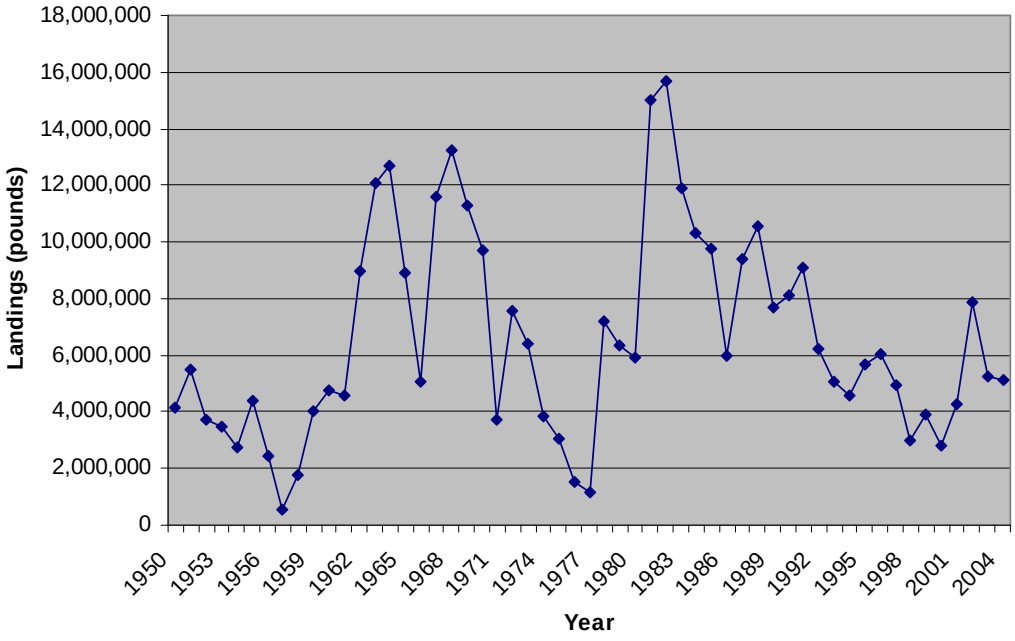


Figure 6. Alaska landings of Dungeness crabs from 1950-2004. Note the moderate level of landings in 2003 and 2004 (Data from NMFS 2004b).

Although an increase in Dungeness crab landings suggests healthy stock abundance, it is possible that an increase in landings is a result of increasing fishing effort, as is seen in other fisheries. To definitively determine if an increase in landings is a result of an increase in abundance or an

increase in effort it is necessary to examine catch per unit of effort (CPUE) data. ODF&W, CA DFG, WDFW, and ADF&G, however, do not collect CPUE data. They collect catch information per ticket, but one ticket does not equal one landing. When a boat makes a landing, the crab can be sold to multiple dealers, and each dealer writes a ticket. There is no limit on the number of dealers to which a fisherman can sell crabs; therefore, one landing could have one ticket or multiple tickets (Michelle Grooms, pers. comm.). Without adequate CPUE data, Seafood Watch® cannot conclude that stocks are healthy based solely on high landings data.

A complete evaluation of the British Columbia Dungeness crab fishery has been performed by SeaChoice; however, it is important to briefly address the catch and population status of the fishery in this Seafood Watch© report in order to fully understand the population dynamics of Dungeness crab. In British Columbia, Dungeness crabs have been commercially fished since the late 1800s. Like in the U.S., the Dungeness crab populations in British Columbia are fully-exploited but are not considered overfished. Commercial landings were relatively stable until 1990 when landings rose dramatically due to increased value of the crabs and less opportunity in other fisheries (Figure 7) (SeaChoice 2006). Unlike in the U.S., landings in British Columbia have not had cyclic patterns.

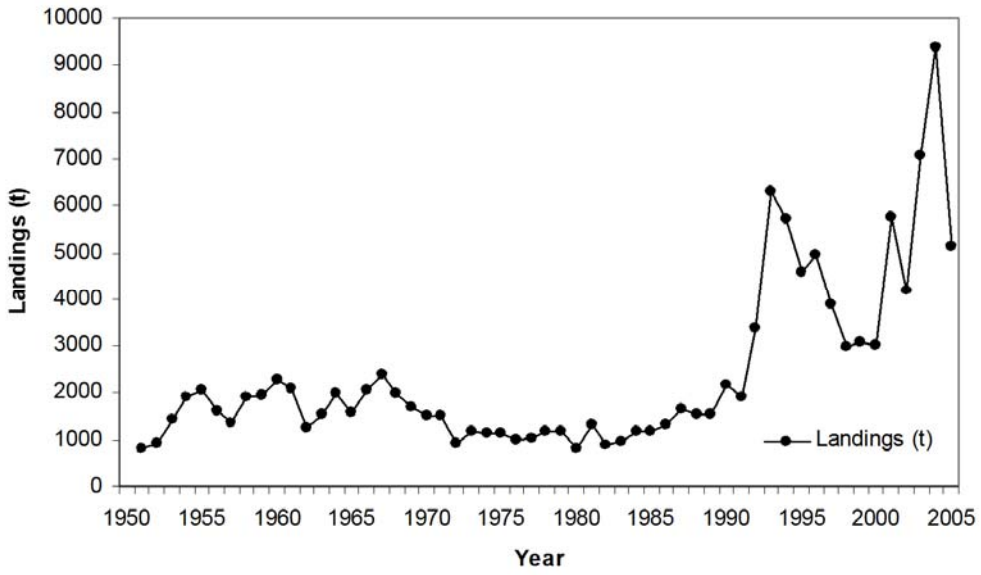


Figure 7. Coastwide landings (tons) of Dungeness crab from British Columbia (figure from SeaChoice 2006).

Table 2. Stock status of Dungeness crab.

Stock	B/B_{MSY}	Occurrence of Overfishing	F/F_{MSY}	Abundance Trends/CPUE	Age/Size/Sex Distribution	Degree of Uncertainty in Stock Status	Sources	SFW Rank
Oregon	Unknown	Unknown	Unknown	Landings are variable and cyclical	Unknown	Moderate	Michelle Grooms, pers. comm.; NMFS 2004b	Moderate
California	Unknown	Unknown	Unknown	Landings are variable and cyclical	Unknown	Moderate	Ed Roberts, pers. comm.; NMFS 2004b; Hankin and Warner 2001	Moderate
Washington	Unknown	Unknown	Unknown	Landings are variable and cyclical	Unknown	Moderate	Heather Reed, pers. comm.; NMFS 2004b; WDFW 2006	Moderate
Alaska	Unknown	Unknown	Unknown	Landings are variable and cyclical	Unknown	Moderate	Joe Stratman, pers. comm.; NMFS 2004 b	Moderate

Synthesis

ODF&W, CA DFG, WDFW, and ADF&G do not conduct routine stock assessments. As a result, population abundance and occurrence of overfishing for the U.S. Dungeness crab fisheries are unknown. In addition, CPUE is unknown. The state management agencies examine annual landings to determine stock status. Landings could increase either as a result of an increase in population abundance or an increase in fishing effort; therefore, without CPUE data, Seafood Watch® cannot conclude that stocks are healthy based on high landings alone. Given these unknown parameters, Seafood Watch® considers the status of Dungeness crab stocks to be a moderate conservation concern.

Status of Wild Stocks Rank:

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 managed in some way.

Bycatch data in the U.S. Dungeness crab fisheries are not collected, but bycatch is reportedly very low (Michelle Grooms, pers. comm.; Heather Reed, pers. comm.; Ed Roberts, pers. comm.; and Joe Stratman, pers. comm.). The high selectivity of the Dungeness crab fisheries results in sublegal males making up the majority of bycatch (Joe Stratman, pers. comm.). Egg-bearing females aggregate and bury themselves in the sand in order for their eggs to successfully adhere to their abdomens. As a result, most females do not enter pots (Wild 1980 as cited in Snohomish county Marine Resources Advisory Committee 2003). Any females or sublegal males that do enter the pots can easily exit through one of two escape mechanisms required on each pot. In addition, any crabs not of legal size brought on deck must be released unharmed within 15 minutes of capture (Michelle Grooms, pers. comm.). The shallow depths fished and the size of the crab pots limit the ability of larger invertebrates and finfish to enter the pots (Joe Stratman, pers. comm.). Occasionally lingcod, sculpins, flat fish, or rockfish are caught in the pots, but they either exit through the pots' escape mechanisms or are discarded alive at sea (Heather Reed, pers. comm.; Michelle Grooms, pers. comm.). A low, but unquantified number of octopuses are also caught, but they are sold and are thus not considered bycatch (Michelle Grooms, pers. comm.).

Bycatch in the Dungeness crab fisheries differs from bycatch in finfish fisheries in that the discard mortality rate of crabs is substantially lower than that of finfish. The majority of finfish bycatch die before being discarded at sea, whereas hard-shelled Dungeness crab bycatch has only a 2-4% mortality rate and soft-shelled Dungeness crab bycatch a 22-25% mortality rate (Alverson et al. 1996). The impacts of bycatch not only depend on the amount taken, but also the mortality rates of discarded species; therefore, Seafood Watch® applies this mortality rate to overall bycatch rates when determining the level and conservation concern of bycatch generally.

In the absence of bycatch data for the Dungeness crab fishery, Seafood Watch® made a rough estimation using data from similar fisheries. Bycatch in the Dungeness crab fishery was assumed to be similar to that in the Bering Sea snow crab fishery[4] (19%) and the mortality rates of Dungeness crabs were applied to this bycatch level to estimate the amount of Dungeness crab bycatch that dies relative to landings. The mortality rate of hard-shelled Dungeness crabs (2-4%) is approximately one-sixth the mortality rate of snow crabs (24%), while the mortality rate of soft-shelled Dungeness crab (22-25%) is approximately the same as that of snow crabs (24%). Therefore, the percentage of hard-shelled Dungeness crab bycatch that dies relative to landings is one-sixth the percentage of snow crab bycatch that dies relative to landings (0.073%), and the

[4] See the Seafood Watch® Snow and Tanner Crab Report written by Stephanie Danner. This report is available at: http://www.mbayaq.org/cr/SeafoodWatch/web/sfw_factsheet.aspx?gid=8. As a precautionary note, Dungeness crabs have more oval-shaped bodies, smaller legs, and shorter leg-to-body size ratio than snow crabs, which may cause differences in escape, injury, and mortality rates.

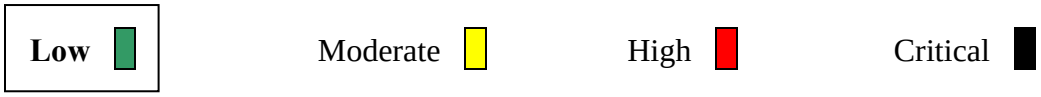
percentage of soft-shelled Dungeness crab bycatch that dies relative to landings is the same as the percentage of snow crab bycatch that dies relative to landings (4.4%). Seafood Watch® also assumed the impacts of bycatch on Dungeness crab populations to be similar to or less than the impacts of bycatch on snow crab populations due to the lower percentage of bycatch that dies relative to landings. Therefore, these calculations allow Seafood Watch® to conclude that Dungeness crab bycatch has little impact on population levels. Note that these bycatch and population impact percentages are probably high estimates because a low, but unquantified, number of females (egg-bearing females) are caught in the Dungeness crab fishery, whereas many females are caught in the snow crab fishery.

As with other crab fisheries, ghostfishing also occurs in the Dungeness crab fishery. Ghostfishing refers to pots that are lost by the fishery, which continue to unintentionally catch organisms until their netting or escape panels disintegrate (Stevens et al. 2000). Poon (2005) conducted a study using Monte Carlo simulations to estimate the effect of ghost fishing by lost pots and traps on crabs and lobsters. Based on forty-four case studies since 1970 on the amount of lost traps and their mortality rates, and the assumption that 96.9% of lost pots ghost fish, Poon (2005) estimated ghost fishing to be 3.8% of reported landings. While this number is not inconsequential, Seafood Watch® concludes that ghostfishing is not likely having a large impact on Dungeness crab population levels.

Synthesis

Bycatch data in the U.S. Dungeness crab fisheries are not collected, but bycatch is reportedly very low (Michelle Grooms, pers. comm.; Heather Reed, pers. comm.; Ed Roberts, pers. comm.; and Joe Stratman, pers. comm.). Due to the high selectivity of the fishery, sublegal males compose the majority of bycatch. Egg-bearing females aggregate and bury themselves in the sand in order for their eggs to successfully adhere to their abdomens, and as a result, most females do not enter pots. The shallow depths fished and the size of the crab pots limit the ability of larger invertebrates and finfish to enter the pots. Any female Dungeness crabs, sublegal male Dungeness crabs, other invertebrates, or finfish that enter the pots exit easily through the pots' escape mechanisms or are discarded alive at sea. Additionally, the mortality rate of Dungeness crabs is low (2-4% for hard-shell and 22-25% for soft-shell). Assuming a similar bycatch rate as the snow crab fishery, and then applying the Dungeness crab mortality rates, the percentage of Dungeness crab bycatch that dies relative to landings is less than 5%. This low amount of bycatch would have little impact on Dungeness crab population levels. Moreover, these bycatch and population impact percentages are probably high estimates because a low, but unquantified number of females (egg-bearing females) are caught in the Dungeness crab fishery, whereas many females are caught in the snow crab fishery. Given this information, bycatch in the Dungeness crab fisheries is considered to be a low conservation concern.

Nature of Bycatch Rank:



Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Habitat Effects

Dungeness crabs are caught with diving gear, crab rings/hoop nets, or crab pots. Crab rings/hoop nets are composed of coarse mesh webbing attached to two iron hoops. Crabs are attracted to the center of the net by bait (herring, squid, or clams). When the net is hauled to the surface, it quickly collapses, capturing any crabs in the net (Figure 8) (Phillips et al. 1986). Dungeness crab pots are circular, steel-framed pots approximately 36 to 48 inches in diameter and 14 inches in height, covered with 2-inch squares of woven stainless steel wire (Figure 9). A pot weighs 60 to 125 pounds and is attached to a line and a buoy that marks its location for retrieval. State management agencies require that each pot has two escape rings to allow undersized crabs to escape (WAC 220-52-043; OAR 635-005-0055; FGC 9011; 5 AAC 32.050). The pots generally soak for one to four days depending on weather conditions (ADF&G 2004; ODCC 2007).

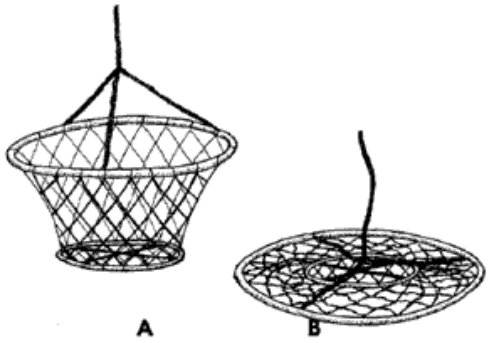


Figure 8. Crab ring or hoop net. (A) The net as it is when on the bottom of the ocean. (B) The net collapsed as it is while being hauled to the surface (Figure from Phillips et al. 1986).

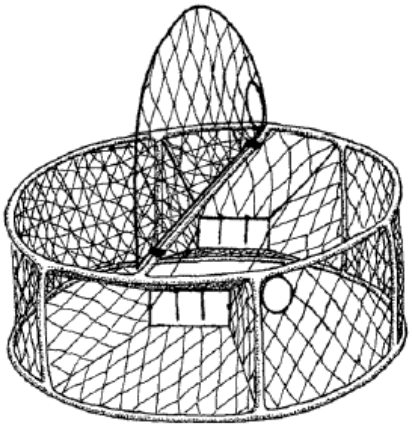


Figure 9. A crab pot with escape rings (Figure from Phillips et al. 1986).

Pots are less damaging than trawls or dredges because pots are not highly mobile, so although they are bottom gear, they have contact with a substantially smaller area of the seafloor than do these other gears. Pots can affect habitat, however, because they do not always remain entirely stable on the seafloor. They bounce off the seafloor in the presence of large swells, and get dragged across the bottom when being removed, especially during a storm or when pots are stuck in the sand (Morgan and Chuenpagdee 2003).

Morgan and Chuenpagdee (2003) conducted a study, using existing information and expert knowledge on bycatch and habitat damage, to gauge the relative severity of impacts associated with all commercial fishing gears, and to compare and rank the overall ecological impact of each gear type. They found that pots generally have a medium impact on physical structure and a low impact on biological habitat (seafloor organisms), receiving an overall ranking of medium impact (Figure 10).

Figure 5 Experts' Impact Rating, Survey Severity Ranking, and Policy Implications

GEAR CLASS	HABITAT IMPACTS: Physical	HABITAT IMPACTS: Biological	BYCATCH: Shellfish & crabs	BYCATCH: Finfish	BYCATCH: Sharks	BYCATCH: Marine mammals	BYCATCH: Sea birds & turtles	MANAGEMENT CATEGORY (Policy responses)
Trawls – bottom	5	5	3	5	2	2	2	HIGH IMPACT (Very Stringent)
Gillnets – bottom	3	2	1	4	3	4	3	
Dredges	5	5	4	2	1	1	1	
Gillnets – midwater	1	1	1	4	4	5	5	
Pots and traps	3	2	4	2	1	3	1	MEDIUM IMPACT (Moderately Stringent)
Longlines – pelagic	1	1	1	3	4	3	5	
Longlines – bottom	2	2	1	4	3	1	2	
Trawls – midwater	1	1	1	3	2	2	2	LOW IMPACT (Least Stringent)
Purse seines	1	1	1	2	2	3	2	
Hook and line	1	1	1	2	3	1	2	

KEY: 5 VERY HIGH IMPACT 4 HIGH IMPACT 3 MEDIUM IMPACT 2 LOW IMPACT 1 VERY LOW IMPACT

Figure 10. Experts' Impact Rating, Survey Severity Ranking, and Policy Implications (Figure from Morgan and Chuenpagdee 2003).

The extent of bottom impacts from pots depends on the type of bottom habitat where the setting and retrieval of the pots occurs (NMFS 2004c). The preferred habitat of Dungeness crabs are sandy bottoms and eel grass beds, but they can also be found on muddy bottoms (Snohomish County Marine Resources Advisory Committee 2003). Soft sediments are less likely to be impacted than hard structures that rise above the seafloor (Quandt 1999). Eno et al. (2001) studied the effects of pots set over a wide range of sediment types and observed that mud communities fully recovered from pot impact within 72 to 144 hours of pot removal. Hauling the pots along the bottom during pot removal left a track in the sediments, but biological abundance within the area was not affected. This conclusion is based on the physical manifestation of crab pot disturbance, but not on a solid understanding of changes in infaunal organisms. It is important to note that although abundance may not be significantly impacted, crabs near or on the outside of pots could become injured (e.g., leg loss).

The impact of fishing gear on habitat also depends on the spatial scale of the fishery because although each pot may have a small impact, the cumulative effect of thousands of pots can be larger (Morgan and Chuenpagdee 2003). The Dungeness crab fisheries cover a limited geographic area, occurring in the Pacific Ocean from Alaska to California; however, hundreds of thousands of pots are utilized, which can lead to a more substantial impact. Approximately 200,000 pots were fished during the 2005/2006 Oregon fishery, approximately 800,000 pots were fished at the beginning of the 2004/2005 Washington fishery, and according to an informal survey with fishermen, approximately 142,000 pots were fished during the 2006/2007 California fishery (Phillips et al. 1986; Heather Reed, pers. comm.; Ed Roberts, pers. comm.). The cumulative impacts of these pots may be considerable.

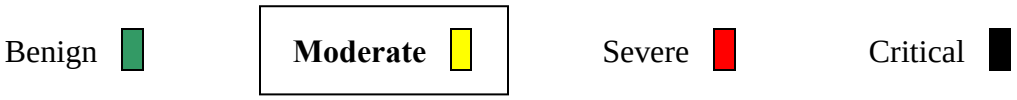
Ecosystem Effects

The '3-S' management approach is generally believed to provide adequate opportunity for sexually mature male Dungeness crabs to mate for one to two years before reaching legal fishery size (SCMRAC 2003; Joe Stratman, pers. comm.; Heather Reed, pers. comm.). A study conducted in the British Columbia Dungeness crab fishery, which also has a minimum size limit, suggested that heavy exploitation of large males in the fishery can greatly reduce the amount of mating opportunities for females, however, resulting in low or no egg production (Smith and Jamieson 1991). Further research would be needed to determine if the '3-S' management method used in the U.S. Dungeness crab fisheries is causing reproductive effects similar to those observed in the British Columbia fishery.

Synthesis

Crab pots are known to have a moderate impact on habitats and ecosystems. The U.S. Dungeness crab fisheries occur primarily in shallow sandy bottom areas, which are more resilient to fishing gear than coral or rocky bottoms. Crab pots are more stationary than other types of fishing gear, such as bottom trawling or dredging; however, they can bounce off the seafloor or get dragged across the bottom during pot removal. The fishery is of moderate spatial scale, occurring in the Pacific Ocean from Alaska to Southern California; however, hundreds of thousands of pots are utilized each season, which can lead to a more substantial habitat impact. The Dungeness crab fisheries intensively target only male Dungeness crabs, and a 1991 study conducted in the British Columbia fishery suggested that this can greatly reduce the amount of mating opportunities for female Dungeness crabs, which could result in low or no egg production. Further research is needed to determine if the '3-S' management method used in the U.S. Dungeness crab fisheries is causing reproductive effects similar to those observed in the British Columbia fishery. Given this information, the U.S. Dungeness crab fisheries are considered to have moderate effects on habitats and ecosystems.

Effect of Fishing Practices Rank:



Criterion 5: Effectiveness of the Management Regime

Unlike other fisheries occurring outside of state waters, the Alaska, California, Oregon, and Washington Dungeness crab fisheries are managed by the states. Congress passed the Dungeness Crab Fisheries Conservation Act of 1996 extending state management authority of the Dungeness crab fisheries to outside of state waters (3 to 200 miles offshore) (Balsiger 2006). The states have jurisdiction over the fisheries as long as the Pacific Fishery Management Council (PFMC) has not adopted a fishery management plan (FMP) for Dungeness crab (WDFW 2006; ODF&W 2004). The Dungeness crab fisheries are managed by the state legislatures and administrative branches. ODF&W, CA DFG, WDFW, and ADF&G collect and analyze fishery data and make recommendations for regulations (Didier 2002; Ed Roberts, pers. comm.). Coordination of issues among the Oregon, Washington, and California Dungeness crab fisheries is handled by the Pacific States Marine Fisheries Commission (PSMFC) under a tri-state committee process (ODF&W 2004). The committee signed an interstate Memorandum of Understanding stating that all 3 state management agencies will develop consistent and complementary management actions for Dungeness crab.

The Dungeness crab fisheries are not managed using typical fisheries management methods such as stock assessments, biomass estimates, and total allowable catches (TACs). Instead, the states manage their Dungeness crab fisheries under the '3-S' principles: size, sex, and season. In Oregon, California, and Washington, only mature males of at least 6-1/4 inches in size are allowed to be harvested. In Alaska, the minimum size limit is 6-1/2 inches. The size limits provide adequate opportunity for sexually mature male crabs to mate with female crabs for one to two years before reaching legal fishery size (SCMRAC 2003; Joe Stratman, pers. comm.; Heather Reed, pers. comm.). Fishermen may not harvest female or soft-shelled crabs in any of the Dungeness crab fisheries, and fishing seasons are scheduled to avoid the primary molt period (Balsiger 2006; Heather Reed, pers. comm.). The opening of a season can be delayed in an area until soft-shell preseason testing indicates the appropriate meat recovery rate has been achieved. This regulation is designed to ensure harvest begins after the major molting and hardening of the newly-molted crabs (OAR 635-005-0045; Michelle Grooms, pers. comm.). The '3-S' management approach is effective because it protects the reproductive ability of the Dungeness crab population by allowing for healthy female populations and adequate opportunities for males to mate before being harvested.

Dungeness crab populations undergo cyclic fluctuations due to varying oceanic conditions, including wind-driven currents, ocean temperature, and food availability (Higgins et al. 1997; WDFW 2006; Hankin and Warner 2001). As a result, landings within the U.S. Dungeness crab fisheries have experienced periods of highs and lows. Oregon and California landings are currently at historically high levels, while Washington and Alaska landings are at moderate levels. The respective management agencies have maintained stock productivity in the California, Oregon, and Washington Dungeness crab fisheries; however, ADF&G has not maintained stock productivity in the Alaska fishery, as several stocks in Alaska have collapsed (ADF&G 2006a). Dungeness crab fisheries in Alaska have historically occurred throughout the Alaskan coast. The cumulative catch in Alaska from 1969 to 1994 came from Southeast Alaska/Yakutat (47%), Kodiak (35%), Prince William Sound (10%), and Cook Inlet (7%). Currently, however, only the Southeast Alaska and Kodiak fisheries remain open; the other

Alaskan Dungeness crab fisheries closed during the 1980s and 1990s due to stock collapses. The depletion of the Orca Inlet stock was a result of the reintroduction of sea otters in 1979, while depletion of the other stocks is uncertain, but most likely due to climatic changes and overfishing (Orensanz et al. 1998).

Total landings in the Dungeness crab fisheries are not restricted by quotas, but all four states have successfully enacted license limitation programs that restrict the number of vessels participating in the fishery. The current moratorium on new licenses will eventually lead to a reduction of capacity in the fisheries (Didier 2002). In addition, Washington, Oregon, and Alaska limit the number of pots per vessel in their Dungeness crab fisheries. Washington assigns a crab pot limit of 300 to each vessel that has total landings of 0 to 35,999 pounds and 500 to each vessel that has total landings of 36,000 pounds or more. In addition, Grays Harbor in Washington has a pot limit of 200 per vessel (WAC 220-52-040). Oregon has implemented a three-tiered pot limitation program, effective at the beginning of the 2006/2007 fishing season. Each vessel will be limited to 200, 300, or 500 pots depending on the vessel's landings during the six seasons between 1995 and 2001. The goal of this system is to reduce the total number of pots in the fishery from approximately 200,000 pots to approximately 150,200 pots (Phillips et al. 1986). In 1997, a tiered pot limit system was adopted in the Southeast Alaska Dungeness crab fishery. Pot permits are issued in one of 4 tier classes: 75 pots, 150 pots, 225 pots, and 300 pots. The pot permit holder is allowed to use up to the number of pots allowed under the tier class on the permit (Alaska Commercial Fisheries Entry Commission 1995). California is working to create a pot limitation program, but it has not yet been implemented.

Table 3. Commercial harvest management measures for the Dungeness crab fishery. States are in order of their contribution to the overall Dungeness crab fishery (largest to smallest percent contribution).

Management Jurisdictions & Agencies	Total Allowable Landings	Size Limit	Gear Restrictions	Trip Limit	Area Closures	Sources
Oregon Department of Fish & Wildlife	None	Only allowed to take or possess males greater than 6-1/4 inches	Only crab rings or crab pots allowed; pots must be no greater than 13 cu. ft., and must have at least 2 escape ports and a release mechanism; limits on number of pots	None	Established fishing seasons; unlawful to fish in any area where season opening has been delayed due to preseason sampling	Oregon Admin. Rules 635-005-0055, 635-005-0045, 635-005-0060
California Department of Fish & Game	None	Only allowed to take, possess, buy, or sell males greater than 6-1/4 inches	Only Dungeness crab traps allowed; traps must have at least 2 escape ports and at least 1 destruction device	None	Established fishing seasons; Dungeness crab may not be taken within the portions of Crescent City Harbor between the south sand barrier and the Breakwater, the Eel river and its tributaries, Humboldt Bay, Trinidad Bay, and Bodega Lagoon	Fish and Game Codes 8278, 8284, 8276, 8279
Washington Department of Fish & Wildlife	None	Only allowed to take or fish for males greater than 6-1/4 inches	Commercial gear limited to ring nets and pots; pots must be no greater than 13 cu. ft., and have at least 2 escape ports and an escapement mechanism; limits on number of pots	None	Established fishing season; Unlawful to fish in any area where season opening has been delayed; WDF&W may establish a soft-shell crab demarcation line	Washington Admin. Codes 220-52-040, 220-52-043, 220-52-035, 220-52-046
Alaska Department of Fish & Game	None	Only allowed to take or possess males greater than 6-1/2 inches	May only fish with ring nets, diving gear, and Dungeness crab pots; pots must have 2 escape rings and tunnel eye openings; limits on number of pots	None	Established fishing seasons; some closed waters in Registration Area A; District 16, the Yakutat, and Glacier Bay are closed	Alaska Admin. Codes 5 AAC 32.055, 32.050, 32.150

Synthesis

The U.S. Dungeness crab fisheries are not managed using typical fisheries management methods, such as stock assessments, biomass estimates, and TACs. These are highly selective fisheries, however, with a male-only harvest, strict minimum size limits that protect the reproductive ability of the population, and fishing seasons that protect sensitive molting periods. The high selectivity of the fishery and the required pot escape mechanisms also result in minimal amounts of bycatch. In California, Oregon, and Washington, this strategy, commonly referred to as "3-S management", has effectively maintained stock productivity over the past 50 years. Management in these fisheries is thus considered to be highly effective. Alaskan Dungeness crab fisheries are also managed by size, sex, and season; however, several Alaskan stocks have collapsed and several Alaskan fisheries have thus been closed. These collapses are most likely a result of spatial expansion and overfishing. Due to their inability to maintain stock productivity, Alaskan management is considered to be moderately effective.

Effectiveness of Management Rank:

California, Oregon, and Washington Dungeness crab:

Highly Effective	Moderately Effective	Ineffective	Critical

Alaska Dungeness crab:

Highly Effective	**Moderately Effective**	Ineffective	Critical

IV. Overall Evaluation and Seafood Recommendation

Dungeness crabs (*Cancer magister*) exhibit life history characteristics that make them inherently resilient to fishing pressure, as they have low age at first maturity, a short lifespan, and high fecundity. Like other crabs, Dungeness crab populations undergo cyclic fluctuations due to varying oceanic conditions, including wind-driven currents, ocean temperature, and food availability (Higgins et al. 1997; WDFW 2006; Hankin and Warner 2001), and as a result, landings within Dungeness crab fisheries have periods of highs and lows. Currently, landings in Oregon and California are at historically high levels, while landings in Washington and Alaska are at moderate levels. The Dungeness crab stocks in Oregon, California, and Washington have never collapsed, but several stocks in Alaska have. Possible causes of these collapses include sea otter predation, climatic changes, and overfishing (ADF&G 2006a; Orensanz et al. 1998).

Population abundance and occurrence of overfishing for the U.S. Dungeness crab fisheries are unknown. In addition, CPUE is unknown. Instead of conducting stock assessments, the state management agencies examine annual landings to determine stock status. Landings could increase, however, as a result of either an increase in population abundance or an increase in fishing effort. Therefore, without CPUE data, Seafood Watch® cannot conclude that stocks are healthy based on high landings alone. Given these unknown parameters, Seafood Watch® considers the status of Dungeness crab stocks to be a moderate conservation concern.

Dungeness crabs are captured with pots, which are known to have moderate impacts on habitats and ecosystems. The pots are primarily set in shallow sandy or mud bottom areas, which are moderately resilient to fishing activities. Bycatch data in the Dungeness crab fisheries are not collected, but bycatch is reportedly very low (Michelle Grooms, pers. comm.; Heather Reed, pers. comm.; Ed Roberts, pers. comm.; and Joe Stratman, pers. comm.). Any female Dungeness crabs, sublegal male Dungeness crabs, other invertebrates, or finfish that enter the pots either exit easily through the pots' escape mechanisms or are discarded alive at sea. The mortality rate of Dungeness crabs is low (2-4% for hard-shell and 22-25% for soft-shell). Assuming a similar bycatch rate as the snow crab fishery, and then applying the Dungeness crab mortality rates, the percentage of Dungeness crab bycatch that dies relative to landings is less than 5%. Seafood Watch® also concludes that this low amount of bycatch has little impact on Dungeness crab population levels. These bycatch and population impact percentages are likely maximum estimates because few females (egg-bearing) are caught in the Dungeness crab fishery, whereas

many females are caught in the snow crab fishery. Given this information, bycatch in the Dungeness crab fisheries is considered to be a low conservation concern.

The Dungeness crab fisheries are managed using a male-only harvest, strict minimum size limits that protect the reproductive ability of the population, and fishing seasons that protect sensitive molting periods. In California, Oregon, and Washington, this strategy, commonly referred to as "3-S management", has effectively maintained stock productivity over the past 50 years. Management in these fisheries is thus considered to be highly effective. Alaskan Dungeness crab fisheries are also managed by size, sex, and season; however, several stocks have collapsed. These collapses are most likely a result of spatial expansion and overfishing. Due to their inability to maintain stock productivity, Alaskan management is considered to be moderately effective.

The low inherent vulnerability of Dungeness crabs to fishing pressure, low amounts of bycatch, and highly effective management regime result in the California, Oregon, and Washington Dungeness crab fisheries receiving a recommendation of **Best Choice**. The moderate stock status, moderate impacts to habitats and ecosystems, and moderately effective management regime result in the Alaskan Dungeness crab fishery receiving a recommendation of **Good Alternative**. The British Columbia Dungeness crab fishery was evaluated by SeaChoice and is also listed as a **Best Choice**.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√		
Nature of Bycatch	√			
Habitat & Ecosystem Effects		√		
Management Effectiveness	√ **California, Oregon, and Washington**	√ **Alaska**		

Overall Seafood Recommendation:

California, Oregon, & Washington Dungeness crab:

Best Choice | Good Alternative | Avoid

Alaska Dungeness crab:

Best Choice | **Good Alternative** | Avoid

Acknowledgements

Seafood Watch© thanks Michelle Grooms of the Oregon Department of Fish and Wildlife and Heather Reed of the Washington Department of Fish and Wildlife who graciously reviewed this paper for scientific accuracy.

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.

Supplemental Information

Consumption advice on the Seafood Watch® pocket guides is provided by Environmental Defense. Environmental Defense applies the same risk-based methodology as the U.S. Environmental Protection Agency (EPA) to data from government studies and papers published in scientific journals. Environmental Defense has issued a consumption advisory for Dungeness crab for children under 6 years of age due to elevated mercury levels. Consumption of Dungeness crab for this age group should be limited to four meals per month. A meal size is considered to be 3 ounces (a little less than ¼ pound of fish before cooking). There is no consumption advisory for men or women of childbearing age. More detailed information about the Environmental Defense advisory can be found at http://www.oceansalive.org/eat.cfm?subnav=fishpage&fish=17.

The internal organs, including the "crab butter" (hepatopancreas) of Dungeness crabs may contain a natural toxin that, when ingested, can result in paralytic shellfish poisoning (PSP). The toxin cannot be destroyed by cooking or freezing (ADF&G 2004; Seafood Choices Alliance 2006).

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Appendix 1

Capture Fisheries Evaluation

Species: *Dungeness Crab*	**Region:** *West Coast*
Analyst: *Stephanie Danner*	**Date:** *December 3, 2007*

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished[5] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that capture fisheries must possess to be considered sustainable by the Seafood Watch program. Species from sustainable capture fisheries:

- have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics;
- have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity;
- are captured using techniques that minimize the catch of unwanted and/or unmarketable species;
- are captured in ways that maintain natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and do not result in irreversible ecosystem state changes; and
- have a management regime that implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Seafood Watch has developed a set of five sustainability **criteria,** corresponding to these guiding principles, to evaluate capture fisheries for the purpose of developing a seafood recommendation for consumers and businesses. These criteria are:

1. Inherent vulnerability to fishing pressure
2. Status of wild stocks
3. Nature and extent of discarded bycatch
4. Effect of fishing practices on habitats and ecosystems
5. Effectiveness of the management regime

Each criterion includes:

- Primary factors to evaluate and rank
- Secondary factors to evaluate and rank
- Evaluation guidelines[6] to synthesize these factors
- A resulting **rank** for that criterion

Once a rank has been assigned to each criterion, an **overall seafood recommendation** for the species in question is developed based on additional evaluation guidelines. The ranks for each criterion, and the

[5] "Fish" is used throughout this document to refer to finfish, shellfish and other wild-caught invertebrates.
[6] Evaluation Guidelines throughout this document reflect common combinations of primary and secondary factors that result in a given level of conservation concern. Not all possible combinations are shown – other combinations should be matched as closely as possible to the existing guidelines.

resulting overall seafood recommendation, are summarized in a table. Criterion ranks and the overall seafood recommendation are color-coded to correspond to the categories of the Seafood Watch pocket guide:

Best Choices/Green: Consumers are strongly encouraged to purchase seafood in this category. The wild-caught species is sustainable as defined by Seafood Watch.

Good Alternatives/Yellow: Consumers are encouraged to purchase seafood in this category, as they are better choices than seafood in the Avoid category. However there are some concerns with how this species is fished and thus it does not demonstrate all of the qualities of a sustainable fishery as defined by Seafood Watch.

Avoid/Red: Consumers are encouraged to avoid seafood in this category, at least for now. Species in this category do not demonstrate enough qualities to be defined as sustainable by Seafood Watch.

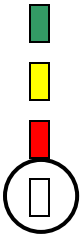
CRITERION 1: INHERENT VULNERABILITY TO FISHING PRESSURE

Guiding Principle: Sustainable wild-caught species have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics.

Primary Factors[7] to evaluate

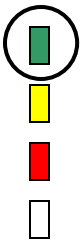
Intrinsic rate of increase ('r')

- High (> 0.16)
- Medium (0.05 - 0.16)
- Low (< 0.05)
- Unavailable/Unknown



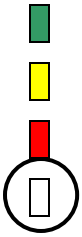
Age at 1st maturity

- Low (< 5 years)
- Medium (5 - 10 years)
- High (> 10 years)
- Unavailable/Unknown



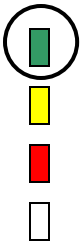
Von Bertalanffy growth coefficient ('k')

- High (> 0.16)
- Medium (0.05 - 0.15)
- Low (< 0.05)
- Unavailable/Unknown



Maximum age

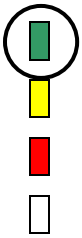
- Low (< 11 years)
- Medium (11 - 30 years)
- High (> 30 years)
- Unavailable/Unknown



[7] These primary factors and evaluation guidelines follow the recommendations of Musick et al. (2000). Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25:6-30.

Reproductive potential (fecundity)

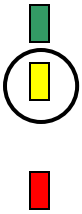
- High (> 100 inds./year)
- Moderate (10 – 100 inds./year)
- Low (< 10 inds./year)
- Unavailable/Unknown



Secondary Factors to evaluate

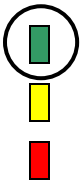
Species range

- Broad (e.g. species exists in multiple ocean basins, has multiple intermixing stocks or is highly migratory)
- Limited (e.g. species exists in one ocean basin)
- Narrow (e.g. endemism or numerous evolutionary significant units or restricted to one coastline)



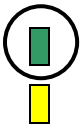
Special Behaviors or Requirements: Existence of special behaviors that increase ease or population consequences of capture (e.g. migratory bottlenecks, spawning aggregations, site fidelity, unusual attraction to gear, sequential hermaphrodites, segregation by sex, etc., OR specific and limited habitat requirements within the species' range).

- No known behaviors or requirements OR behaviors that decrease vulnerability (e.g. widely dispersed during spawning)
- Some (i.e. 1 - 2) behaviors or requirements
- Many (i.e. > 2) behaviors or requirements



Quality of Habitat: Degradation from non-fishery impacts

- Habitat is robust
- Habitat has been moderately altered by non-fishery impacts
- Habitat has been substantially compromised from non-fishery impacts and thus has reduced capacity to support this species (e.g. from dams, pollution, or coastal development)



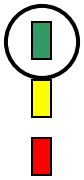
Evaluation Guidelines

1) Primary Factors
   a) If 'r' is known, use it as the basis for the rank of the Primary Factors.
   b) If 'r' is unknown, then the rank from the remaining Primary Factors (in order of importance, as listed) is the basis for the rank.

2) Secondary Factors
   a) If a majority (2 out of 3) of the Secondary Factors rank as Red, reclassify the species into the next lower rank (i.e. Green becomes Yellow, Yellow becomes Red). No other combination of Secondary Factors can modify the rank from the Primary Factors.
   b) No combination of primary and secondary factors can result in a Critical Conservation Concern for this criterion.

Conservation Concern: Inherent Vulnerability

- Low (Inherently Resilient)
- Moderate (Moderately Vulnerable)
- High (Highly Vulnerable)



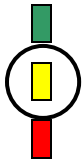
CRITERION 2: STATUS OF WILD STOCKS

Guiding Principle: Sustainable wild-caught species have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity.

Primary Factors to evaluate

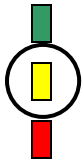
Management classification status

- Underutilized OR close to virgin biomass
- Fully fished OR recovering from overfished OR unknown
- Recruitment or growth overfished, overexploited, depleted or "threatened"



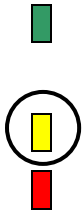
Current population abundance relative to B_{MSY}

- At or above B_{MSY} (> 100%)
- Moderately Below B_{MSY} (50 – 100%) OR unknown
- Substantially below B_{MSY} (< 50%)



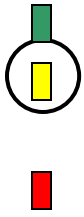
Occurrence of overfishing (current level of fishing mortality relative to overfishing threshold)

- Overfishing not occurring (F_{curr}/F_{msy} < 1.0)
- Overfishing is likely/probable OR fishing effort is increasing with poor understanding of stock status OR Unknown
- Overfishing occurring (F_{curr}/F_{msy} > 1.0)



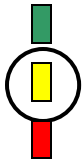
Overall degree of uncertainty in status of stock

- Low (i.e. current stock assessment and other fishery-independent data are robust OR reliable long-term fishery-dependent data available)
- Medium (i.e. only limited, fishery-dependent data on stock status are available)
- High (i.e. little or no current fishery-dependent or independent information on stock status OR models/estimates broadly disputed or otherwise out-of-date)



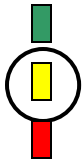
Long-term trend (relative to species' generation time) in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up
- Trend is flat or variable (among areas, over time or among methods) OR Unknown
- Trend is down



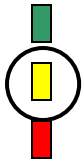
Short-term trend in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up
- Trend is flat or variable (among areas, over time or among methods) OR Unknown
- Trend is down



Current age, size or sex distribution of the stock relative to natural condition

- Distribution(s) is(are) functionally normal
- Distribution(s) unknown
- Distribution(s) is(are) skewed



Evaluation Guidelines

A "Healthy" Stock:

1) Is underutilized (near virgin biomass)
2) Has a biomass at or above BMSY AND overfishing is not occurring AND distribution parameters are functionally normal AND stock uncertainty is not high

A "Moderate" Stock:

1) Has a biomass at 50-100% of BMSY AND overfishing is not occurring
2) Is recovering from overfishing AND short-term trend in abundance is up AND overfishing not occurring AND stock uncertainty is low
3) Has an Unknown status because the majority of primary factors are unknown.

A "Poor" Stock:

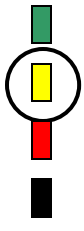
1) Is fully fished AND trend in abundance is down AND distribution parameters are skewed
2) Is overfished, overexploited or depleted AND trends in abundance and CPUE are up.
3) Overfishing is occurring AND stock is not currently overfished.

A stock is considered a **Critical Conservation Concern** and the species is ranked "Avoid**"**, regardless of other criteria, if it is:

1) Overfished, overexploited or depleted AND trend in abundance is flat or down
2) Overfished AND overfishing is occurring
3) Listed as a "threatened species" or similar proxy by national or international bodies

Conservation Concern: Status of Stocks

- Low (Stock Healthy)
- Moderate (Stock Moderate or Unknown)
- High (Stock Poor)
- Stock Critical



CRITERION 3: NATURE AND EXTENT OF DISCARDED BYCATCH[8]

Guiding Principle: A sustainable wild-caught species is captured using techniques that minimize the catch of unwanted and/or unmarketable species.

Primary Factors to evaluate

Quantity of bycatch, including any species of "special concern" (i.e. those identified as "endangered", "threatened" or "protected" under state, federal or international law)

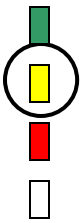
- Quantity of bycatch is low (< 10% of targeted landings on a per number basis) AND does not regularly include species of special concern
- Quantity of bycatch is moderate (10 – 100% of targeted landings on a per number basis) AND does not regularly include species of special concern OR Unknown
- Quantity of bycatch is high (> 100% of targeted landings on a per number basis) OR bycatch regularly includes threatened, endangered or protected species

Population consequences of bycatch

- Low: Evidence indicates quantity of bycatch has little or no impact on population levels
- Moderate: Conflicting evidence of population consequences of bycatch OR Unknown
- Severe: Evidence indicates quantity of bycatch is a contributing factor in driving one or more bycatch species toward extinction OR is a contributing factor in limiting the recovery of a species of "special concern"

Trend in bycatch interaction rates (adjusting for changes in abundance of bycatch species) as a result of management measures (including fishing seasons, protected areas and gear innovations):

- Trend in bycatch interaction rates is down
- Trend in bycatch interaction rates is flat OR Unknown
- Trend in bycatch interaction rates is up
- Not applicable because quantity of bycatch is low

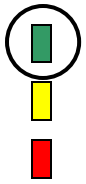


[8] Bycatch is defined as species that are caught but subsequently discarded because they are of undesirable size, sex or species composition. Unobserved fishing mortality associated with fishing gear (e.g. animals passing through nets, breaking free of hooks or lines, ghost fishing, illegal harvest and under or misreporting) is also considered bycatch. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, is accounted for, and is managed in some way.

Secondary Factor to evaluate

Evidence that the ecosystem has been or likely will be substantially altered (relative to natural variability) in response to the continued discard of the bycatch species

- Studies show no evidence of ecosystem impacts
- Conflicting evidence of ecosystem impacts OR Unknown
- Studies show evidence of substantial ecosystem impacts



Evaluation Guidelines

Bycatch is **"Minimal"** if:

1) Quantity of bycatch is <10% of targeted landings AND bycatch has little or no impact on population levels.

Bycatch is **"Moderate"** if:

1) Quantity of bycatch is 10 - 100% of targeted landings
2) Bycatch regularly includes species of "special concern" AND bycatch has little or no impact on the bycatch population levels AND the trend in bycatch interaction rates is not up.

Bycatch is "Severe" if:

1) Quantity of bycatch is > 100% of targeted landings
2) Bycatch regularly includes species of "special concern" AND evidence indicates bycatch rate is a contributing factor toward extinction or limiting recovery AND trend in bycatch is down.

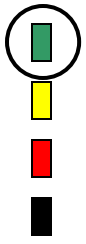
Bycatch is considered a **Critical Conservation Concern** and the species is ranked "Avoid",

regardless of other criteria, if:

1) Bycatch regularly includes species of special concern AND evidence indicates bycatch rate is a factor contributing to extinction or limiting recovery AND trend in bycatch interaction rates is not down.
2) Quantity of bycatch is high AND studies show evidence of substantial ecosystem impacts.

Conservation Concern: Nature and Extent of Discarded Bycatch

- Low (Bycatch Minimal)
- Moderate (Bycatch Moderate)
- High (Bycatch Severe)
- Bycatch Critical



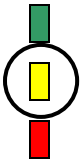
CRITERION 4: EFFECT OF FISHING PRACTICES ON HABITATS AND ECOSYSTEMS

Guiding Principle: Capture of a sustainable wild-caught species maintains natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and does not result in irreversible ecosystem state changes.

Primary Habitat Factors to evaluate

Known (or inferred from other studies) effect of fishing gear on physical and biogenic habitats

- Minimal damage (i.e. pelagic longline, midwater gillnet, midwater trawl, purse seine, hook and line, or spear/harpoon)
- Moderate damage (i.e. bottom gillnet, bottom longline or some pots/ traps)
- Great damage (i.e. bottom trawl or dredge)



For specific fishery being evaluated, resilience of physical and biogenic habitats to disturbance by fishing method

- High (e.g. shallow water, sandy habitats)
- Moderate (e.g. shallow or deep water mud bottoms, or deep water sandy habitats)
- Low (e.g. shallow or deep water corals, shallow or deep water rocky bottoms)
- Not applicable because gear damage is minimal

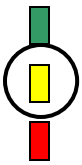
If gear impacts are moderate or great, spatial scale of the impact

- Small scale (e.g. small, artisanal fishery or sensitive habitats are strongly protected)
- Moderate scale (e.g. modern fishery but of limited geographic scope)
- Large scale (e.g. industrialized fishery over large geographic areas)
- Not applicable because gear damage is minimal

Primary Ecosystem Factors to evaluate

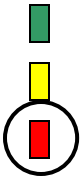
Evidence that the removal of the targeted species or the removal/deployment of baitfish has or will likely substantially disrupt the food web

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts
- Conflicting evidence of ecosystem impacts OR Unknown
- Ecosystem impacts of targeted species removal demonstrated



Evidence that the fishing method has caused or is likely to cause substantial ecosystem state changes, including alternate stable states

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts
- Conflicting evidence of ecosystem impacts OR Unknown
- Ecosystem impacts from fishing method demonstrated



Evaluation Guidelines

The effect of fishing practices is **"Benign"** if:

1) Damage from gear is minimal AND resilience to disturbance is high AND neither Ecosystem Factor is red.

The effect of fishing practices is **"Moderate"** if:

1) Gear effects are moderate AND resilience to disturbance is moderate or high AND neither Ecosystem Factor is red.
2) Gear results in great damage AND resilience to disturbance is high OR impacts are small scale AND neither Ecosystem Factor is red.
3) Damage from gear is minimal and one Ecosystem factor is red.

The effect of fishing practices **is "Severe"** if:

1) Gear results in great damage AND the resilience of physical and biogenic habitats to disturbance is moderate or low.
2) Both Ecosystem Factors are red.

Habitat effects are considered a **Critical Conservation Concern** and a species receives a recommendation of "**Avoid"**, regardless of other criteria if:

- Four or more of the Habitat and Ecosystem factors rank red.

Conservation Concern: Effect of Fishing Practices on Habitats and Ecosystems

- Low (Fishing Effects Benign)
- Moderate (Fishing Effects Moderate)
- High (Fishing Effects Severe)
- Critical Fishing Effects

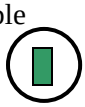
CRITERION 5: EFFECTIVENESS OF THE MANAGEMENT REGIME

Guiding Principle: The management regime of a sustainable wild-caught species implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Primary Factors to evaluate

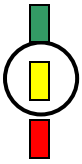
Stock Status: Management process utilizes an independent scientific stock assessment that seeks knowledge related to the status of the stock

- Stock assessment complete and robust OR stock assessment not necessary for sustainable management of the species
- Stock assessment is planned or underway but is incomplete OR stock assessment complete but out-of-date or otherwise uncertain
- No stock assessment available now and none is planned in the near future



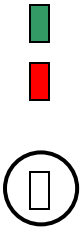
Scientific Monitoring: Management process involves regular collection and analysis of data with respect to the short and long-term abundance of the stock

- Regular collection and assessment of both fishery-dependent and independent data
- Regular collection of fishery-dependent data only
- No regular collection or analysis of data



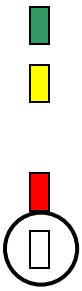
Scientific Advice: Management has a well-known track record of consistently setting or exceeding catch quotas beyond those recommended by its scientific advisors and other external scientists:

- No
- Yes
- Not enough information available to evaluate OR not applicable because little or no scientific information is collected



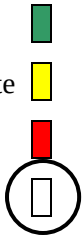
Bycatch: Management implements an effective bycatch reduction plan

- Bycatch plan in place and reaching its conservation goals (deemed effective)
- Bycatch plan in place but effectiveness is not yet demonstrated or is under debate
- No bycatch plan implemented or bycatch plan implemented but not meeting its conservation goals (deemed ineffective)
- Not applicable because bycatch is “low”



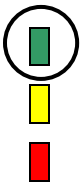
Fishing practices: Management addresses the effect of the fishing method(s) on habitats and ecosystems

- Mitigative measures in place and deemed effective
- Mitigative measures in place but effectiveness is not yet demonstrated or is under debate
- No mitigative measures in place or measures in place but deemed ineffective
- Not applicable because fishing method is moderate or benign



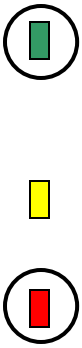
Enforcement: Management and appropriate government bodies enforce fishery regulations

- Regulations regularly enforced by independent bodies, including logbook reports, observer coverage, dockside monitoring and similar measures
- Regulations enforced by fishing industry or by voluntary/honor system
- Regulations not regularly and consistently enforced



Management Track Record: Conservation measures enacted by management have resulted in the long-term maintenance of stock abundance and ecosystem integrity

- Management has maintained stock productivity over time OR has fully recovered the stock from an overfished condition **California, Oregon, and Washington**
- Stock productivity has varied and management has responded quickly OR stock has not varied but management has not been in place long enough to evaluate its effectiveness OR Unknown
- Measures have not maintained stock productivity OR were implemented only after significant declines and stock has not yet fully recovered **Alaska**



Evaluation Guidelines

Management is deemed to be "**Highly Effective**" if the majority of management factors are green AND the remaining factors are not red.

Management is deemed to be "**Moderately Effective**" if:

1) Management factors "average" to yellow
2) Management factors include one or two red factors

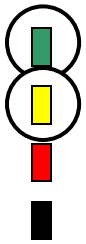
Management is deemed to be "**Ineffective**" if three individual management factors are red, including especially those for Stock Status and Bycatch.

Management is considered a **Critical Conservation Concern** and a species receives a recommendation of "**Avoid"**, regardless of other criteria if:

1) There is no management in place
2) The majority of the management factors rank red.

Conservation Concern: Effectiveness of Management

- Low (Management Highly Effective) **California, Oregon, and Washington**
- Moderate (Management Moderately Effective) **Alaska**
- High (Management Ineffective)
- Critical (Management Critically Ineffective)



Overall Seafood Recommendation

Overall Guiding Principle: Sustainable wild-caught seafood originates from sources that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

Evaluation Guidelines

A species receives a recommendation of "**Best Choice**" if:

1) It has three or more green criteria and the remaining criteria are not red.

A species receives a recommendation of "**Good Alternative**" if:

1) Criteria "average" to yellow
2) There are four green criteria and one red criteria
3) Stock Status and Management criteria are both ranked yellow and remaining criteria are not red.

A species receives a recommendation of "**Avoid**" if:

1) It has a total of two or more red criteria
2) It has one or more Critical Conservation Concerns.

Summary of Criteria Ranks

	Conservation Concern			
Sustainability Criteria	Low	Moderate	High	Critical
Inherently Vulnerability	●			
Status of Wild Stocks		●		
Nature and Extent of Discarded Bycatch	●			
Habitat and Ecosystem Effects		●		
Effectiveness of Management	●	●		

Low: California, Oregon, and Washington; Moderate: Alaska

Overall Seafood Recommendation

Best Choice	**California, Oregon, and Washington**	●
Good Alternative	**Alaska**	●
Avoid		●