Monterey Bay Aquarium
Seafood Watch®

Dungeness crab

Metacarcinus magister formerly *Cancer magister*

Image ©Monterey Bay Aquarium

U.S.

Pot

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About Seafood Watch®

The Monterey Bay Aquarium Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the North American 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. The program's mission is to engage and empower consumers and businesses to purchase environmentally responsible seafood fished or farmed in ways that minimize their impact on the environment or are in a credible improvement project with the same goal.

Each sustainability recommendation 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 sustainability criteria to arrive at a recommendation of "Best Choice," "Good Alternative," or "Avoid." In producing the seafood reports, Seafood Watch utilizes research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch research analysts also communicate 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. Both the detailed evaluation methodology and the scientific reports, are available on seafoodwatch.org.

For more information about Seafood Watch and seafood reports, please contact the Seafood Watch program at Monterey Bay Aquarium by calling 1-877-229-9990 or visit online at seafoodwatch.org.

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Guiding Principles

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

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

- *Stocks are healthy and abundant.*
- *Fishing mortality does not threaten populations or impede the ecological role of any marine life.*
- *The fishery minimizes bycatch.*
- *The fishery is managed to sustain long-term productivity of all impacted species.*
- *The fishery is conducted such that impacts on the seafloor are minimized and the ecological and functional roles of seafloor habitats are maintained.*
- *Fishing activities should not seriously reduce ecosystem services provided by any fished species or result in harmful changes such as trophic cascades, phase shifts, or reduction of genetic diversity.*

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

1. Impacts on the species under assessment
2. Impacts on other species
3. Effectiveness of management
4. Habitat and ecosystem impacts

Each criterion includes:

- Factors to evaluate and score
- Evaluation guidelines to synthesize these factors and to produce a numerical score
- A resulting numerical score and **rating** for that criterion

Once a score and rating has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ratings and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide:

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

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

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

Avoid/Red: Take a pass on these for now. These items are overfished or caught or farmed in ways that harm other marine life or the environment.

Summary

This report provides recommendations for Dungeness crab (*Metacarcinus magister* formerly *Cancer magister*), caught commercially by pot/trap, in the Northeast Pacific Ocean ranging from Alaska to California. The assessment is divided based upon management region: Alaska, British Columbia and Washington/California. The Oregon fishery is not covered here as it has already been certified as sustainable by the Marine Stewardship Council.

Dungeness crab have low inherent vulnerability due to their early age of reproductive maturity, high fecundity, and relatively short life span as compared to fish and shellfish stocks worldwide. There is low conservation concern, as targeted stocks are not indicated to be in an overfished state based on landings data, however, stock abundance is uncertain. British Columbia has a regionally limited stock assessment, but there are no formal fishery independent stock assessment programs in the United States. Fishing is restricted through a 3-S management strategy which limits harvest by size, sex and season. Although landings are thought to reflect abundance of legal-sized male crab, which fluctuates cyclically, information is lacking on abundance of females and population size structure.

Fishing mortality is a moderate concern due to high exploitation and uncertainty to future sustainability as a result of insufficient data. Legal-sized males are considered to be fully fished annually leaving the fishery dependent on annual recruitment. There is concern that increased spatial effort may remove portions of the population that could act as a buffer during poor environmental conditions. Despite these issues the fishery has maintained stable average landings historically with fluctuations attributed to environmental factors.

Bycatch in the fishery is not quantified but considered to be low due to passive fishing and high gear selectivity. Female and male soft-shell crabs caught as bycatch may experience handling mortality, although closed seasons reduce encounters with soft-shell crabs and the discard rate is estimated to be low based on similar fisheries. Humpback whales (*Megaptera novaeangliae*), an endangered species, are sometimes entangled in pot line, albeit rarely, which may lead to injury or mortality. Concern is rated low as cumulative fisheries mortality does not exceed half of the potential biological removal (PBR). Discarding in Dungeness crab fisheries is relatively low, although bait use is approximately 40% of the landings.

Management of harvest strategy is moderately effective in British Columbia and Washington/California. Research is limited and there is a need for increased precaution to address stock uncertainty and handling mortality of female and soft-shell crab. Management improvement is needed in Alaska due to historic regional stock declines which failed to recover

despite fishery closures. Bycatch strategy is considered well managed in all regions, however, gear regulations could be improved to further reduce ghostfishing.

Seafood Watch considers pot gear used in the fishery to be a low conservation concern to the seafloor habitat. Pot limits and size restrictions further mitigate gear impacts. There is a moderate conservation concern regarding the effects of Dungeness crab removal on ecosystem functioning. More research is necessary to determine the implications of fishing to community structure.

Table of Conservation Concerns and Overall Recommendations

Stock / Fishery	Impacts on the Stock	Impacts on other Spp.	Management	Habitat and Ecosystem	Overall Recommendation
Dungeness crab Alaska Northeast Pacific - Pot	Yellow (2.64)	Yellow (2.99)	Green (3.46)	Yellow (3.12)	**Good Alternative (3.040)**
Dungeness crab British Columbia Northeast Pacific - Pot	Yellow (3.05)	Yellow (2.99)	Green (3.46)	Yellow (3.12)	**Good Alternative (3.151)**
Dungeness crab United States Northeast Pacific - Pot	Yellow (3.05)	Red (1.72)	Green (3.46)	Yellow (3.12)	**Good Alternative (2.747)**

Scoring Guide

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

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

- **Best Choice/Green** = Final Score >3.2, **and** no Red Criteria, **and** no Critical scores
- **Good Alternative/Yellow** = Final score >2.2, **and** neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern[2], **and** no more than one Red Criterion, **and** no Critical scores, **and** does not meet the criteria for Best Choice (above)
- **Avoid/Red** = Final Score <=2.2, **or** either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern [2], **or** two or more Red Criteria, **or** one or more Critical scores.

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

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Introduction

Scope of the analysis and ensuing recommendation

This report includes recommendations for Dungeness crab (*Metacarcinus magister* formerly *Cancer magister*), caught by pot/trap, in the Northeastern Pacific Ocean ranging from Alaska to California. The assessment is divided into three groups based upon management region: Alaska, British Columbia and Washington/California. The Oregon fishery is not covered here as it has already been certified as sustainable by the Marine Stewardship Council.

Overview of the species and management bodies

Dungeness crab are Brachyuran true crabs occupying nearshore coastal environments from the Aleutian Islands, Alaska to Santa Barbara, California (Garth & Abbott 1980). They occur subtidally to a depth of 230 m, but are most commonly found shallower than 90 m in mud and silt habitats. This species is the largest edible true crab on the Pacific coast of North America with males growing larger than females. They have hard exoskeletons and must undergo molting for growth, which generally occurs for females in the spring and males in the summer. Timing of molting varies latitudinally, with molting occurring later in the season farther north. During the molting and mating season, Dungeness crabs move inshore (Diamond & Hankin 1985). Female crab mate immediately after molting, however, they can store sperm for up to 2.5 years and may skip egg extrusion in some years (Swiney et al. 2003, Jensen & Bentzen 2012). Fertilized eggs are carried under an abdominal flap until hatching as pelagic larvae. Larvae metamorphose through six stages, disperse and return to nearshore habitat in 3-5 months through larval behavior, physical transport and, occasionally, by riding on jellies and the by-the-wind sailor, *Velella velella,* (Wickham 1979). Juveniles settle to shallow habitat in estuaries and eelgrass beds, which serve as nursery grounds (Armstrong et al. 2003). Dungeness crab are carnivorous scavengers and predators, feeding primarily on crustaceans and clams as juveniles, and shrimp and fishes as they get older (Stevens et al. 1982).

The Dungeness crab fishery ranked 9th in value among United States commercial fisheries in 2011, valued at 187 million dollars (NOAA 2013a). The US fishery is managed at the state level; in Alaska by the Alaska Department of Fish & Game and in Washington, Oregon and California by their respective Fish & Wildlife agencies, which consult through a Tri-state Dungeness Crab Committee (US Congress 1998). Management in British Columbia is overseen by the Department of Fisheries & Oceans. The commercial fishery originated in 1848 in San Francisco, Calif. and expanded northward along the west coast of the United States and Canada by the early 1900s (Demory 1990, ADFG 1994, Hankin & Warner 2001, DFO 2013a). Despite historic regional declines in Alaska and California, Dungeness crab populations are generally considered healthy.

Production Statistics

The United States and Canada are the exclusive producers of Dungeness crab. The west coast of the United States produces the greatest quantity of crab with Washington (36%) leading in 2011, followed by California (27%), Oregon (23%) and Alaska (4%), Figure 1. In 2011, British Columbia contributed 10% to global production, which reached 34,426 metric tons (NOAA 2013a).

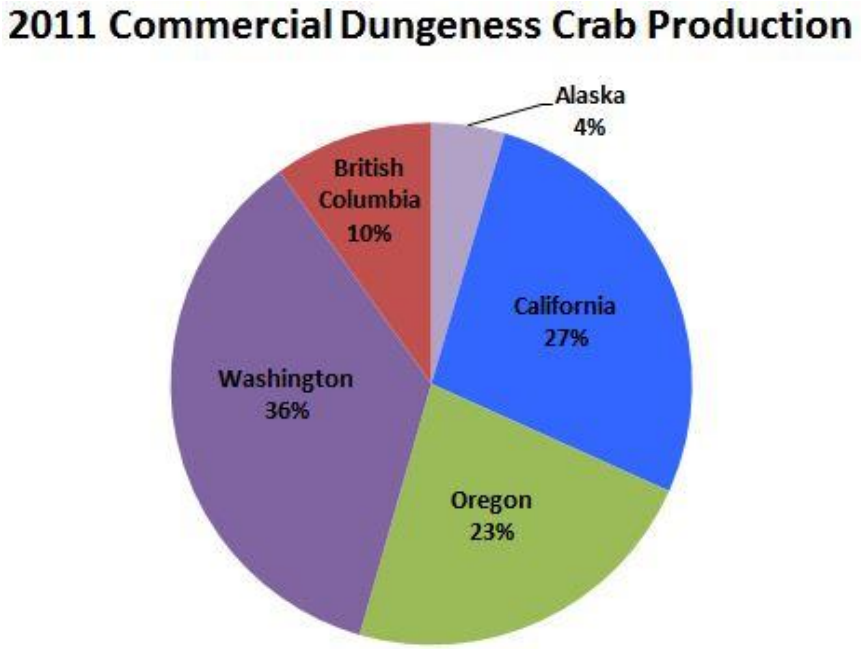

Figure 1: Commercial Dungeness crab production. Percent reflects relative contribution to landings by weight in 2011 (data source: NOAA 2013a).

Landings fluctuate, but stable means have been maintained over time in each management area (Figures 2 and 4). In recent decades, landing in Alaska have been reduced, due to historical regional fishery collapse and closure (Figure 2).

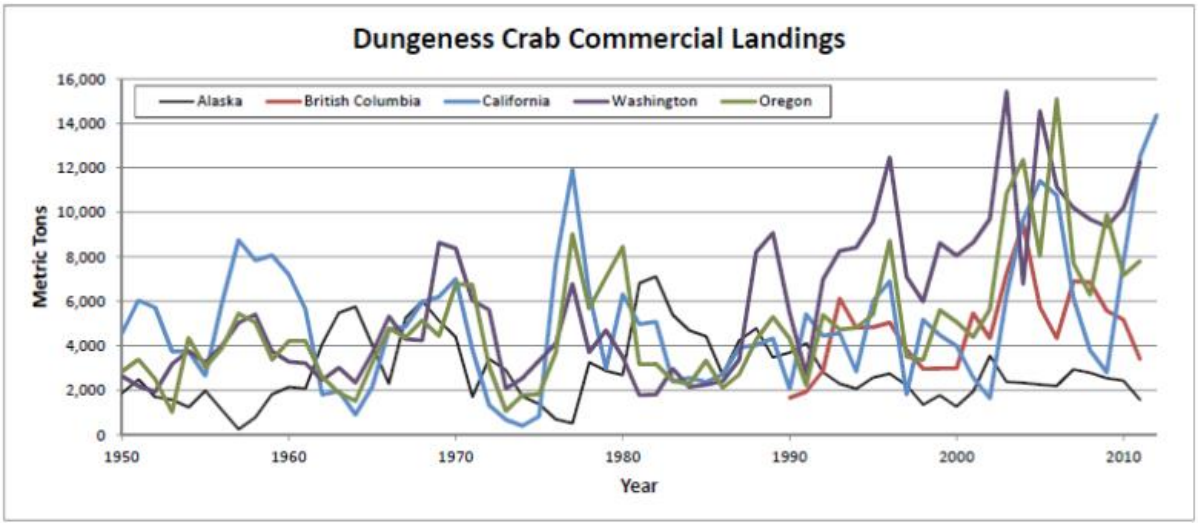

Figure 2: Annual Dungeness crab commercial fishery landings 1950-2012 (DFG 2012a, NOAA 2013a, DFO 2013b).

Importance to the US/North American market

Although Dungeness crab are not produced outside of North America, they are sometimes processed overseas and imported into the United States. In 2012, 94 metric tons were imported, with the majority sourced from Indonesia (57%), followed by China (26%), Canada (16%) and Vietnam (1%) (Figure 3, NOAA 2013b).

In recent years, Dungeness exports have increased due to the demand for live crab in China (Figure 4). In 2012, exports reached 1331 metric tons with the majority sent to China (67%) and Canada (30%) (Figure 4, NOAA 2013b). Japan, The Russian Federation, Singapore, South Korea, Indonesia, Vietnam, Australia and The Bahamas each imported ≤ 1%.

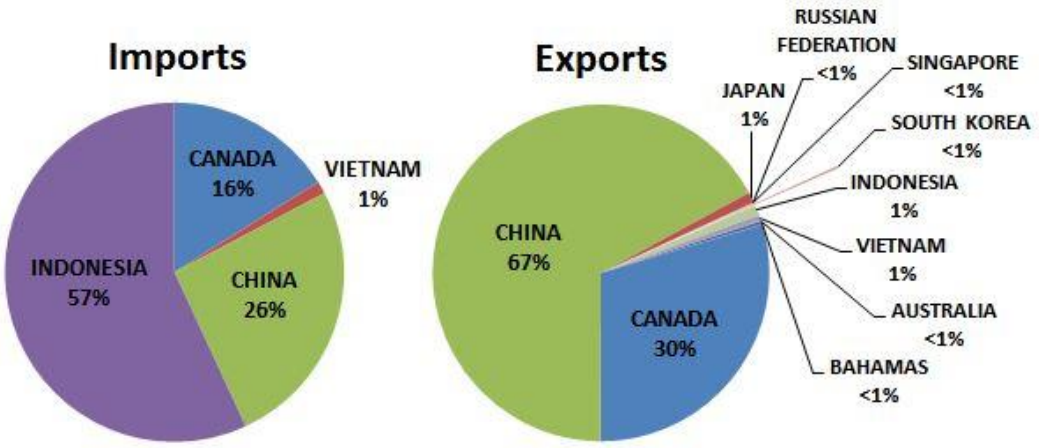

Figure 3: Commercial Dungeness crab trade in 2012. Percent reflects relative contribution by weight (all product forms combined, data source: NOAA 2013b).

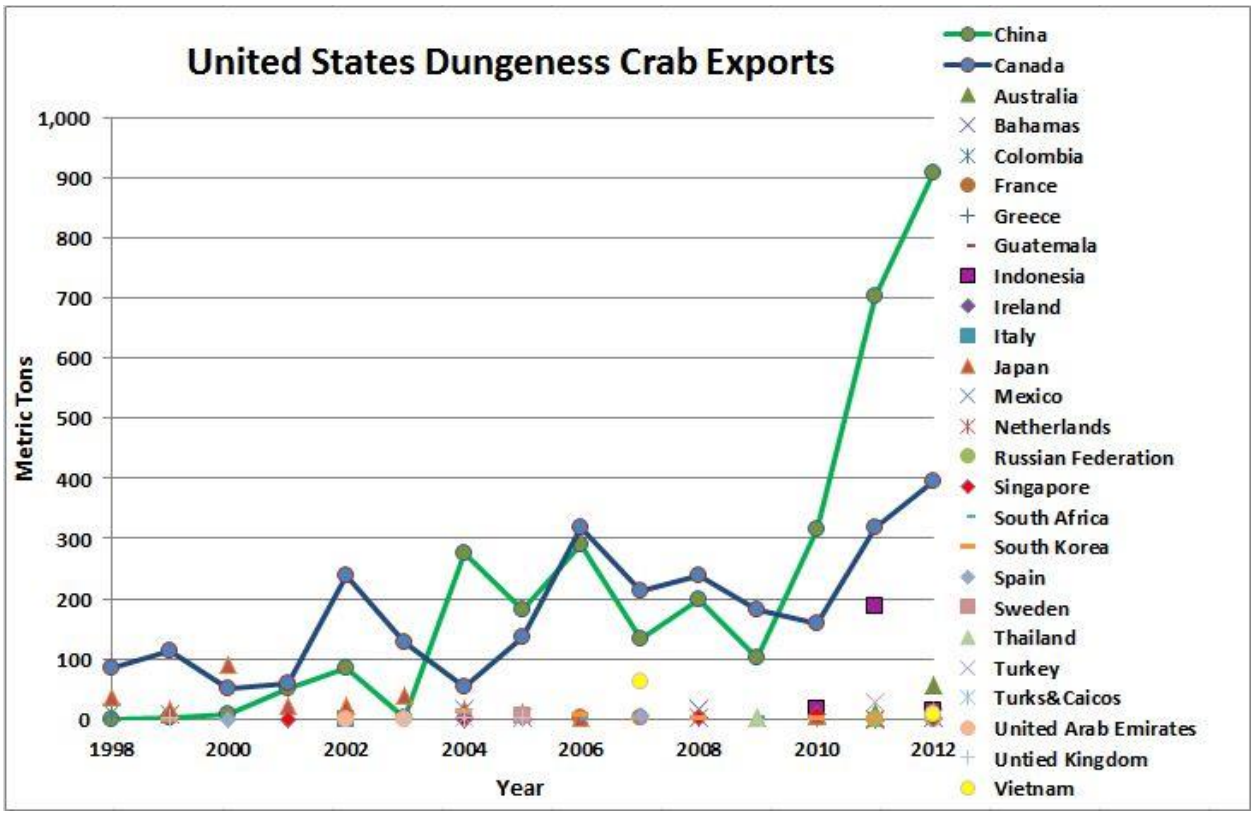

Figure 4: United States commercial Dungeness crab exports for the last fifteen years by weight (all product forms combined, data source: NOAA 2013b).

Common and market names

Commercial crab, Dungeness crab, edible crab, market crab, Pacific edible crab, San Francisco crab

Primary product forms

Dungeness crab are sold live or cooked. Cooked crab are offered fresh and frozen whole, as legs in sections or singles, and as picked meat. Meat is also available in pasteurized canned form and legs are sometimes pre-cracked and marketed as snap-'n-eats for ease of opening (Seafood Business 2013).

Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Criteria for Fisheries, available at http://www.seafoodwatch.org.

Criterion 1: Impacts on the Species under Assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. The inherent vulnerability to fishing rating influences how abundance is scored, when abundance is unknown. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

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

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

Criterion 1 Summary

DUNGENESS CRAB				
Region / Method	**Inherent Vulnerability**	**Stock Status**	**Fishing Mortality**	**Subscore**
Alaska Northeast Pacific Pot	3.00:Low	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**
British Columbia Northeast Pacific Pot	3.00:Low	4.00:Low Concern	2.33:Moderate Concern	**Yellow (3.053)**
United States Northeast Pacific Pot	3.00:Low	4.00:Low Concern	2.33:Moderate Concern	**Yellow (3.053)**

Criterion 1 Assessment

Factor 1.1 — Inherent Vulnerability

Scoring guidelines

- *Low—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing (<5 years), short lived (< 10 years), small maximum size, and low on food chain).*
- *Medium—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).*

High—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make is particularly vulnerable to fishing, (e.g., long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator).

Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling, aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.

Factor 1.2 — Abundance

Scoring guidelines

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

Factor 1.3 - Fishing Mortality

Scoring guidelines

- *5 (Very Low Concern)—Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY), OR fishery does not target species and its contribution to the mortality of species is negligible (≤ 5% of a sustainable level of fishing mortality).*
- *3.67 (Low Concern)—Probable (>50%) chance that fishing mortality is at or below a sustainable level, but some uncertainty exists, OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible, OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught).*
- *2.33 (Moderate Concern)—Fishing mortality is fluctuating around sustainable levels, OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery and, if species is depleted, reasonable management is in place.*

- *1 (High Concern)—Overfishing is occurring, but management is in place to curtail overfishing, OR fishing mortality is unknown, species is depleted, and no management is in place.*
- *0 (Critical)—Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

DUNGENESS CRAB

1.1 - Inherent Vulnerability

Alaska Northeast Pacific, Pot

3.00 **Low**

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

Rationale:

Table 1: Life history characteristics for Dungeness crab in the Northeast Pacific

Factor	Alaska	British Columbia	California / Washington	Score	Sources
Average age at maturity	2-3 years	2 years	2 years	3	Hoopes 1973, Butler 1961, Tasto 1983
Average maximum age (or range if unavailable)	8-13 years	8 years	6-8 years	3	ADFG 1994, Hankin & Warner 2001
Reproductive Strategy	egg brooder	egg brooder	egg brooder	2	Pauley et al. 1989
Density dependence	unknown	unknown	unknown	-	-
Average Score:				**2.67**	

British Columbia Northeast Pacific, Pot

3.00 **Low**

Dungeness crab have low inherent vulnerability (score of 2.67) due to their early age at sexual maturity, high fecundity and short lifespan. In British Columbia, sexual maturity is reached at 2 years of age and the maximum lifespan is approximately 8 years (Butler 1961) (see table 1).

United States Northeast Pacific, Pot

3.00 **Low**

Dungeness crab have low inherent vulnerability (score of 2.67) due to their early age at sexual maturity, high fecundity and short lifespan. Along the US West Coast, sexual maturity is reached at 2 years of age and maximum lifespan is 6-8 years (Tasto 1983 and Hankin & Warner 2001) (see table 1).

1.2 - Abundance

Alaska Northeast Pacific, Pot

3.00 **Moderate Concern**

There is no active Dungeness crab stock assessment program in Alaska (Messmer et al. 2011). Some regions have experienced historic population collapse and have been closed to fishing for several years without rebounding. It is unknown if these stocks are genetically distinct from currently fished stocks. In areas of active commercial fishing, the stock is not considered overfished by management based on landings data. Current fishery independent information is lacking. Pot surveys have revealed high spatial and temporal variability in life history timing, complicating assessment (Bishop et al. 2010).

British Columbia Northeast Pacific, Pot

4.00 **Low Concern**

The Dungeness crab stock assessment in British Columbia is based on CPUE from pot surveys (DFO 2013a). Populations fluctuate cyclically, with periods of higher abundance followed by periods of lower abundance, likely influenced by fluctuations in annual recruitment due to environmental conditions. In the Fraser River Delta, relative abundance indices from standardized catch rates (CPUEs) indicate an increase in legal crab abundance between 1991 and 2003 followed by a decrease from 2004 to 2010 (Zhang & Dunham 2013). Female abundance has been stable since 1994 while sublegal crab abundance has declined since 2005. The population of Dungeness crab in British Columbia is not considered to be overfished by the Canadian Department of Fisheries and Oceans.

United States Northeast Pacific, Pot

4.00 **Low Concern**

There is no active Dungeness crab stock assessment program in California or Washington. Dungeness populations are fully exploited such that annual catch is considered to be a proxy for population size.

Management considers the stock healthy, with annual landings that fluctuate around a fairly stable long-term mean (Figures 4 & 5, Hankin & Warner 2001, DFG 2012a, NOAA 2013a). Landings have increased in recent years, reaching a record high in California in 2011 representing the largest catch by weight over the last 100 years (DFG 2012c). Little is known about female abundance and population size structure.

1.3 - Fishing Mortality

Alaska Northeast Pacific, Pot

2.33 **Moderate Concern**

Maximum sustainable yield for Dungeness stocks is unknown as population abundance is uncertain. Fishery mortality is ranked as a moderate concern due to high exploitation rates resulting in dependence on annual recruitment for population persistence since the 1980s (Orensanz et al. 1998). A fishery-independent survey conducted in Southeast Alaska from 2000 to 2004 found exploitation rates ranging from 83% to 99% varying with location and gear type (Bishop et al. 2010). Although fishery mortality is assumed to be high in all regions, exploitation rates are presumed acceptable due to a management strategy that restricts landings based on size, sex and season. Landings in Alaska fluctuate cyclically but have been stable overall with recent declines since 2007 (Figure 2, (NOAA 2013a), (Kelley et al. 2011)).

United States Northeast Pacific, Pot

2.33 **Moderate Concern**

Legal-sized male Dungeness populations in California and Washington are fully exploited, with 80%–90% estimated fishery capture, but are not considered overfished (Hankin & Warner 2001). Intense harvest does not appear to impair mating success (Hankin et al. 1997, Oh & Hankin 2004). Fishery mortality is ranked as a moderate concern due to high exploitation rates resulting in dependence on annual recruitment for population persistence. Landings in Washington and California fluctuate but have had a stable long-term mean overall (Figures 4 & 5, (DFG 2012a), (NOAA 2013a)). In recent years, fishery effort has increased as have landings, with California reaching record highs in the past two seasons. Fishery mortality is regulated through management regulations limiting collection by size, sex and season, however, adequate data are not available to determine maximum sustainable yield.

British Columbia Northeast Pacific, Pot

2.33 **Moderate Concern**

Adequate data are not available to determine maximum sustainable yield. Fishery mortality is managed through regulations limiting collection by size, sex and season rather than quota. Exploitation rates have

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

Landings have decreased in 2011 to the lowest commercial harvest level since 2000. Although regulations limit collection by size, sex and season, there is growing concern about the extent of mortality to undersize, female, and soft shell crab due to handling. A comparison of female relative abundance indices from standardizing catch rates (CPUEs) both before and after the commercial fishing season has shown post-season declines since 1990 implying increased female mortality (Zhang & Dunham 2013).

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated in the same way as the species under assessment were evaluated in Criterion 1. Seafood Watch® defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing.

To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard rate score (ranges from 0-1), which evaluates the amount of non-retained catch (discards) and bait use relative to the retained catch. The Criterion 2 rating is determined as follows:

- *Subscore >3.2=Green or Low Concern*
- *Subscore >2.2 and <=3.2=Yellow or Moderate Concern*
- *Subscore <=2.2=Red or High Concern*

Rating is Critical if Factor 2.3 (Fishing Mortality) is Critical.

Criterion 2 Summary

Only the lowest scoring main species is/are listed in the table and text in this Criterion 2 section; a full list and assessment of the main species can be found in Appendix B.

Dungeness crab: Alaska Northeast Pacific, Pot

Subscore:: **3.318** **Discard Rate:** **0.90** **C2 Rate:** **2.986**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
DUNGENESS CRAB	3.00: Low	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
BENTHIC INVERTS	2.00: Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**
FINFISH	2.00: Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**

Dungeness crab: British Columbia Northeast Pacific, Pot				
Subscore:	**3.318**	**Discard Rate:**	**0.90**	**C2 Rate:** **2.986**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
DUNGENESS CRAB	3.00: Low	4.00: Low Concern	2.33: Moderate Concern	**3.053**
BENTHIC INVERTS	2.00: Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**
FINFISH	2.00: Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**

Dungeness crab: United States Northeast Pacific, Pot				
Subscore:	**1.916**	**Discard Rate:**	**0.90**	**C2 Rate:** **1.724**

Species	Inherent Vulnerability	Stock Status	Fishing Mortality	Subscore
HUMPBACK WHALE: CALIFORNIA/OREGON/WASHINGTON	1.00: High	1.00: Very High Concern	3.67: Low Concern	**1.916**
DUNGENESS CRAB	3.00: Low	4.00: Low Concern	2.33: Moderate Concern	**3.053**
BENTHIC INVERTS	2.00: Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**
FINFISH	2.00: Medium	3.00: Moderate Concern	3.67: Low Concern	**3.318**

There is little information available on the bycatch associated with Dungeness crab traps, therefore the unknown bycatch matrix was used and identified that finfish and benthic invertebrates are likely to be caught alongside the target species. There are also known to be interactions with humpback whales and gray whales in the Dungeness crab fisheries. These interactions are rare and in Alaska and British Columbia they are believed to be at a negligible level. In California, Oregon and Washington however, the Dungeness crab fishery is a Category II listed fishery, according to NOAA, due to interactions with humpback whales in the region, therefore, Seafood Watch has considered the interactions with this species as part of the assessment for this fishery.

Criterion 2 Assessment

BENTHIC INVERTS

2.1 - Inherent Vulnerability

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

2.00	**Medium**

Invertebrates have moderate inherent vulnerability according to Seafood Watch criteria (SFW 2012).

2.2 - Abundance

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.00	**Moderate Concern**

Stock status is scored as moderate using Seafood Watch criteria (SFW 2012).

2.3 - Fishing Mortality

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.67	**Low Concern**

Fishing mortality is scored as low under Seafood Watch criteria for invertebrates caught as bycatch via the pot fishery (SFW 2012).

FINFISH

2.1 - Inherent Vulnerability

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

2.00	**Medium**

Finfishes have moderate inherent vulnerability under Seafood Watch criteria (SFW 2012).

2.2 - Abundance

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.00	**Moderate Concern**

Stock status is scored as moderate using Seafood Watch criteria (SFW 2012).

2.3 - Fishing Mortality

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.67	**Low Concern**

Fishing mortality is scored as low under Seafood Watch criteria for finfishes caught as bycatch via the pot fishery (SFW 2012).

HUMPBACK WHALE: CALIFORNIA/OREGON/WASHINGTON

2.1 - Inherent Vulnerability

United States Northeast Pacific, Pot

1.00 **High**

As a marine mammal, this species has high inherent vulnerability under Seafood Watch criteria (SFW 2012).

2.2 - Abundance

United States Northeast Pacific, Pot

1.00 **Very High Concern**

Humpback whales are designated as endangered in their entire range under the Endangered Species Conservation Act (NOAA 2011a). Stock abundance was recently estimated to be 2,043 with the population growing at a rate of approximately 7% per year (NOAA 2010).

2.3 - Fishing Mortality

United States Northeast Pacific, Pot

3.67 **Low Concern**

Whales in the California/Oregon/Washington humpback stock are occasionally entangled in gear from the crab fishery resulting in incidental mortality or serious injury (NOAA 2012). In this region, the Dungeness fishery is listed as a Category II fishery. Interaction between the crab fishery and humpback whales is limited temporally with the majority of crab fishing occurring prior to humpback whale migration to the region (Hankin & Warner 2001, NOAA 2010). Although many fishermen cease fishing early in the season and there are fewer pots actively fishing by the time whales migrate north to feed, gear remains in the water posing an entanglement threat to whales. The percent of potential biological removal (PBR) due to entanglement in pot or trap gear is 15.9% (11.3 whales per year NOAA 2010). The exact contribution from the Dungeness crab fishery is unknown as not all gear is identifiable to source fishery. Cumulative fisheries mortality does not exceed PBR therefore fishery mortality is ranked as low.

2.4 - Discard Rate

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

0.90	40%–60%

Discard data specific to the Dungeness crab fishery are unavailable, however, average discard rate for global crab catch is 12.4 % (Kelleher 2005). Dungeness crab mortality rate is 2%–4% for undersize crab, 22%–25% for soft shell crab and unknown for females (Alverson et al. 1994). Since female mortality is unknown, using an estimated conservative mortality rate of 50% for all discards, total dead discard rate is estimated to be 6.2%.

Information on bait use is lacking as it is not quantified in the fishery. The best available estimate is 2.5 lbs. of crab landed for every pound of bait, about 40% bait-to-landings ratio (pers. comm. Forrest Bowers ADF&G).

Criterion 3: Management Effectiveness

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

The final score for this criterion is the geometric mean of the two scores. The Criterion 3 rating is determined as follows:

- *Score>3.2 = Green or Low Concern;*
- *Score>2.2 and <=3.2 = Yellow or Moderate Concern;*
- *Score<=2.2 or either the Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern = Red or High Concern.*

Rating is Critical if either or both of Harvest Strategy (Factor 3.1) and Bycatch Management Strategy (Factor 3.2) ratings are Critical.

Criterion 3 Summary

Region / Method	Management of Retained Species	Management of Non-Retained Species	Overall Recommendation
Alaska Northeast Pacific Pot	3.000	4.000	Green(3.464)
British Columbia Northeast Pacific Pot	3.000	4.000	Green(3.464)
United States Northeast Pacific Pot	3.000	4.000	Green(3.464)

3.1.0 - Critical?

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

0.00	**No**

Factor 3.1: Harvest Strategy

Scoring Guidelines

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

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

Factor 3.1: Management of fishing impacts on retained species							
Region / Method	**Strategy**	**Recovery**	**Research**	**Advice**	**Enforce**	**Track**	**Inclusion**
Alaska Northeast Pacific Pot	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Moderately Effective	Highly Effective
British Columbia Northeast Pacific Pot	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
United States Northeast Pacific Pot	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective

Subfactor 3.1.1 - Management Strategy and Implementation

Considerations: What type of management measures are in place, are there appropriate management goals, and is there evidence that management goals are being met. To achieve a highly effective rating, there must be appropriate management goals and evidence that the measures in place have been successful at maintaining/rebuilding species.

Alaska Northeast Pacific, Pot

2.00 **Moderately Effective**

The Alaska Department of Fish and Game manages the fishery utilizing a 3S-stragety with a minimum size limit of 165 mm carapace width, restricted to male harvest with seasonal closures (Messmer et al. 2011). In contrast to seasonal management in other regions of North America, collection in some Alaskan regions is permitted during the summer, which allows for harvest during the molting period. This results in removal of males prior to the mating season and increased handling mortality of soft shell crab, which are concerns to future sustainability. Seasonal closures in Alaska vary between management regions. In most areas, however, harvest closures are implemented during the peak molting period from mid-August to the end of September. The fishery is limited entry with gear requirements including maximum pot size, escape rings and pot limits in some regions. Viability of the historically passive management plan is uncertain (Kelley et al. 2011).This passive management strategy has failed in the Cook Inlet, Yakutat and Prince William Sound regions where Dungeness crab population collapses have led to fishery closures (Trowbridge & Goldman 2006, Messmer et al. 2011, Wessel et al. 2012). As a precaution, the Southeast Alaska region has implemented provisions for season length reductions if predicted harvests do not meet prescribed thresholds (Messmer et al. 2011). Due to increased exploitation in recent years, all areas are fully fished such that the population lacks a buffer to environmental variability and the fishery is dependent on annual recruitment. Implementation of harvest guidelines could result in more effective future fishery management.

British Columbia Northeast Pacific, Pot

2.00 **Moderately Effective**

Management strategy in British Columbia includes size, sex and hardness harvest restrictions, seasonal closures, limited licensing, trap limits, gear requirements and limits on soak time and weekly haul (DFO 2013a). This strategy has been successful in maintaining crab productivity, based on stability of annual landings on a decadal average. There is growing concern about the effects of increased fisheries effort in recent years and the resulting increased handling mortality of discarded crab. Management is ranked moderately effective due to lack of biological reference points for precautionary population monitoring.

United States Northeast Pacific, Pot

2.00 **Moderately Effective**

The California and Washington Departments of Fish and Wildlife manage the fishery using a 3-S strategy, including size, sex, season and hardness harvest restrictions (WAC 2012a, WAC 2012b, DFG 2012a). The fishery is limited entry and employs pot limits and gear restrictions including size and escape mechanism requirements. Management is ranked as moderately effective due to lack of biological data to

determine stock abundance and resilience to recent increased fishing effort and future environmental fluctuations.

Subfactor 3.1.2 - Recovery of Species of Concern

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

Alaska Northeast Pacific, Pot

2.00 **Moderately Effective**

There are currently no overfished, depleted, endangered or threatened species targeted or retained in the fishery. The Alaska Department of Fish & Game (ADF&G) has maintained regional closures in the Prince William Sound (PWS), Yakutat and Cook Inlet areas where crab populations historically collapsed (Trowbridge & Goldman 2006, Messmer et al. 2011, Wessel et al. 2012). Depletion of these stocks was likely due to a synergistic effect of environmental fluctuations, otter predation and spatial expansion of fishing effort leading to serial depletion of fishing grounds (Orensanz et al. 1998).The Cook Inlet region has been closed to commercial fishing since 1991, Yakutat since 2000, and PWS in entirety since 2000 (Copper River region of PWS since 1992, Orca Inlet since 1980). Despite long-term closures, population abundance remains depressed. Recovery failure is likely due to a variety of factors including sea otter predation, loss as bycatch in other trawl fisheries, recruitment variability and environmental fluctuations. These regions are near the northern limit of the Dungeness crab range, which may further contribute to their vulnerability. ADF&G intends to protect depleted regions until populations recover and stock assessment and management plans are developed for sustainability. Recovery is scored as moderately effective as closures have not generated population recovery and further intervention may be necessary.

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.00 **Highly Effective**

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

Subfactor 3.1.3 - Scientific Research and Monitoring

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

Alaska Northeast Pacific, Pot

2.00 **Moderately Effective**

Data are collected to assess stock health and evaluate population age and size composition through comprehensive fish ticket reporting and dockside sampling (Messmer et al. 2011). Sampling occurs occasionally via onboard observer and on-the-grounds surveys, but is not spatially or temporally comprehensive and life history timing is uncertain. Research is ranked moderately effective due to incomplete coverage, as Dungeness crab display high spatial and temporal variability in life history timing (Bishop et al. 2010). Due to insufficient resources, management lacks a fishery-independent stock assessment program.

British Columbia Northeast Pacific, Pot

2.00 **Moderately Effective**

Fishery-independent stock assessments are conducted twice annually in two of seven designated fishing areas (Areas I & J, (DFO 2013a)). Research surveys are performed in additional regions, on an inconsistent basis, to target specific scientific questions including stock composition, molt timing and injury. Additional biological data are obtained through electronic monitoring programs, harvest logs and biological sampling. The DFO acknowledges that existing biological information is insufficient for implementing future ecosystem-based management and has plans underway to begin monthly fishery-independent surveys in additional fishing areas (DFO 2013a).

United States Northeast Pacific, Pot

2.00 **Moderately Effective**

There is limited data availability for the California and Washington fisheries and no formal stock assessments have been conducted (Hankin & Warner 2001). Preseason testing for shell hardness occurs annually in both states and data are collected from required logbooks in Washington (PSMFC 2012, WAC 2007). More research is needed to determine long-term effects of the fishery's increasing spatial footprint on stock abundance.

Subfactor 3.1.4 - Management Record of Following Scientific Advice

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

Alaska Northeast Pacific, Pot

3.00 **Highly Effective**

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

British Columbia Northeast Pacific, Pot

3.00 **Highly Effective**

Management follows scientific advice, modifying and implementing regulations in response to research findings, however, research on stock abundance is extremely limited. A move toward precautionary management of crab populations through development of biological reference points to indicate stock status has been recommended (Zhang & Dunham 2013). Fisheries and Oceans Canada intends to base future management of the crab fishery on biological information (DFO 2013a).

United States Northeast Pacific, Pot

3.00 **Highly Effective**

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

Subfactor 3.1.5 - Enforcement of Management Regulations

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

Alaska Northeast Pacific, Pot

3.00 **Highly Effective**

Fishery vessels are subject to inspection and dockside sampling occurs in some regions (ADF&G 2012).

Alaska Wildlife Troopers patrol fishing waters, monitoring for proper gear and licensing and inspecting buoy tags to enforce pot limits.

British Columbia Northeast Pacific, Pot

3.00 **Highly Effective**

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

United States Northeast Pacific, Pot

3.00 **Highly Effective**

The California and Washington Departments of Fish and Wildlife conduct monitoring and enforcement via land and at-sea patrols (Spear & Babich 2001, IACP 2008). Efforts include license, catch, and gear and vessel inspection.

Subfactor 3.1.6 – Management Track Record

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

Alaska Northeast Pacific, Pot

2.00 **Moderately Effective**

Management measures currently in place have resulted in regional stock collapses in the Cook Inlet, Yakutat and Prince William Sound areas, which have since failed to recover despite closures (Trowbridge & Goldman 2006, Messmer et al. 2011, Wessel et al. 2012). This may be due to a number of factors including complex predator-prey relationships.

British Columbia Northeast Pacific, Pot

3.00 **Highly Effective**

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

United States Northeast Pacific, Pot

3.00 **Highly Effective**

Stock abundance, based on annual landings, fluctuates cyclically (Hankin & Warner 2001). The mechanisms underlying interannual variability in recruitment success are uncertain. Larval survival appears to be impacted by environmental factors (the Pacific Decadal Oscillation, the El Nino Southern Oscillation, and timing of the spring transition and upwelling intensity) that influence biological productivity and larval transport (Botsford 2001, Shanks 2013). The central California fishery experienced a dramatic decline in the 1950s, presumably due to warming water temperatures and late timing of the spring transition (Hankin & Warner 2001, Shanks & Roegner 2007). Measures enacted by management have, however, resulted in long-term maintenance of average stock abundance.

Subfactor 3.1.7 - Stakeholder Inclusion

Considerations: Are stakeholders involved/included in the decision-making process. Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g. fishermen, conservation groups, etc.). A highly effective will be given if the management process is transparent and includes stakeholder input.

Alaska Northeast Pacific, Pot

3.00 **Highly Effective**

The Southeast Alaska Commercial Dungeness Task Force, composed of ten commercial fisherman, serves as an advisory industry group to management (ADF&G 2000). Public comment is also welcome at Alaska Board of Fisheries meetings.

British Columbia Northeast Pacific, Pot

3.00 **Highly Effective**

The crab fishery management process is inclusive of stakeholder groups (DFO 2013a). Fishery planning involves an annual consultative process through a Crab Sectoral Committee comprised of

representatives from DFO, commercial license holders, and processors.

United States Northeast Pacific, Pot

3.00 **Highly Effective**

The California and Washington Departments of Fish & Wildlife solicit input on fishery management from the public and advisory industry groups: the California Dungeness Crab Task Force and Washington Coastal Dungeness Crab Advisory Board (DCTF 2012, WADFW 2013).

Factor 3.2: Bycatch Management Strategy

Scoring Guidelines

Four subfactors are evaluated: Management Strategy, Scientific Research/Monitoring, Following of Scientific Advice, and Enforcement of Regulations. Each is rated as 'ineffective,' 'moderately effective,' or 'highly effective.' Unless reason exists to rank Scientific Research/Monitoring, Following Scientific Advice, and Enforcement of Regulations differently, these ranks are the same as in 3.1.

- *5 (Very Low Concern)—Rated as 'highly effective' for all four subfactors considered.*
- *4 (Low Concern)—Management Strategy rated 'highly effective' and all other subfactors rated at least 'moderately effective.'*
- *3 (Moderate Concern)—All subfactors rate at least 'moderately effective.'*
- *2 (High Concern) — meets standards for 'moderately effective' for Management Strategy but some other factors rated 'ineffective.'*
- *1 (Very High Concern)—Management exists, but Management Strategy is rated 'ineffective.'*
- *0 (Critical)–No bycatch management exists even when overfished, depleted, endangered or threatened species are known to be regular components of bycatch and are substantially impacted by the fishery.*

Criterion 3.2 Summary

Factor 3.2: Management of fishing impacts on bycatch species				
Region / Method	**Strategy**	**Research**	**Advice**	**Enforce**
Alaska Northeast Pacific Pot	No	Highly Effective	Moderately Effective	Highly Effective
British Columbia Northeast Pacific Pot	No	Highly Effective	Moderately Effective	Highly Effective
United States Northeast Pacific	No	Highly	Moderately	Highly

Pot		Effective	Effective	Effective

3.2.0 - All Species Retained?

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

0.00 **No**

3.2.0 - Critical?

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

0.00 **No**

Criterion 3.2 Assessment

Subfactor 3.2.1 – Management Strategy and Implementation

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

Alaska Northeast Pacific, Pot

3.00 **Highly Effective**

Management mitigates impacts of the fishery on bycatch through gear requirements. Traps must have two 4 3/8 inch diameter escape rings to allow for escape of undersize crab and females (Messmer et al.

2011). An escape panel secured with biodegradable twine acts to reduce effects of ghostfishing when pots are lost at sea. This escape mechanism could use improvement as the current design is vulnerable to unsuccessful lid release due to metal fatigue and biofouling (Maselko et al. 2013). The use of single trap gear and pot limits minimizes whale entanglement through reduction of gear in the water.

British Columbia Northeast Pacific, Pot

3.00 **Highly Effective**

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

United States Northeast Pacific, Pot

3.00 **Highly Effective**

Management mitigates impacts of the fishery on bycatch through gear requirements. Traps must have two 4 1/4 inch diameter escape rings in the upper half of the pot to allow for escape of undersize crab and females (WAC 2012b, DFG 2012b). The gear must be equipped with rot cord that serves as a biodegradable escape mechanism to reduce effects of ghostfishing when pots are lost at sea. Researchers recommend reducing cord diameter to increase efficacy as it takes 126 days for this cord to decompose at sea (Antonelis et al. 2011). The use of single trap gear and pot limits (in effect in WA, pending in CA) minimizes whale entanglement through reduction of gear in the water.

Subfactor 3.2.2 - Scientific Research and Monitoring

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

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

2.00 **Moderately Effective**

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

Subfactor 3.2.3 - Management Record of Following Scientific Advice

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

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.00 **Highly Effective**

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

Subfactor 3.2.4 - Enforcement of Management Regulations

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

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

2.00	**Moderately Effective**

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

Criterion 4: Impacts on the Habitat and Ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment.

The final score is the geometric mean of the impact of fishing gear on habitat score (plus the mitigation of gear impacts score) and the Ecosystem Based Fishery Management score. The Criterion 2 rating is determined as follows:

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

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region / Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Overall Recomm.
Alaska Northeast Pacific Pot	3.00:Low Concern	0.25:Minimal Mitigation	3.00:Moderate Concern	**Yellow (3.123)**
British Columbia Northeast Pacific Pot	3.00:Low Concern	0.25:Minimal Mitigation	3.00:Moderate Concern	**Yellow (3.123)**
United States Northeast Pacific Pot	3.00:Low Concern	0.25:Minimal Mitigation	3.00:Moderate Concern	**Yellow (3.123)**

Criterion 4 Assessment

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

- 5 (None) = Fishing gear does not contact the bottom
- 4 (Very Low) = Vertical Line Gear
- 3 (Low) = Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Bottom seine on resilient mud/sand habitats. Midwater trawl that is known to contact bottom *occasionally* (<25% of the time) or purse seine known to commonly contact bottom
- 2 (Moderate) = Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Bottom seine except on mud/sand;

- 1 (High) = Hydraulic clam dredge. Dredge or trawl gear fished on moderately sensitive habitats (e.g. cobble or boulder).
- 0 (Very High) = Dredge or trawl fished on biogenic habitat, e.g. deep-sea corals, eelgrass and maerl.

Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive plausible habitat type.

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.00 **Low Concern**

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

Factor 4.2 - Mitigation of Gear Impacts

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

Alaska Northeast Pacific, Pot

0.25 **Minimal Mitigation**

Fishing effort and spatial footprint are reduced via pot limits and gear size restrictions (Messmer et al. 2011). The magnitude of a spatial footprint is uncertain as pots are deployed several times within the season and may drag across the seafloor during storm events. Fishing is closed in Glacier Bay National Park and Preserve and the Prince William Sound, Yakutat and Cook Inlet areas (Trowbridge & Goldman

2006, Messmer et al. 2011, Wessel et al. 2012).

British Columbia Northeast Pacific, Pot

0.25 **Minimal Mitigation**

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

United States Northeast Pacific, Pot

0.25 **Minimal Mitigation**

Damage to the seafloor is mitigated through maximum trap size and pot limits (in effect in WA, WAC 2012b; pending in CA, DFG 2012b). There are no-take Marine Protected Areas in both states, but they represent less than 20% of Dungeness crab habitat.

Factor 4.3 – Ecosystem-Based Fisheries Management

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

- 2 (High Concern) = The fishery catches species that play an exceptionally large role in the ecosystem and no efforts are being made to incorporate their ecological role into management.
- 1 (Very High Concern) = The use of hatchery supplementation or Fish Aggregating Devices (FADs) in the fishery is having serious negative ecological or genetic consequences. OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.

Alaska Northeast Pacific, Pot

British Columbia Northeast Pacific, Pot

United States Northeast Pacific, Pot

3.00	**Moderate Concern**

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

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

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