Monterey Bay Aquarium Seafood Watch®

Crab, Dungeness

Metacarcinus magister

©Monterey Bay Aquarium

Alaska, British Columbia, California, Oregon, Washington

Pots

November 4, 2019

Seafood Watch Consulting Researcher

Seafood Watch Standard used in this assessment: Standard for Fisheries vF3

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About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Watch Assessment. Each assessment 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." This ethic is operationalized in the Seafood Watch standards, available on our website here. In producing the assessments, Seafood Watch seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying assessments 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 Watch assessments in any way they find useful.

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 fisheries must possess to be considered sustainable by the Seafood Watch program (these are explained further in the Seafood Watch Standard for Fisheries):

- Follow the principles of ecosystem-based fisheries management.
- Ensure all affected stocks are healthy and abundant.
- Fish all affected stocks at sustainable levels.
- Minimize bycatch.
- Have no more than a negligible impact on any threatened, endangered or protected species.
- Managed to sustain the long-term productivity of all affected species.
- Avoid negative impacts on the structure, function or associated biota of aquatic habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.

These guiding principles are operationalized in the four criteria in this standard. Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and rating

Once a rating has been assigned to each criterion, we develop an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guide and online guide:

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

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

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

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

Summary

This report provides recommendations for Dungeness crab (Metacarcinus magister a.k.a. Cancer magister) caught commercially by pot/trap in the Northeast Pacific Ocean, ranging from Alaska to California. The assessment is divided into five groups based upon management region: Alaska, British Columbia, Washington, Oregon, and California.

Dungeness crab have low inherent vulnerability due to early age at reproductive maturity, high fecundity, and short life span, compared to fish and shellfish stocks worldwide. There is "moderate" conservation concern because landings data indicate that targeted stocks are not overfished; however, stock abundance is uncertain. British Columbia has a regionally limited stock assessment, but the US has no formal, fishery-independent stock assessment program. Fishing is restricted through a 3-S management strategy that limits harvest by size, sex, and season. The intention of this management strategy is to maintain productivity and manage sustainability by protecting crab during sensitive molting periods and allowing 1 to 2 years of reproduction prior to harvest (ODFW 2014). Although landings are thought to reflect the legal-sized male crab abundance (which fluctuates cyclically), information is lacking on the abundance of females and the population size structure.

Fishing mortality is of "moderate" concern due to high exploitation and uncertainty over future sustainability (as a result of insufficient data). There is no reference point for maximum sustainable yield. Legal-sized males are considered to be fully fished annually, which leaves 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 historically maintained stable average landings, with fluctuations attributed to environmental factors.

Bycatch in the fishery is not quantified but considered to be "low," due to passive fishing and high selectivity of gear. Female and male softshell crab caught as bycatch may experience handling mortality, although closed seasons reduce encounters with softshell crab and the discard rate is estimated to be "low," based on similar fisheries. In California, Oregon and Washington humpback whales (*Megaptera novaeangliae*), an ESA listed species, are sometimes entangled in pot line, which sometimes leads to injury or mortality. Concern is rated as "high" for fisheries mortality since there is a strong possibility that the sustainable level of take for the Central America humpback DPS is being exceeded. Discarding in Dungeness crab fisheries is relatively low with dead discards representing 35% of landings, although bait use is ~16 to 23% of landings.

Management 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 softshell crab. Management strategy is considered "highly effective" in Oregon due to a precautionary policy implementing limit reference points. 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 Alaska and British Columbia; however, gear regulations could be improved to further reduce ghostfishing. Bycatch strategy is considered to be "moderately effective" in Washington, Oregon, and California since management measures to minimize interactions with marine mammals and sea turtles have only recently been implemented and their effectiveness is unknown.

Seafood Watch considers pot gear used in the fishery to be of "low" conservation concern for 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.

Final Seafood Recommendations

SPECIES | FISHERY	CRITERION 1: Impacts on the Species	CRITERION 2: Impacts on Other Species	CRITERION 3: Management Effectiveness	CRITERION 4: Habitat and Ecosystem	OVERALL RECOMMENDATION
Dungeness crab California/Eastern Central Pacific | Pots | United States of America	Yellow (2.644)	Red (1.000)	Yellow (3.000)	Green (3.464)	**Good Alternative (2.289)**
Dungeness crab Alaska/Northeast Pacific | Pots | United States of America	Yellow (2.644)	Green (3.413)	Yellow (3.000)	Green (3.464)	**Good Alternative (3.111)**
Dungeness crab British Columbia/Northeast Pacific | Pots | Canada	Yellow (2.644)	Green (3.413)	Yellow (3.000)	Green (3.464)	**Good Alternative (3.111)**
Dungeness crab Oregon/Northeast Pacific | Pots | United States of America	Yellow (2.644)	Red (1.000)	Green (4.000)	Green (3.464)	**Good Alternative (2.460)**
Dungeness crab Washington/Northeast Pacific | Pots | United States of America	Yellow (2.644)	Red (1.000)	Yellow (3.000)	Green (3.464)	**Good Alternative (2.289)**

Summary

Dungeness crab harvested in British Columbia, Alaska, Washington, Oregon and California are considered a "Good Alternative."

Scoring Guide

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

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

- **Best Choice/Green** = Final Score >3.2, and no Red Criteria, and no Critical scores
- **Good Alternative/Yellow** = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern2, and no more than one Red Criterion, and no Critical scores
- **Avoid/Red** = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

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[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).

Introduction

Scope of the analysis and ensuing recommendation

This report includes recommendations for Dungeness crab (*Metacarcinus magister* a.k.a. *Cancer magister*) caught by pot/trap in the Northeastern Pacific Ocean ranging from Alaska to California. Both *M. magister* and *C. magister* may be used to describe this species because there is no current consensus on nomenclature; however, this report will refer to the former scientific name because it is officially recognized by the FDA. The assessment is divided into five groups based upon management region: Alaska, British Columbia, Washington, Oregon and California.

Species Overview

Dungeness crab are a Brachyuran true crab occupying nearshore coastal environments from the Aleutian Islands, Alaska to Santa Barbara, California (Garth and Abbott 1980). They occur subtidally to a depth of over 800 m, but are most commonly found shallower than 90 m in mud and silt habitats (Garth and Abbott 1980) (Bradburn et al. 2011). This species is the largest edible true crab on the Pacific coast of North America, with males growing larger than females. Dungeness crab have a hard exoskeleton and must undergo molting for growth, which generally occurs for females in the spring and males in the summer. Timing of molting varies by latitude, with molting occurring later in the season further north. During the molting and mating season, Dungeness crab move inshore (Diamond and 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 and 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 to 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 in nearshore and estuarian habitats, 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 including shrimp and fishes into their diet as they get older (Stevens et al. 1982).

The Dungeness crab fishery is ranked sixth in value among United States commercial fisheries in 2016, reaching USD 222.6 million (NOAA 2018a). The US fishery is managed at a state level: in Alaska by the Alaska Department of Fish and Game; and in Washington, Oregon, and California by their respective Fish and Wildlife agencies, which consult through a Tri-state Dungeness Crab Committee (U.S. Congress 1998). Management in British Columbia is overseen by the Department of Fisheries and Oceans. The commercial fishery originated in 1848 in San Francisco, CA and expanded northward along the West Coast of the United States and Canada by the early 1900s (Demory 1990) (ADFG 1994) (Hankin and Warner 2001) (DFO 2018). 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 producing 32,511 metric tons (MT) in 2016 (NOAA 2018a) (DFO 2018). The West Coast of the United States produces the greatest quantity of crab, with California (37%) leading in 2016 followed by Washington (27%), Oregon (22%) and Alaska (4%). In Alaska, the majority of the commercial Dungeness fishery is in the southeast region with small fisheries (harvest <225 MT annually) in the Kodiak and Alaska Peninsula areas. British Columbia contributed 10% to global Dungeness crab production in 2016.

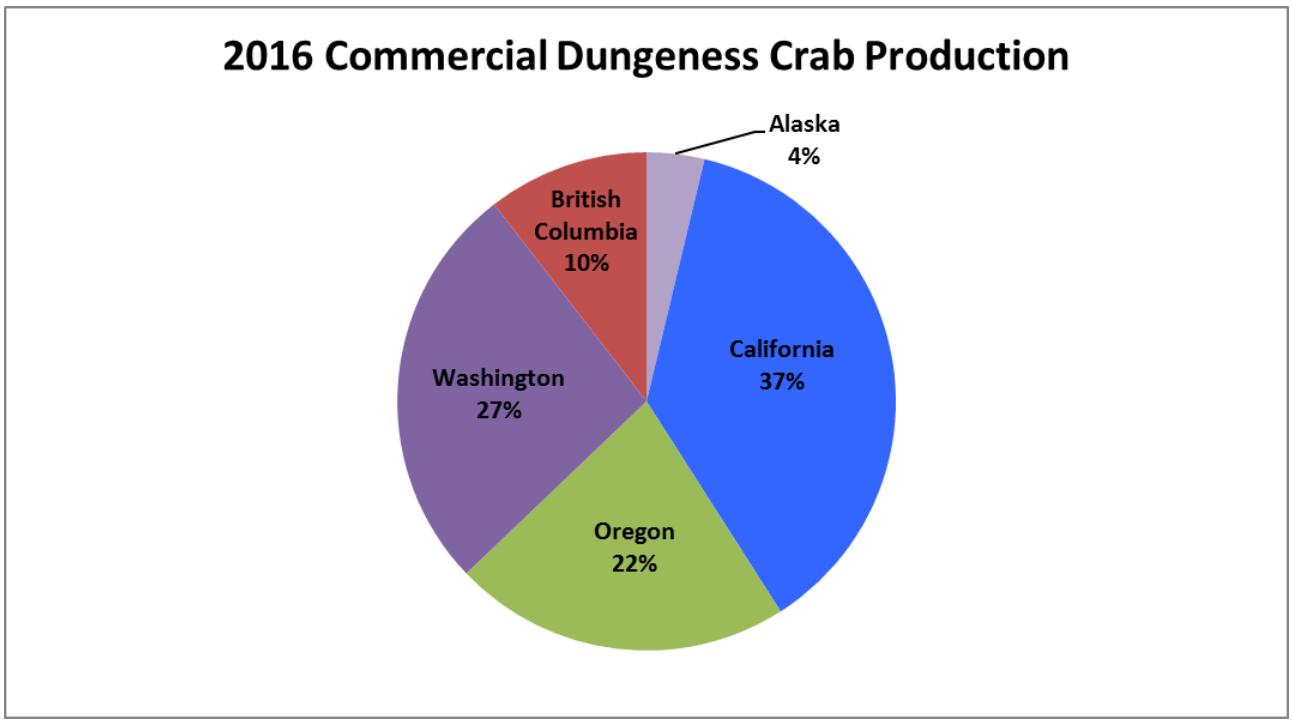

Figure 1 Commercial Dungeness crab global production in 2016 (NOAA 2018)(DFO 2018).

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

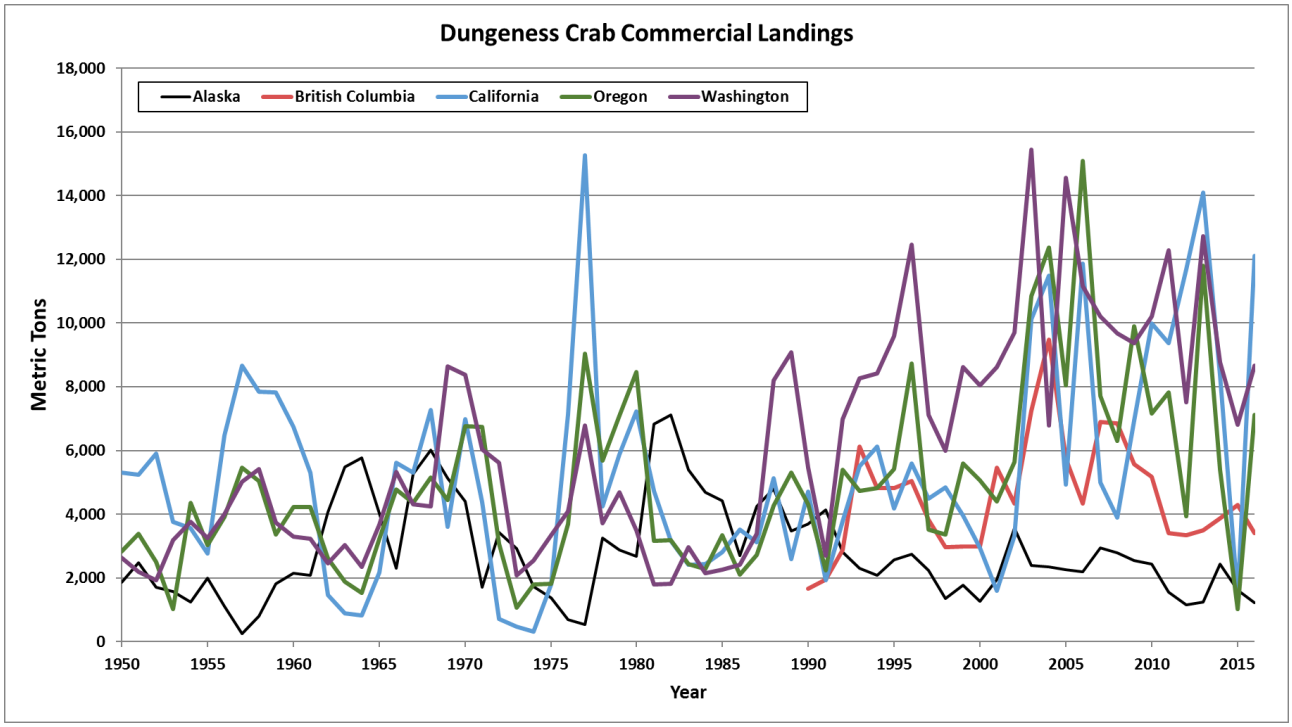

Figure 2 Annual Dungeness crab commercial fishery landings 1950–2016.

Importance to the US/North American market.

Although Dungeness crab is not produced outside of North America, processing is sometimes done overseas and reimported into the United States. In 2017, 41.7 MT were imported from China (86%), Canada (12%) and

Vietnam (2%) (NOAA 2018b).

In recent years, both the United States and Canada's Dungeness exports have increased due to the demand for live crab in China. In 2017, US exports reached 1,787.5 MT, with the majority sent to China (85%) and Canada (8%) (NOAA 2018b). Australia, Ecuador, Indonesia, Japan, Lebanon, Singapore, South Korea, Taiwan, Thailand, Ukraine, United Arab Emirates, United Kingdom and Vietnam each imported ≤ 1%. In Canada in 2017 the majority of crab exports were sent to China (92%) followed by the United States (5%), Singapore (1%) and other countries (2%) (DFO 2019).

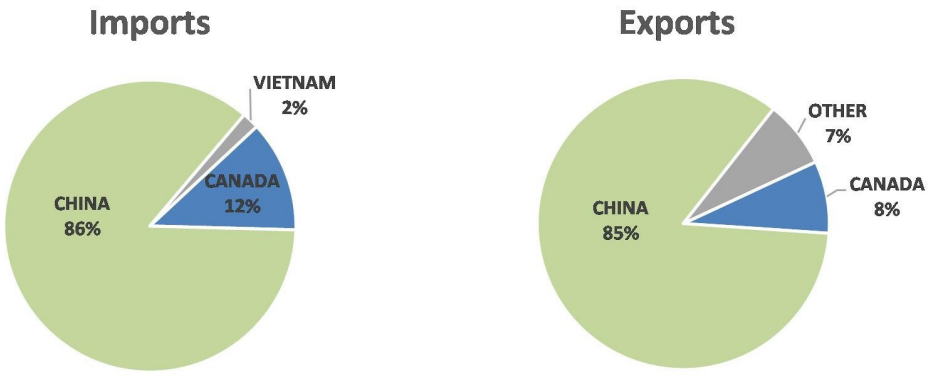

Figure 3 Commercial Dungeness crab trade in 2017. Percent reflects relative contribution by weight (all product forms combined, datasource: NOAA 2018b).

Common and market names.

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

Primary product forms

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

Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at www.seafoodwatch.org. The specific standard used is referenced on the title page of all Seafood Watch assessments.

Criterion 1: Impacts on the Species Under Assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species' inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. 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

Guiding Principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*

Criterion 1 Summary

DUNGENESS CRAB			
Region | Method	**Abundance**	**Fishing Mortality**	**Score**
California/Eastern Central Pacific | Pots United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
Alaska/Northeast Pacific | Pots United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
British Columbia/Northeast Pacific | Pots Canada	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
Oregon/Northeast Pacific | Pots United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
Washington/Northeast Pacific | Pots United States of America	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)

Criterion 1 Assessment

SCORING GUIDELINES

Factor 1.1 - Abundance

Goal: Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity.

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate target abundance level (given the species' ecological role), or near virgin biomass.*
- *3.67 (Low Concern) — Population may be below target abundance level, but is at least 75% of the target level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.*
- *2.33 (Moderate Concern) — Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.*
- *1 (High Concern) — Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.*

Factor 1.2 - Fishing Mortality

Goal: Fishing mortality is appropriate for current state of the stock.

- *5 (Low Concern) — Probable (>50%) that fishing mortality from all sources is at or below a sustainable level, given the species ecological role, OR fishery does not target species and fishing mortality is low enough to not adversely affect its population.*
- *3 (Moderate Concern) — Fishing mortality is fluctuating around sustainable levels, OR fishing mortality relative to a sustainable level is uncertain.*
- *1 (High Concern) — Probable that fishing mortality from all source is above a sustainable level.*

DUNGENESS CRAB

Factor 1.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

There is no active Dungeness crab stock assessment program in California or Washington. Dungeness populations are fully exploited for legal-sized males, so annual catch is considered to be a proxy for population size. Caution must be taken in using landings data as an indicator of relative abundance trends, since fishing effort in recent years has fluctuated in relation to several factors such as poor crab quality, domoic acid, whale entanglement avoidance. Management considers the stock healthy, with annual landings that fluctuate around a fairly stable long-term mean (Figure 4) (Hankin and Warner 2001) (CDFW 2018) (NOAA 2018). Landings reached a record high in California in 2011—the largest catch by weight over the last 100 years— but in recent years have remained around the 10-year average until increasing again in the 2016–17 season (CDFW 2016) (CDFW 2018). Caution must be taken in using landings data as an indicator of relative abundance trends, since fishing effort in recent years has fluctuated in relation to several factors such as poor crab quality, domoic acid, and whale entanglement avoidance. CPUE data are not available for California. CPUE has been stable in Washington over the past six seasons (Figure 5). Little is known about female abundance and population size structure. Because Dungeness crab are not highly vulnerable (see Productivity-Susceptibility Analysis (PSA) table Figure 6) but lack quantitative stock assessment, stock abundance is considered a "moderate" concern.

Justification:

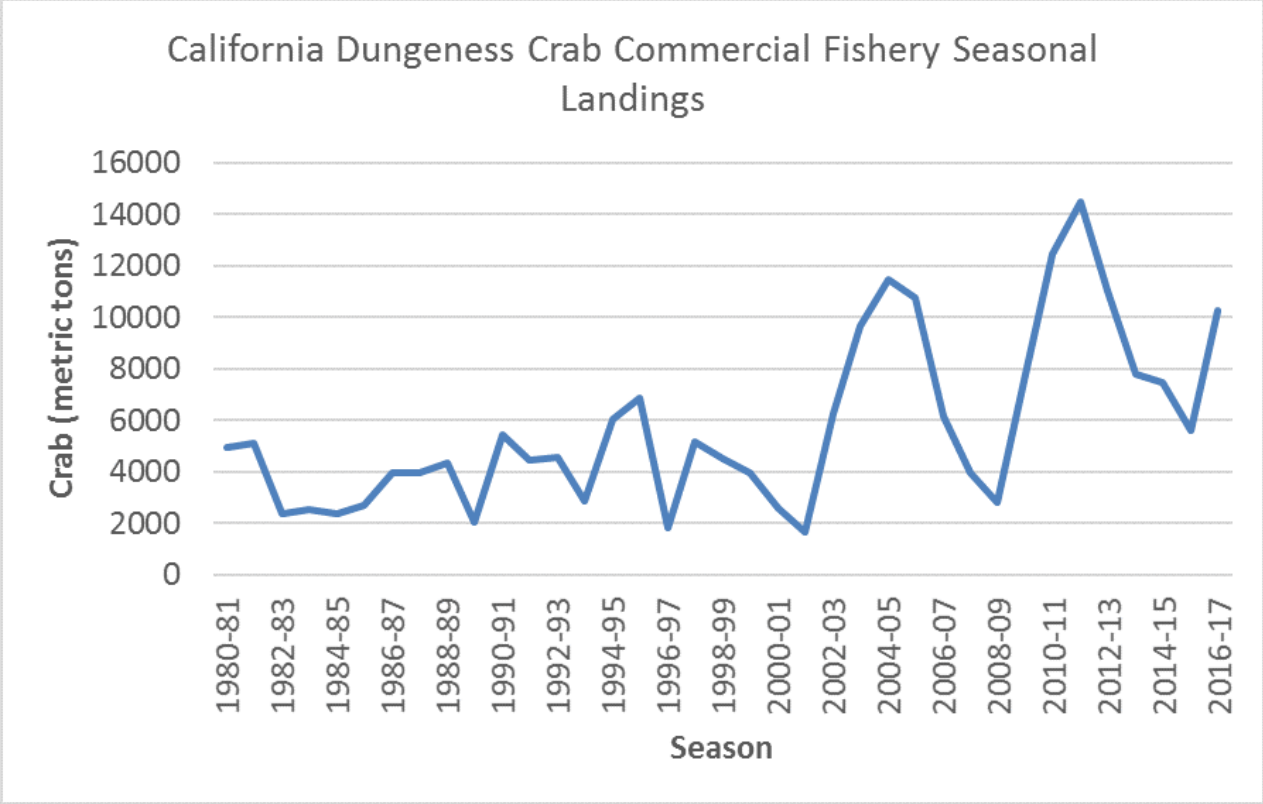

Figure 4 There is a high degree of interannual fluctuation in seasonal landings of California commercial Dungeness crab with a stable mean overall (data courtesy of Christy Juhasz CADFW 2018)

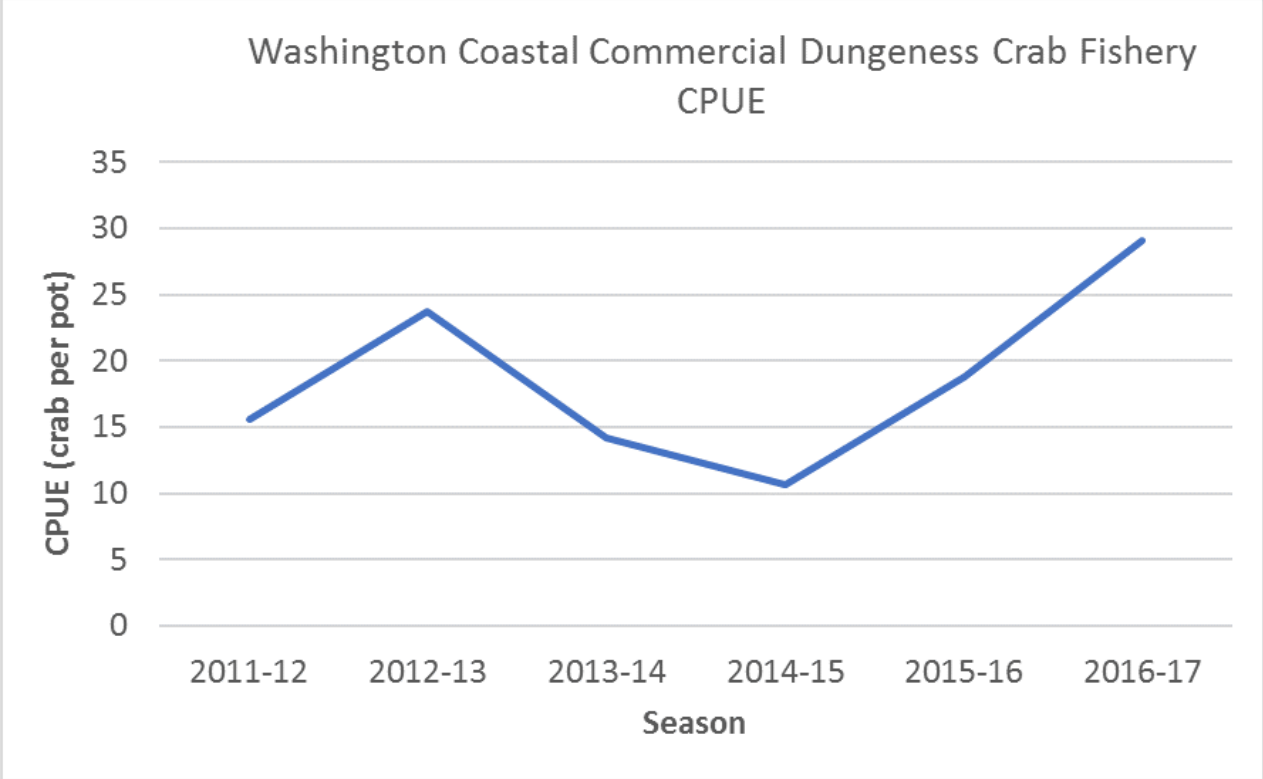

Figure 5 CPUE (crab per pot) has remained stable over the past six seasons in the Washington commercial Dungeness crab coastal fishery (Data courtesy of Dan Ayres WDFW 2018).

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity (years)	2 (2-3 in AK)	1
Average maximum age (years)	6-8 (8-13 in AK)	1
Fecundity	>30,000	1
Reproductive strategy	Egg brooder	2
Trophic level	2	1

Refs: Butler 1961, Hoopes 1973, Tasto 1983, Pauley et al. 1989, ADFG 1994, Hankin & Warner 2001. The average Productivity score is 1.20

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Default score (there is high overlap between the fishery and this species; it is the target species)	3
Vertical overlap (Considers all fisheries)	Default score (there is high overlap between the fishery and this species; it is the target species)	3
Selectivity of fishery (Specific to fishery under assessment)	Default score (Species is targeted and there are no special circumstances increasing its susceptibility)	2
Post-capture mortality (Specific to fishery under assessment)	Default score (species is retained)	3

The multiplicative Susceptibility score is 2.62 – Low

Figure 6 Productivity-Susceptibility Analysis (PSA) table

ALASKA / NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

There is no active Dungeness crab stock assessment program in Alaska and current fishery-independent information is lacking (Messmer et al. 2011) (Stratman et al. 2017). In areas of active commercial fishing, management does not consider the stock to be overfished, based on landings data. Some regions have experienced historic population collapse and have been closed to fishing for several years without rebounding; however, it is unknown if these stocks are genetically distinct from currently fished stocks.

Pot surveys have revealed high spatial and temporal variability in life-history timing, which complicates assessment (Bishop et al. 2010). Data from port sampling programs indicate stable mean weight and carapace width since 1975 (Strathman et al. 2017). CPUE has fluctuated but remained stable for the past thirty seasons (Figure 7). In Southeast Alaska harvest projections are determined at the beginning of the summer season, which serve as an index of relative abundance and are used to determine if closures are necessary (see Justification section for details). In the 2017 summer season, management closed the Dungeness crab season 3 weeks early, since it fell below the required threshold of a projected 2.25 million lb using projections based on early season landings. Since Dungeness crab are not highly vulnerable (see Productivity-Susceptibility Analysis (PSA) table Figure 6) but lack quantitative stock assessment, stock status is considered a "moderate" concern.

Justification:

A harvest trigger determination of season length is used as a precautionary management strategy (Stratman et al. 2017). At the beginning of the summer season, harvest projections are used to determine relative abundance. Thresholds are in place such that if abundance is determined to be low management will implement closures. If catch is projected to be <1.5 million lb, the summer season will be closed within 21 days of opening and the fall season will not open. If catch is >1.5 million lb, but <2.25 million lb, the summer season will be closed within 28 days of opening and the fall season will be open for 30 days. If thresholds are not met due to early summer soft-shelled crab, management may open the regularly specified fall season.

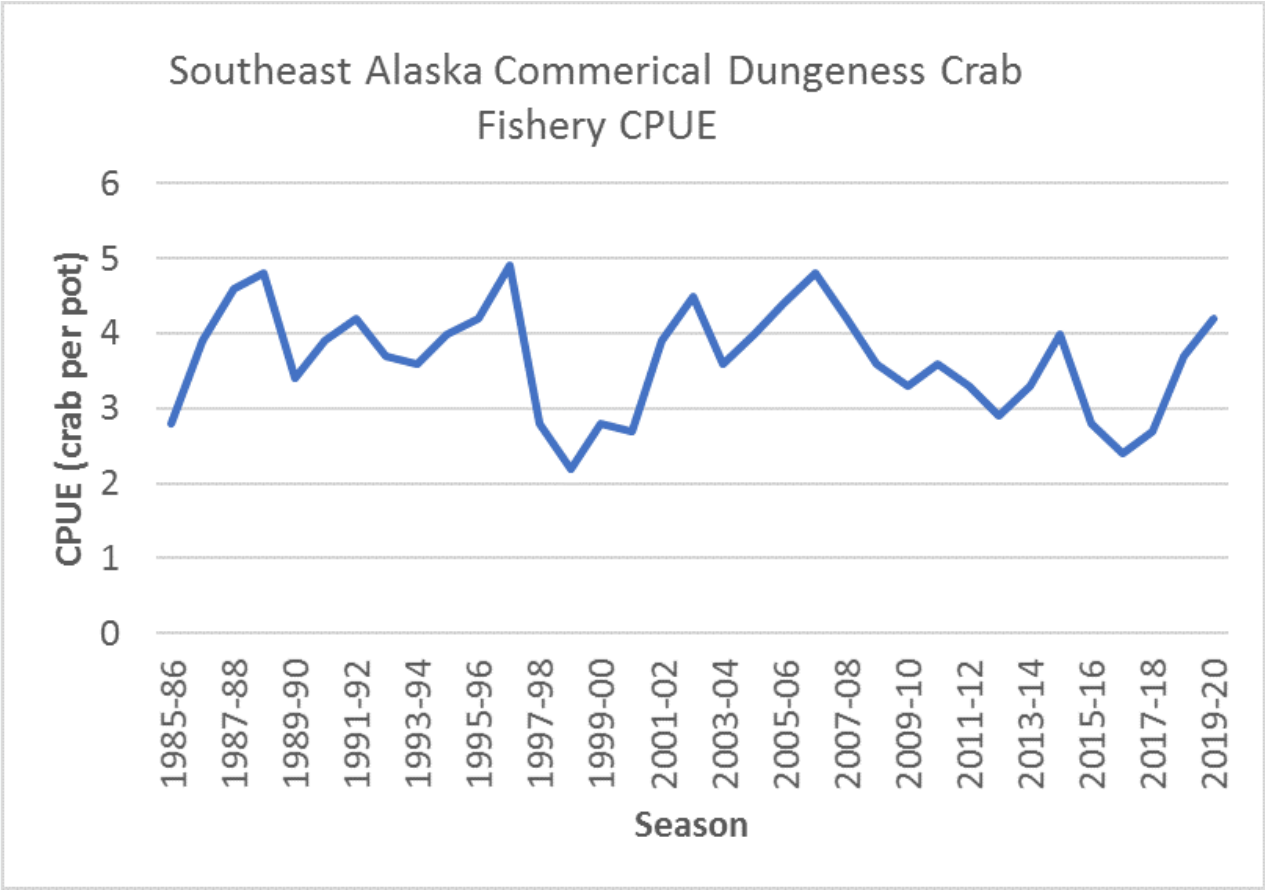

Figure 7 CPUE (crab per pot) has fluctuated but remained stable over the 30 year timeseries in the Southeast Alaska commercial Dungeness crab fishery (ADFG 2019).

OREGON/NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

The Oregon fishery lacks an active stock assessment based on fishery-independent data; however, management considers the stock to be stable, based on landings and monitoring studies. Mandatory logbooks have been submitted to ODFW with information on fishing date, depth, number of pots in the string, gear soak time, string start and end locations, and estimated pounds caught in the string allowing for calculations of CPUE (ODFW 2014b). Annual landings and CPUE increased in the early 2000s while fluctuating around fairly stable means both prior and following (Figure 8). A 17-year time series monitoring annual recruitment of megalopae demonstrated a strong relationship between abundance of recruiting megalopae and Oregon commercial catch (Shanks et al. 2010) (Shanks 2017). There is a high level of interannual fluctuation in recruitment (Figure 9) with stock abundance heavily impacted by the environment (correlations to both annual timing of the spring transition and interannual variation in climate) with reduced recruitment during warm years. Although legal-sized males in the population are fully exploited, female mating success does not appear to be impaired (Dunn and Shanks 2014). There is no evidence of decreased genetic diversity or population substructure of Dungeness crab sampled off the Oregon coast (O'Malley and Roegner 2014). Little is known about female abundance and population size structure. As Dungeness crab are not highly vulnerable (see Productivity-Susceptibility Analysis (PSA) table Figure 6), but lack quantitative stock assessment, stock abundance is considered a "moderate" concern.

Justification:

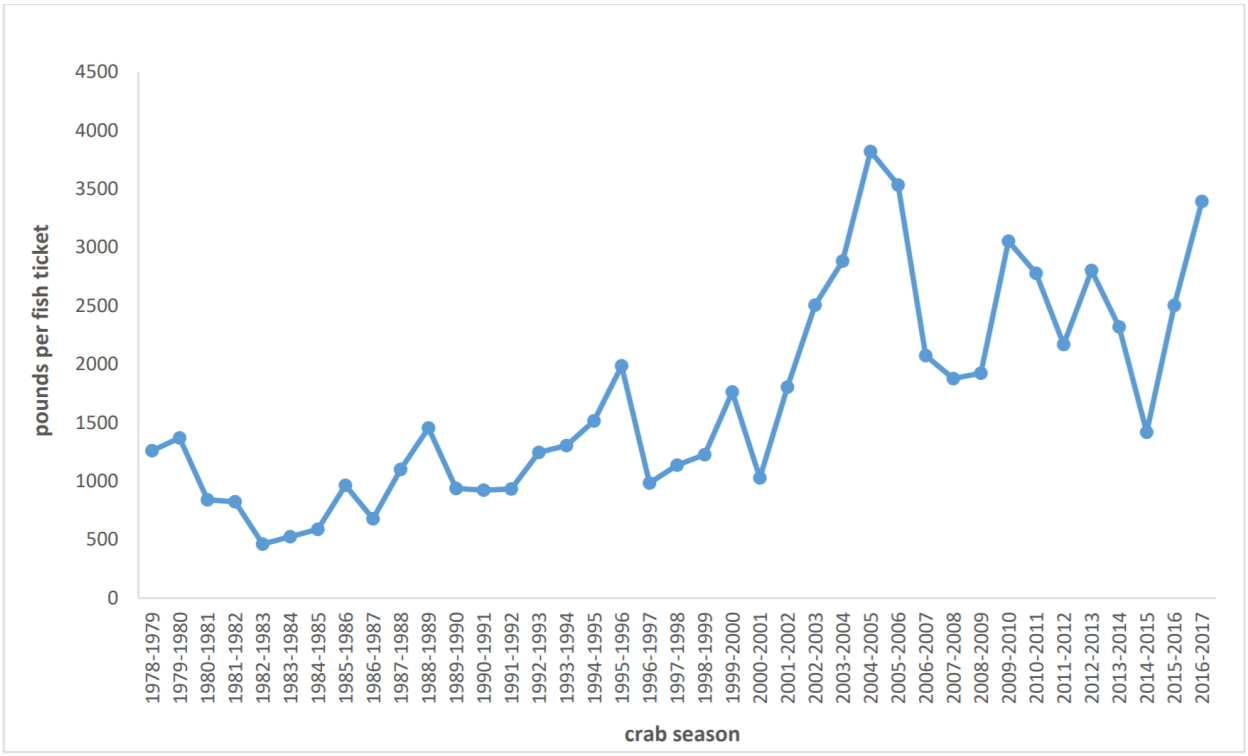

Figure 8 Long-term CPUE based on pounds per fish ticket for the Oregon ocean commercial Dungeness crab fishery (data courtesy ODFW 2018).

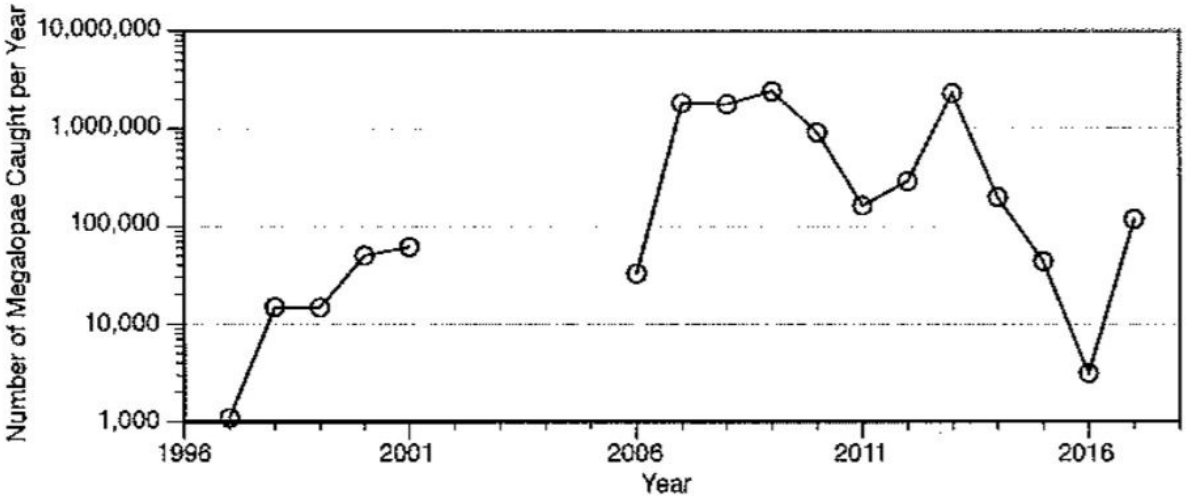

Figure 9 Annual catch of megalopae in Oregon fluctuates over the time series. Recent years of low recruitment occurred during warm environmental conditions (2015 'warm blob' & 2016 strong El Nino) but megalopae abundance rose again in 2017 (Shanks 2017).

Factor 1.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

Legal-sized male Dungeness populations in California and Washington are fully exploited, with 80 to 90% estimated fishery capture, but are not considered overfished (Hankin and Warner 2001). Intense harvest does not appear to impair mating success (Hankin et al. 1997) (Oh and Hankin 2004). Landings in Washington and California fluctuate but have had a stable long-term mean overall (CDFW 2018)(NOAA 2018a). Fishery effort has increased, as have landings, with California reaching record highs in 2011 and 2012; however, the most recent landings for both states are comparable to the 10-year average. 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. Fishing mortality is ranked as "moderate" concern due to high exploitation rates resulting in dependence on annual recruitment for population persistence with no available frame of reference for maximum sustainable yield.

ALASKA / NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

The maximum sustainable yield (MSY) for Dungeness stocks is unknown because population abundance is uncertain. A fishery-independent survey conducted in Southeast Alaska from 2000 to 2004 found exploitation rates ranging from 83 to 99% that varied 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 the five year average from the 2012/13 through 2016/17 seasons 3.1 million lb of crab landed annually (NOAA 2018a) (Kelley et al. 2011) (Stratman et al. 2017). In Southeast Alaska harvest triggers are used to determine season length (see C1.1 Justification section for details). Fishing mortality is ranked as a "moderate" concern due to high exploitation rates that result in dependence on annual recruitment for population persistence since the 1980s (Orensanz et al. 1998) with no available reference point for maximum sustainable yield.

OREGON / NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

Commercial fishery landings in Oregon fluctuate around a generally increasing 10-year mean (ODFW 2018). Fishery mortality is regulated through management regulations that limit collection by size, sex, and season; however, adequate data on size structure, and female spawning stock biomass are currently unavailable to determine maximum sustainable yield. The Oregon Department of Fish and Wildlife and the Oregon Dungeness Crab Commission have developed a Limit Reference Point (LRP) harvest policy, based on information from landings and logbooks, and an adaptive management framework to respond to breaches of the LRP (ODFW 2014). The LRP will be reached if landings decline for three consecutive seasons and are projected to continue declining in the fourth season to below 20% of the 20-year average, or if the logbook CPUE falls below the average range from the 1980–1981 to 1986–1987 seasons. Four consecutive declining years would equate to approximately one generation time. If the LRP is reached, management intervention

will vary after evaluation of the cause of decline, and may include seasonal closure, reduced pot limits, trip limits, area closure, and/or increasing minimum size limits. Since the LRP has only been implemented recently and is dependent on landings data rather than on fishery-independent assessment, there is uncertainty that it is effective or appropriate. Due to the uncertainty surrounding the suitability of this reference point, fishing mortality is ranked as "moderate" concern.

DUNGENESS CRAB

Factor 1.1 - Abundance

BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada

Moderate Concern

Dungeness crab stock health in British Columbia is evaluated based on catch per unit effort (CPUE) from pot surveys (DFO 2019). Landings data indicate populations fluctuate cyclically, with periods of higher abundance followed by periods of lower abundance; these are likely influenced by fluctuations in annual recruitment due to environmental conditions (Figure 10). In the Fraser River delta, relative abundance indices from standardized catch rates (CPUEs) indicate an increase in legal crab abundance between 1991 and 2003, followed by a decrease from 2004 to 2010 (Zhang and Dunham 2013). Female abundance has been stable since 1994, but sublegal crab abundance has declined since 2005 (Zhang and Dunham 2013).
Because Dungeness crab are not highly vulnerable (see Productivity-Susceptibility Analysis (PSA) table Figure 6) but lack quantitative stock assessment, stock status is considered a "moderate" concern.

Justification:

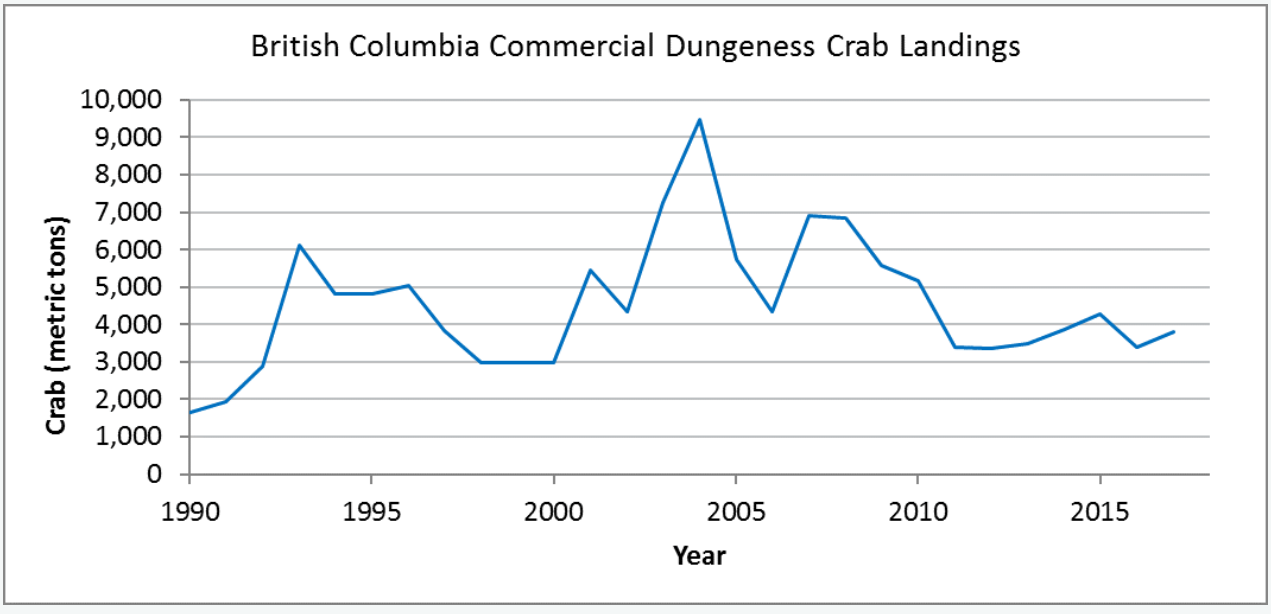

Figure 10 Coastwide annual landings of Dungeness crab in British Columbia (Data courtesy of DFO 2018)

Factor 1.2 - Fishing Mortality

BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada

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 and Jamieson 1989). Despite an intense harvest, annual fishery landings fluctuate cyclically around a relatively stable mean, a pattern thought to be tied to environmental variability (Figure 2) (DFO 2018).

Landings decreased from 2008 to 2011, but have since been stable. 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, which implies increased female mortality (Zhang and Dunham 2013). Fishing mortality is ranked as a "moderate" concern due to high exploitation rates that result in dependence on annual recruitment for population persistence with no reference point for maximum sustainable yield.

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated under Criterion 2. 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. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery's potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait 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 is Critical if Factor 2.3 (Fishing Mortality) is Crtitical

Guiding Principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*
- *Minimize bycatch.*

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 A.

DUNGENESS CRAB
Alaska/Northeast Pacific | Pots | United States Of America

Subscore:	**3.413**	**Discard Rate:**	**1.00**	**C2 Rate:**	**3.413**

Species | Stock	**Abundance**	**Fishing Mortality**	**Subscore**
Benthic inverts	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
Finfish	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)

DUNGENESS CRAB
British Columbia/Northeast Pacific | Pots | Canada

Subscore:	**3.413**	**Discard Rate:**	**1.00**	**C2 Rate:**	**3.413**

Species | Stock	**Abundance**	**Fishing Mortality**	**Subscore**
Benthic inverts	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
Finfish	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)

DUNGENESS CRAB California/Eastern Central Pacific | Pots | United States Of America					
Subscore:	**1.000**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.000**

Species | Stock	Abundance	Fishing Mortality	Subscore
Humpback whale	1.00:High Concern	1.00:High Concern	Red (1.000)
Leatherback turtle	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Killer whale | Transient	1.00:High Concern	5.00:Low Concern	Yellow (2.236)
blue whale	1.00:High Concern	5.00:Low Concern	Yellow (2.236)
Benthic inverts	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
Finfish	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
gray whale	3.67:Low Concern	5.00:Low Concern	Green (4.284)

DUNGENESS CRAB Oregon/Northeast Pacific | Pots | United States Of America					
Subscore:	**1.000**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.000**

Species | Stock	Abundance	Fishing Mortality	Subscore
Humpback whale	1.00:High Concern	1.00:High Concern	Red (1.000)
Finfish	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
Benthic inverts	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
gray whale	3.67:Low Concern	5.00:Low Concern	Green (4.284)

DUNGENESS CRAB Washington/Northeast Pacific | Pots | United States Of America					
Subscore:	**1.000**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.000**

Species | Stock	Abundance	Fishing Mortality	Subscore
Humpback whale	1.00:High Concern	1.00:High Concern	Red (1.000)
Finfish	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
Benthic inverts	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
gray whale	3.67:Low Concern	5.00:Low Concern	Green (4.284)

Little information is available on the bycatch associated with Dungeness crab traps. The unknown bycatch matrix was used to identifiy finfish and benthic invertebrates as likely to be caught alongside the target species. Interactions with humpback, gray, blue, and killer whales, and leatherback turtles are known to occur in the Dungeness crab fisheries. These interactions are historically rare, and in Alaska and British Columbia they are believed to be at a negligible level. In California, Oregon, and Washington, the Dungeness crab fishery is listed as a Category II fishery driven by interactions with humpback whales resulting in annual mortality and serious injury ranging from >1% to <50% or PBR, although gray whales are also recognized as interacting with the fishery in the LOF (83 FR 5349). Recently (2017 to the present) documented interactions of crab gear and killer, blue, and gray whales (ENP stock) have yet to be evaluated by NOAA and incorporated into the LOF.

Increasing entanglements, attributed to the commercial Dungeness crab trap fishery, have been observed in recent years reaching record highs in 2016 with documentation of 19 humpback whales, 2 blue whales, 1 killer whale, and 1 leatherback sea turtle (NOAA 2017). In 2017, 1 gray, 3 humpback, and 1 blue whale entanglement were attributed to the CA Dungeness commercial fishery, and 1 gray and 1 humpback whale entanglement were attributed to the WA Dungeness commercial fishery (NOAA 2018c). In 2018 the trend continued with 7 humpback whale entanglements attributed to CA Dungeness fishery gear, 3 gray and 2 humpback entanglements due to WA Dungeness gear, 1 gray and 1 humpback entanglement due to OR Dungeness fishery gear, and 1 humpback whale entanglement due to commercial Dungeness gear not attributable to state (NOAA 2019). NOAA Fisheries attributes the increase in entanglements to a combination of factors including changes in whale abundance, climate-driven shifts in prey abundance and distribution resulting in changes in whale distribution, shifting temporal and spatial fishing patterns, and increased public reporting.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance

(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality

(same as Factor 1.2 above)

BENTHIC INVERTS

Factor 2.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON / NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

Abundance of unidentified benthic invertebrates is scored as a "moderate" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

Factor 2.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON / NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America

Low Concern

Fishing mortality of unidentified benthic invertebrates is scored as a "low" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

Factor 2.3 - Modifying Factor: Discards and Bait Use

Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

RATIO OF BAIT + DISCARDS/LANDINGS	FACTOR 2.3 SCORE
<100%	1
>=100	0.75

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON / NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America

< 100%

Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). The Dungeness crab mortality rate is 1 to 4% for undersize crabs, 1.2% for hard-shell males, 9 to 25% for soft-shell males, and 8% for females (Alverson et al. 1994) (SCS Global Services 2014) (Yochum et al. 2017). Limited research has been conducted on bycatch mortality. Mortality rate can vary temporally, spatially, and with stressors of repeated capture and varied handling time. Using a range of mortality rates of 1 to 25% for all discards, the net dead discard rate is estimated to range from 1.43 to 35.75%. Information on bait use is lacking because it is not quantified in the fishery. The best available estimate is 4.3 to 6.3 lb of crab landed for every pound of bait used in Oregon: approximately a 16 to 23% bait-to-landing ratio (ODFW, personal communication 2015). This is considered an appropriate estimate for the Alaskan region (F. Bowers, ADFG, personal communication 2015).

FINFISH

Factor 2.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

Abundance of unknown finfishes is scored as a "moderate" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

Factor 2.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

Low Concern

Fishing mortality for finfishes is scored as a "low" concern following scoring guidelines for the pot fisheries provided by the Seafood Watch Unknown Bycatch Matrix (Seafood Watch 2016).

Factor 2.3 - Modifying Factor: Discards and Bait Use

Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

RATIO OF BAIT + DISCARDS/LANDINGS	FACTOR 2.3 SCORE
<100%	1

>=100	0.75

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

< 100%

Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). The Dungeness crab mortality rate is 1 to 4% for undersize crabs, 1.2% for hard-shell males, 9 to 25% for soft-shell males, and 8% for females (Alverson et al. 1994) (SCS Global Services 2014) (Yochum et al. 2017). Limited research has been conducted on bycatch mortality. Mortality rate can vary temporally, spatially, and with stressors of repeated capture and varied handling time. Using a range of mortality rates of 1 to 25% for all discards, the net dead discard rate is estimated to range from 1.43 to 35.75%. Information on bait use is lacking because it is not quantified in the fishery. The best available estimate is 4.3 to 6.3 lb of crab landed for every pound of bait used in Oregon: approximately a 16 to 23% bait-to-landing ratio (ODFW, personal communication 2015). This is considered an appropriate estimate for the Alaskan region (F. Bowers, ADFG, personal communication 2015).

HUMPBACK WHALE

Factor 2.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

High Concern

Humpback whales in the California/Oregon/Washington stock feed along the US West Coast but are attributed to three Distinct Population Segments (DPS) (81 Federal Register 62259). The stock includes whales from the Central American DPS that are ESA listed as endangered (411 individuals), whales from the threatened Mexico DPS (3,264 individuals) and some from the non-listed Hawaii DPS (11,398 individuals). Those in the Hawaii DPS comprise a smaller proportion of the total stock, and feed in waters of northern Washington and southern British Columbia. The minimum population estimate for the California/Oregon/Washington stock is 2,784 with the population growing over the long term, but with trends that have varied in recent years (Carretta et al. 2019). Population trends are uncertain as humpback whales from three DPS are currently being managed as one stock. Since the stock includes endangered and threatened whales, abundance is considered a "high" concern.

Factor 2.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

High Concern

Along the west coast of the United States all Dungeness crab commercial fisheries are listed as Category II under the Marine Mammal Protection Act due to occasional incidental death or serious injury of humpback whales in the California/Oregon/Washington stock (83 Federal Register 5349) (Carretta et al. 2017a) (Carretta et al. 2017b). 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 and Warner 2001). Although typically many fishers cease fishing early in the season and there are less pots actively fishing by the time whales migrate north to feed, gear remains in the water posing an entanglement threat to whales. In 2016 the fishery opened four months later than is typical due to the presence of harmful algal blooms creating high temporal overlap with migrating whales (Chavez et al. 2017). Whales also moved nearshore during this season, presumably to feed on schooling fishes due to the low abundance of krill, resulting in more spatial overlap with fishery gear.

Annual average serious injury or mortality attributed to entanglement in Dungeness crab fishery gear for 2012 to 2016 is 20.3% of Potential Biological Removal (PBR, 16.7 whales per year) for CA, 0.9% for WA and 0.9% for OR (Carretta et al. 2019). For the entire region, 9.6% of PBR is attributed to unspecified pot and trap gear and 46.4% of PBR is attributed to unidentified fisheries. It is difficult to determine the region for serious injury and mortality as there is a high likelihood of the incident originating in one region and being observed later in migration in another region (NOAA 2018c). The exact contribution from the Dungeness crab fishery is unknown because not all gear is identifiable to source fishery. Since it is likely that most of the mortalities and serious injuries in the unidentified category are due to pot/trap fisheries (Carretta et al. 2019) and region is unknown, to err on the side of caution PBR for scoring purposes is inclusive of uncertainty as follows: 57% of PBR for WA/OR, and 76% of PBR for CA. There is uncertainty surrounding the estimate of cumulative fisheries mortality (94% of PBR), which likely is an underestimate since not all entanglements or ship-struck whales are documented (Carretta et al. 2019).

In recent years, reports of humpback whale entanglements in Dungeness crab gear have increased reaching a record high in 2016 with 19 cases reported along the US West Coast (NOAA 2017). In 2017, 5 cases were documented with 3 attributed to the CA Dungeness crab fishery, and 2 attributed to the WA Dungeneness crab fishery (NOAA 2018c). In 2018, humpback whales were the most common species entangled on the West Coast of the US (NOAA 2019). Of 34 entangled whales in 2018, 24 were identifiable to fishery with 7 attributed to the CA Dungeness crab fishery, 2 to the Washington Dungeness crab fishery, 1 to the Oregon Dungeness crab fishery, and one to commercial Dungeness gear unidentifiable to state.
However, entanglements from 2017 to the present have yet to be accounted for in the most recent stock assessment and serious injury and mortality designations are not available (Carretta et al. 2019). Further, the stock designation for the CA/OR/WA stock spans three DPS, inclusive of the endangered Central America DPS, and the serious injury and mortality rates for the stock are not identifiable to DPS (81 Federal Register 6225). The fisheries each account for more than 50% of PBR to the CA/OR/WA feeding group; however, with probable interaction with the endangered Central America DPS, based on spatio-temporal overlap, and an expectation that the average impact will increase as the higher interaction years are included into fishing mortality estimates, there is a high likelihood of exceeding PBR for this DPS. Fishery mortality is rated as a "high" concern since there is a strong possibility that the sustainable level of take for the Central America DPS is being exceeded.

Factor 2.3 - Modifying Factor: Discards and Bait Use

Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

RATIO OF BAIT + DISCARDS/LANDINGS	FACTOR 2.3 SCORE
<100%	1
>=100	0.75

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

< 100%

Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). The Dungeness crab mortality rate is 1 to 4% for undersize crabs, 1.2% for hard-shell males, 9 to 25% for soft-shell males, and 8% for females (Alverson et al. 1994) (SCS Global Services 2014) (Yochum et al. 2017). Limited research has been conducted on bycatch mortality. Mortality rate can vary temporally, spatially, and with stressors of repeated capture and varied handling time. Using a range of mortality rates of 1 to 25% for all discards, the net dead discard rate is estimated to range from 1.43 to 35.75%. Information on bait use is lacking because it is not quantified in the fishery. The best available estimate is 4.3 to 6.3 lb of crab landed for every pound of bait used in Oregon: approximately a 16 to 23% bait-to-landing ratio (ODFW, personal communication 2015). This is considered an appropriate estimate for the Alaskan region (F. Bowers, ADFG, personal communication 2015).

Criterion 3: Management Effectiveness

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective,' 'moderately effective,' 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

- *5 (Very Low Concern) — Meets the standards of 'highly effective' for all five factors considered.*
- *4 (Low Concern) — Meets the standards of 'highly effective' for 'management strategy and implementation' and at least 'moderately effective' for all other factors.*
- *3 (Moderate Concern) — Meets the standards for at least 'moderately effective' for all five factors.*
- *2 (High Concern) — At a minimum, meets standards for 'moderately effective' for Management Strategy and Implementation and Bycatch Strategy, but at least one other factor is rated 'ineffective.'*
- *1 (Very High Concern) — Management Strategy and Implementation and/or Bycatch Management are 'ineffective.'*
- *0 (Critical) — Management Strategy and Implementation is 'critical'.*

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 = Red or High Concern*

Rating is Critical if Management Strategy and Implementation is Critical.

GUIDING PRINCIPLE

- The fishery is managed to sustain the long-term productivity of all impacted species.

Criterion 3 Summary

Fishery	Management Strategy	Bycatch Strategy	Research and Monitoring	Enforcement	Stakeholder Inclusion	Score
Fishery 1: California/Eastern Central Pacific | Pots | United States of America	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)
Fishery 2: Alaska/Northeast Pacific | Pots | United States of America	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)
Fishery 3: British Columbia/Northeast Pacific | Pots | Canada	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)
Fishery 4: Oregon/Northeast Pacific | Pots | United States of America	Highly Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Green (4.000)

Fishery 5: Washington/Northeast Pacific | Pots | United States of America	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)

Criterion 3 Assessment

Factor 3.1 - 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? Do manages follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON/NORTHEAST PACIFIC
Pots | United States Of America

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) (CDFW 2014). The fishery is limited-entry and employs pot limits and gear restrictions, including size and escape mechanism requirements. To minimize handling mortality of softshell crab, WDFW annually imposes a Summer Fishery Management Plan that includes a 2,500 trip limit and bi-weekly crab condition testing (WDFW 2015). If testing indicates shell condition is under designated thresholds, trip limits will be reduced to 1,200 lb. Management is ranked as "moderately effective" due to a lack of biological data to determine stock abundance and its resilience to recent increased fishing effort and to future environmental fluctuations.

ALASKA / NORTHEAST PACIFIC
Pots | United States Of America

Moderately Effective

The Alaska Department of Fish and Game manages the fishery utilizing a 3-S strategy with a minimum size limit of 165 mm carapace width, restricted to male harvest with seasonal closures (Messmer et al. 2011) (Stratman et al. 2017). 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; however, in most areas 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. The viability of the historical 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 and Goldman 2006) (Messmer et al. 2011) (Wessel et al. 2012). As a precaution, the Southeast Alaska region

has implemented provisions for reductions in season length if predicted harvests do not meet prescribed thresholds (Messmer et al. 2011). 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. Due to need for increased precaution management strategy is rated as "moderately effective."

Justification:

Commercial Dungeness crab fisheries remain open in Southeast Alaska, Kodiak, and the Alaska Peninsula. The Alaska Department of Fish and Game (ADF&G) has maintained regional closures in the Prince William Sound (PWS), Yakutat, and Cook Inlet areas where crab populations historically collapsed (Trowbridge and 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 that all led 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 its entirety since 2000 (Copper River region of PWS since 1992, and 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. Closures have not generated population recovery and further intervention may be necessary.

BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada

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 2018). 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 a lack of biological reference points for precautionary population monitoring.

OREGON/ NORTHEAST PACIFIC
Pots | United States Of America

Highly Effective

The fishery is managed using a 3-S strategy with limits on size, sex, and season (ODFW 2015) (ODFW 2014). The fishery is limited-entry, employing gear restrictions and pot limits. Logbooks are required and must be completed prior to each landing. The season opening date is based on crab quality testing coordinated by the Tri-State Dungeness Crab Committee. Management is adaptive and continuously improving, most recently adopting Limit Reference Points (LRP) in 2014. The LRP is reached when landings have decreased for three consecutive seasons, landings are projected to continue declining in the fourth season to below 20% of the 20-year average, and logbook CPUE falls below the average for the 1980–1981 through 1986–1987 seasons. The LRP will be evaluated within 8 weeks of the opening of each season. Management has committed to respond by seasonal closure, reduction in pot or trip limits, area closures, or increasing minimum size limits if the LRP is reached. Due to a precautionary policy employing limit reference points, management is ranked as "highly effective."

Factor 3.2 - Bycatch Strategy

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and when applicable, to minimize ghost fishing? How successful are these management measures? To achieve a Highly Effective rating, the fishery must have no or low bycatch, or if there are bycatch or ghost fishing concerns, there must be effective measures in place to minimize impacts.

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

Moderately Effective

Entanglements of species listed as protected under the Endangered Species Act (ESA) are known to occur occasionally in Dungeness crab fishery gear in California (classified as a Category II fishery under the MMPA LOF, (83 Federal Register 5349), see Criterion 2). Since the Dungeness crab commercial fishery does not hold incidental take permits, authorized under section 10(a)(1)(b), these interactions have been in violation of the ESA. California uses single trap gear and permit and pot limits to minimize whale entanglement through reduction of gear in the water.

The California Department of Fish and Wildlife (CDFW) has developed an interim management strategy as they pursue ESA approved incidental take permits from the federal government. Management action was in response to a lawsuit filed by the Center for Biological Diversity (CBD) against CDFW for authorizing the California commercial Dungeness crab trap fishery. The CBD asserted that the fishery is operating illegally in that it entangles ESA listed humpback whales, blue whales, and leatherback sea turtles while not holding a permit that authorizes these incidental takes. In April 2019, a settlement was reached (Center for Biological Diversity vs. Bonham 2019) and CDFW implemented several management measures intended to minimize fishery interactions with the endangered species (see justification section).

Bycatch strategy is scored as "moderately effective" because management has initiated action to comply with relevant legal requirements regarding bycatch, and has implemented an interim management strategy with proactive bycatch management measures that should minimize interaction with whales. Since the effectiveness of these measures requires further scientific analyses, bycatch strategy does not qualify for a "highly effective" score.

Justification:

Terms of the CBD vs CDFW Settlement

A stay has been ruled in the CBD vs. Bonham case with the parties agreeing on a statewide commercial fishery closure (effective 15 April 2019) and a closure on 1 April in subsequent years, effectively minimizing interactions between the fishery and endangered whales during the time of year when the most overlap is expected (Center for Biological Diversity vs. Bonham 2019). These measures will remain in place until an incidental take permit is obtained from the federal government. A Habitat Conservation Plan (HCP) (draft expected by 15 May 2020) and Risk Assessment and Mitigation Plan (RAMP) (expected by 1 November 2020) are currently in development. Regular RAMP workshops will be held to promote public engagement and transparency. Risk assessment will be conducted monthly November to March and twice a month April to June. From the 2020 season onward, the post-1 April closure may be lifted if the RAMP demonstrates low entanglement risk for all factors. The CDFW has set interaction thresholds for triggering management actions including factors of fleet dynamics (behavior changes), ocean conditions (poor forage), presence of species of concern (based on NOAA fall whale aerial surveys, the spring NOAA rockfish survey and non-NOAA whale watch data), and number of entanglements. If there is a confirmed ESA-listed whale or sea turtle species entangled in CA Dungeness fishery gear, or two or more in unidentifiable gear, a district-wide closure or other management action that demonstrates protection of the ESA-listed species will be implemented. If a

confirmed ESA-listed sea turtle (indicated based on NOAA tagging data demonstrating a turtle is present in the fishing district) or if a NOAA survey observes 20 or more ESA-listed whales or a running average of 5 or more ESA-listed whales over a one-week period, a district-wide closure or other management action that demonstrates protection of the ESA-listed species will be implemented. Management actions may include modifications to allowable season, fishing areas, numbers of vessels and/or traps, reporting requirements (such as use of solar loggers) or no action. Rulemakings will be developed for gear retrieval and gear-marking requirements for all fixed gear fisheries (15 Nov 2019). Regulations will be developed by 1 Nov. 2020 that allow alternate gear such as ropeless technology. From the 2021 season onward, post-1 April districts 10, 17 and south will be open to ropeless gear. Funding will also be pursued in support of the California Dungeness Crab Fishing Gear Working Group to provide a stipend to members.

Additional Bycatch Mitigation Measures

Management mitigates impacts of the fishery on bycatch through gear requirements, limitations on soak time, and a specified final trap-retrieval day at the end of each season. Traps must have two 4¼- inch diameter escape rings in the upper half of the pot to allow for escape of undersize and female crab (CDFW 2014). 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.

Lost Dungeness fishery gear can cause marine mammal entanglement, mortality to benthic invertebrates, and habitat degradation. Thousands of Dungeness traps are lost annually: in Puget Sound, WA alone in 2010 loss was estimated at over 14,000 pots with 2,193 attributed to the commercial Dungeness fishery (Drinkwin 2015). Impacts can be wide ranging both temporally and spatially. Derelict Dungeness crab fishery gear has been observed ghostfishing for seven years (Maselko et al. 2013), and trap tags and floats from the Oregon fishery were observed four years after loss in the Northwestern Hawaiian Islands (Ebbesmeyer et al. 2012). Proposed regulations are under review that would enable post-season gear retrieval for lost or abandoned commercial Dungeness fishery gear. Once gear is retrieved the permit holder must be offered return of the gear in exchange for reasonable compensation, or alternatively CDFW will provide reimbursement and fine the permitholder. If implemented this will incentivize fishermen to remove derelict gear, which would reduce entanglement risk, ghostfishing, and damage to marine habitat.

In response to the increased entanglements, the California Dungeness Crab Fishing Gear Working Group (CDCFGWG),composed of 20 diverse stakeholders including commercial and recreational fishermen, environmental organization representatives, members of the whale entanglement response network, and state and federal agencies was created in 2015 to develop solutions to mitigate whale entanglement risk (CDCFGWG 2019b). The CDCFGWG developed a Best Practices Guide that recommends minimizing line length between the main and trailer buoys to reduce entanglement potential (CDCFGWG 2016). The group has also developed a Risk Assessment and Mitigation Plan (RAMP) to evaluate the risk of entanglement using five metrics: whale concentrations, recent entanglements in CA Dungeness crab fishing gear, season delay, fleet dynamics, and forage/ocean conditions. At the March 2019 assessment, current risks were rated low to moderate while risks for April/May 2019 ranged from low to high (CDCFGWG 2019a). Encouraging best fishing practices, NOAA trainings, a trap limit program, a gear recovery program, increased readiness of data gatherers, efforts to reduce vertical lines and gear modifications are all listed among possible management measures in response to elevated threat levels. Co-occurrence modeling of the distribution of whales and that of commercial fishing gear has been suggested as a tool to estimate entanglement risk (Saez et al. 2013). Models using data from 2004 to 2008 identified elevated co-occurrence scores for the Dungeness crab trap fishery and whales with the greatest risk of entanglement during November to January. In light of the recent settlement in the CBD vs. Bonham case the working group released a statement that they will pause on recommending management action but encourage fishermen to consider using as minimal gear as possible, reduce vertical lines and avoid areas with whales, schools of anchovy, or krill (CDCFGWG 2019b). The working group is actively working on development of the RAMP and in conducting future risk evaluations.

Recent Legislation

The Fisheries Omnibus Bill of 2018 (Senate Bill 1309) was chaptered in September 2018 to provide the Director of Fish and Wildlife with interim authority to implement management measures to the Dungeness crab fishery in an effort to address risks to marine life until a robust regulatory program is adopted (California Legislature 2018a).

ALASKA / NORTHEAST PACIFIC

Pots | United States Of America

Highly Effective

Management mitigates impacts of the fishery on bycatch through gear requirements. Traps must have two 4⅜-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, because the current design is vulnerable to unsuccessful lid release due to metal fatigue and biofouling (Maselko et al. 2013). Lost Dungeness fishery gear can cause marine mammal entanglement, mortality to benthic invertebrates, and habitat degradation. Impacts can be wide ranging both temporally and spatially. Derelict Dungeness crab fishery gear has been observed ghostfishing for seven years (Maselko et al. 2013), and trap tags and floats from the Oregon fishery were observed four years after loss in the Northwestern Hawaiian Islands (Ebbesmeyer et al. 2012). The use of single trap gear and permit and pot limits minimizes whale entanglement through reduction of gear in the water.

BRITISH COLUMBIA / NORTHEAST PACIFIC

Pots | Canada

Highly Effective

Management mitigates impacts of the fishery on bycatch through gear requirements (DFO 2019). Traps must have two 105-mm diameter escape rings to allow for escape of undersize crab and females. Since use of hanging bait may increase the catch of soft-shell crab, to reduce handling mortality, hanging bait and bait cages have been banned in some regions. Managers may implement in-season closures if a high frequency of soft-shell capture 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. Lost Dungeness fishery gear can cause marine mammal entanglement, mortality to benthic invertebrates, and habitat degradation. Impacts can be wide ranging both temporally and spatially. Derelict Dungeness crab fishery gear has been observed ghostfishing for seven years (Maselko et al. 2013), and trap tags and floats from the Oregon fishery were observed four years after loss in the Northwestern Hawaiian Islands (Ebbesmeyer et al. 2012).The use of single trap gear and permit and pot limits minimizes whale entanglement through reduction of gear in the water.

OREGON/NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON/NORTHEAST PACIFIC
Pots | United States Of America

Moderately Effective

Entanglements of species listed as protected under the Endangered Species Act (ESA) are known to occur occasionally in Dungeness crab fishery gear in Oregon and Washington (classified as a Category II fisheries under the MMPA LOF, (83 Federal Register 5349), see Criterion 2). Since the Dungeness crab commercial fishery does not hold incidental take permits, authorized under section 10(a) (1) (b), these interactions have been in violation of the ESA. Both Oregon and Washington use single trap gear and permit and pot limits to minimize whale entanglement through reduction of gear in the water.

The Oregon Department of Fish and Wildlife (ODFW) intends to apply for ESA approved incidental take permits from the federal government (Melcher 2019) and is developing an interim management strategy until permits are in place. Interim management measures were proposed at industry meetings in October 2018 and their efficacy was analyzed by ODFW (ODFW 2019a). ODFW will brief the Oregon Fish and Wildlife Commission on proposed measures for a phased rule-making approach toward mitigating whale entanglement in June 2019 (ODFW 2019b) (ODFW 2019d). These include further reduced pot limits, additional buoy tag requirements (color and pattern registration) to enforce pot limits and help in gear identification in the event of an entanglement, setting a control date, and implementing electronic crab ticket submission requirements (to inform fishery effort and whale overlap). The second phase of regulatory measures for spring 2020 would apply to later in the season (timing yet to be defined) when whales are expected to have more spatial overlap with the fishery. Recommendations would be drafted after input from public fall 2019 industry meetings, but would include specified late-season reduced pot limits, buoy tags, derelict gear removal, and eliminate the current two week post-season gear removal period. In the future, ODFW is considering real-time vessel monitoring requirement and late season limits.

In December 2018, Washington Department of Fish and Wildlife (WDFW) declared an intent to apply for ESA approved incidental take permits from the federal government; it is developing an interim management strategy until permits are in place (WDFW 2019). A WDFW workshop was conducted in March 2019 to develop potential whale protective management measures (season and area closures, reduced pot limits and revised gear configurations), and consider implementing electronic monitoring tools to assess the spatial distribution of the crab fishery. A follow up workshop in April 2019 outlined a timeline for potential mitigation measures including consideration of an emergency rule for pot limit reduction in 2019 and for crab fishery start date in 2020 (WDFW 2019b). Required breakaway devices and seasonal tag markings were also proposed. In June 2019, WDFW implemented reduced pot limits (~33% reduction) with the intent of reducing line in the water and minimizing whale entanglement risk (WDFW 2019c).

Bycatch strategy is scored as "moderately effective," since management has initiated action to comply with relevant legal requirements regarding bycatch, and is developing an interim management strategy considering several proactive bycatch management measures that should minimize interaction with whales. Because the effectiveness of these measures requires further scientific analyses, bycatch strategy does not qualify for a "highly effective" score.

Justification:

Oregon Sea Grant, at the request of Oregon fishers, developed a multi-stakeholder Oregon Whale Entanglement Working Group in 2017 to develop strategies to minimize whale entanglement risk in the Dungeness crab fishery. The group released a 2018–2019 directive to minimize whale entanglement risk suggesting best practices of using the minimal line length necessary, keeping the vertical line between the pot

and main buoy as taut as possible, limiting floating line, removing inactive fishing gear, maintaining clear gear markings, avoiding setting gear near whales, and communicating areas of high whale activity to other fishers (ODFW 2019c). They also encourage fishers to participate in post-season derelict gear removal programs. ODFW is seeking funding for whale surveys to better understand temporal and spatial whale distribution at a fine scale in collaboration with the Oregon State University Marine Mammal Institute (ODFW 2019b).

In response to increased whale entanglement in recent years, the Washington Whale Entanglement Working Group was created in 2017 to study and implement solutions towards minimizing interactions between whales and the Dungeness crab fishery (WDFW 2019). The group identifies research priorities, tests alternative gear and communicates with the fleet about best practices. They developed a 2018–2019 directive to minimize entanglement risk including using the minimal line length necessary, keeping the vertical line between the pot and main buoy as taut as possible, limiting floating line, minimizing knots and splices, maintaining clear gear marking, avoiding setting gear near whales and communicating areas of high whale activity to other fishers. They also encourage fishers to participate in post-season derelict gear removal programs.

Both the Oregon and Washington whale entanglement working groups are involved in outreach, entanglement response trainings, and should they occur, learning more from entanglements and how and why they occur through forensic analyses.

Management mitigates impacts of the fishery on bycatch through gear requirements, limitations on soak time, and a specified final trap-retrieval day at the end of each season. Traps must have two 4¼- inch diameter escape rings in the upper half of the pot to allow for escape of undersize and female crab (WAC 2012b). 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. Lost Dungeness fishery gear can cause marine mammal entanglement, mortality to benthic invertebrates, and habitat degradation. Thousands of Dungeness traps are lost annually: in Puget Sound, WA alone in 2010 loss was estimated at over 14,000 pots with 2,193 attributed to the commercial Dungeness fishery (Drinkwin 2015). Impacts can be wide ranging both temporally and spatially. Derelict Dungeness crab fishery gear has been observed ghostfishing for seven years (Maselko et al. 2013) and trap tags and floats from the Oregon fishery were observed four years after loss in the Northwestern Hawaiian Islands (Ebbesmeyer et al. 2012).

Factor 3.3 - Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the fishery's impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON/NORTHEAST PACIFIC
Pots | United States Of America

Moderately Effective

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

Scientific research exists on the fishery's impacts on sublegal and female crab, but data are limited and more comprehensive information is necessary regarding the magnitude of bycatch collected, handling effects, and mortality. Based on co-occurrence, the Dungeness crab trap fishery has the highest whale entanglement risk among commercial fixed-gear fisheries off the US West Coast (Saez et al. 2013). Despite entanglement concerns, 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. More research is necessary to determine the prevalence in other regions and the magnitude attributed specifically to the Dungeness crab fishery. The use of single trap gear and pot limits minimizes whale entanglement through reduction of gear in the water. 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 to 20% of traps are lost at sea annually, with 7.5 to 32.5% of lost pots actively ghostfishing that result in bycatch mortality (Breen 1990) (ODFW 2012). Ghostfishing presents a serious concern because derelict pots can fish effectively for at least 7 years in some regions (Maselko et al. 2013). More information is needed to identify and quantify species that are affected by lost Dungeness crab pots. Due to limited data availability this factor is rated "moderately effective."

ALASKA / NORTHEAST PACIFIC
Pots | United States Of America

Moderately Effective

Data are collected to assess stock health and to evaluate population age and size composition through comprehensive fish ticket reporting and dockside sampling (Messmer et al. 2011) (Stratman et al. 2017). Sampling occurs occasionally via onboard observer and on-the-ground surveys, but sampling is not spatially or temporally comprehensive and life-history timing is uncertain. Due to insufficient resources, management lacks a fishery-independent stock assessment program. Research is ranked as "moderately effective" due to incomplete coverage, since Dungeness crab displays high spatial and temporal variability in life-history timing (Bishop et al. 2010).

BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada

Moderately Effective

Fishery-independent stock assessments are conducted twice annually in two of seven designated fishing areas (Areas I and J) (DFO 2018). 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 recently begun fishery independent surveys in additional fishing areas to collect additional biological information (DFO 2018). As data collected do not meet the standards of "highly effective," but limited data are used to monitor and manage the stock, scientific research and monitoring is rated as "moderately effective."

OREGON/ NORTHEAST PACIFIC
Pots | United States Of America

Moderately Effective

There is no regular stock assessment for Dungeness crab in Oregon. Monitoring programs are in place to assess mating success, population genetic structure, size structure, and to estimate discard mortality (ODFW

2014). Stock health and bycatch composition are assessed through fish-ticket reporting and dockside and at-sea sampling; CPUE data are obtained from logbook records. Monitoring is considered "moderately effective" due to the limited amount of fishery-independent data, which prevents a score of "highly effective" from being achieved.

Factor 3.4 - Enforcement of Management Regulations

Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

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, gear, and vessel inspection.

ALASKA / NORTHEAST PACIFIC
Pots | United States Of America

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
Pots | Canada

Highly Effective

The DFO conducts enforcement activities to survey closed areas for illegal activity; to check gear requirement compliance; to investigate landings of undersize, female, and soft-shell crab; and to investigate fraudulent crab landing reporting (DFO 2018). The enforcement program includes dockside monitoring, vessel inspection, electronic vessel monitoring, and fishery patrol via vessel and air surveillance.

OREGON/ NORTHEAST PACIFIC
Pots | United States Of America

Highly Effective

The Oregon State Police (OSP) Fish and Wildlife Division troopers patrol for violations, ensure fishers are licensed and maintain log books, monitor crab pots for compliance in size and escape mechanisms, and enforce size limits. The OSP works cooperatively with the Oregon Department of Fish and Wildlife in planning enforcement priorities (OSP 2015).

Factor 3.5 - Stakeholder Inclusion

Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent, if high participation by all stakeholders is encouraged, and if there a mechanism to effectively address user conflicts.

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America

Highly Effective

The California and Washington Departments of Fish and Wildlife solicit input on fishery management from the public and industry advisory groups: the California Dungeness Crab Task Force, the California Dungeness Crab Fishing Gear Working Group, and the Washington Coastal Dungeness Crab Advisory Board (DCTF 2012) (WADFW 2013) (NOAA 2017a).

ALASKA / NORTHEAST PACIFIC
Pots | United States Of America

Highly Effective

The Southeast Alaska Commercial Dungeness Task Force, comprised of ten commercial fishers, serves as an industry advisory group to management (ADF&G 2000). Public comment is welcome at Alaska Board of Fisheries meetings and the public can submit proposed regulatory changes for consideration by the Alaska Board of Fisheries.

BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada

Highly Effective

The crab fishery management process is inclusive of stakeholder groups (DFO 2018). Fishery planning involves an annual consultative process through a Crab Sectoral Committee comprised of representatives from DFO, commercial license holders, and processors.

OREGON/ NORTHEAST PACIFIC
Pots | United States Of America

Highly Effective

The Oregon Department of Fish and Wildlife solicits stakeholder input on management issues from the Oregon Dungeness Crab Advisory Committee, the Oregon Dungeness Crab Commission, and the public (ODFW 2014). Agency, industry, and the public are involved in making management decisions through surveys, workshops, and public meetings. The Oregon Fish and Wildlife Commission considers and adopts new regulations at public meetings where all stakeholders have the opportunity for public comment. ODFW distributes a crab fishery annual newsletter to keep stakeholders informed.

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 (factor 4.1 + factor 4.2) and the Ecosystem Based Fishery Management score. The Criterion 4 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*

GUIDING PRINCIPLES

- Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.
- Follow the principles of ecosystem-based fisheries management.

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region | Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Score
Alaska/Northeast Pacific | Pots United States of America	4	0	Moderate Concern	Green (3.464)
British Columbia/Northeast Pacific | Pots Canada	4	0	Moderate Concern	Green (3.464)
California/Eastern Central Pacific | Pots United States of America	4	0	Moderate Concern	Green (3.464)
Oregon/Northeast Pacific | Pots United States of America	4	0	Moderate Concern	Green (3.464)
Washington/Northeast Pacific | Pots United States of America	4	0	Moderate Concern	Green (3.464)

Criterion 4 Assessment

SCORING GUIDELINES

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate

Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

- *5 - Fishing gear does not contact the bottom*
- *4 - Vertical line gear*
- *3 - 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. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 - Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.*
- *1 - Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 - 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.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

- *+1 —>50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very low/limited and for trawled fisheries, expansion of fishery's footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of 'moderate' mitigation measures.*
- *+0.5 —At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery's footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.*
- *0 —No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in factor 4.1*

Factor 4.3 - Ecosystem-Based Fisheries Management

Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

- *5 — Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do*

not have negative ecological effects.

- *4 — Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.*
- *3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 — Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 — Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON / NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America

4

The fishery uses pot/trap gear that contacts the bottom (via a vertical line) primarily in mud and sand habitats with the potential to crush and scour biogenic structures (DFO 2013a).

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
OREGON / NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America

0

Damage to the seafloor is mitigated through maximum trap size and pot limits and through derelict gear removal programs to remove lost traps (WAC 2012b) (DFG 2012b) (ODFW 2015). There are no-take Marine Protected Areas in each state, but they represent less than 20% of Dungeness crab habitat.

ALASKA / NORTHEAST PACIFIC
Pots | United States Of America

0

Fishing effort and spatial footprint are reduced via pot limits and gear size restrictions (Messmer et al. 2011). The magnitude of the spatial footprint is uncertain because 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 and Goldman 2006) (Messmer et al. 2011) (Wessel et al. 2012).

BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada

0

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 2018). Fishery effort is regulated with pot limits; however, some fishers have compensated for this limitation by increasing the frequency of haul—effectively increasing spatial footprint. In the 2013 season, new regulations were implemented in some regions that restrict haul frequency to once per day. The spatial footprint is further reduced through limits on maximum trap size.

Factor 4.3 - Ecosystem-Based Fisheries Management

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
ALASKA / NORTHEAST PACIFIC
Pots | United States Of America
BRITISH COLUMBIA / NORTHEAST PACIFIC
Pots | Canada
OREGON / NORTHEAST PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America

Moderate Concern

Dungeness crab plays important roles in trophic interactions both as predator and prey (Pauley et al. 1989). There is, however, no evidence that they play a disproportionate role in the ecosystem relative to their biomass. No formal assessments of ecosystem impacts of Dungeness crab-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.

Acknowledgements

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

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References

81 Federal Register 6225 (8 September 2016) Endangered and Threatened Species; Identification of 14 Distinct Population Segments of the Humpback Whale (Megaptera novaeangliae) and Revision of Species-Wide Listing. pp 62259-62320

83 Federal Register 5349. List of Fisheries for 2018. A Rule by the National Oceanic and Atmospheric Administration on 02/07/2018. pp. 5349-5372

84 Federal Register 118 (19 June 2019) Department of Commerce National Oceanic and Atmospheric Administration RIN 0648–XG300 2018 Marine Mammal Stock Assessment Reports pp 28489-28510

Alaska Department of Fish and Game (ADFG). 1994. Dungeness Crab. http://www.adfg.alaska.gov/static/education/wns/dungeness_crab.pdf

Alaska Department of Fish and Game (ADFG). 2015. 2015-2018 Commercial fishing regulations shrimp, Dungeness crab and miscellaneous shellfish.

Alaska Department of Fish and Game (ADFG). 2019. Dungeness Crab Fishery Catch, Effort, & Value Registration Area A (Southeast Alaska). Available at: http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareasoutheast.shellfish_harvest_dungenessa

Alverson, D.L., M.H. Freedberg, S.A. Murawski, J.G. Pope. 1994. A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper 339.

Antonelis, K., D. Huppert, D. Velasquez and J. June. 2011. Dungeness crab mortality due to lost traps and a cost-benefit analysis of trap removal in Washington state waters of the Salish Sea. N. Am. J. Fish. Manage. 31(5):880-893.

Armstrong, D.A., C. Rooper, D. Gunderson. 2003. Estuarine production of juvenile Dungeness crab (Cancer magister) and contribution to the Oregon-Washington coastal fishery. Estuaries 26(4B): 1174-1188.

Bishop, G.H., C.E. Siddon, J.M. Rumble. 2010. Change-in-Ratio and Index-Removal Population Estimation of Dungeness Crab in Southeastern Alaska. In: G.H. Kruse, G.L. Eckert, R.J. Foy, R.N. Lipcius, B. SainteMarie, D.L. Stram, and D. Woodby, eds., Biology and Management of Exploited Crab Populations under Climate Change. Alaska Sea Grant, University of Alaska Fairbanks.

Botsford, L.W. 2001. Physical influences on recruitment to California Current invertebrate populations on multiple scales. ICES J. Mar. Sci. 58:1081-1091

Bradburn MJ, Keller AK, and BH Horness. The 2003 to 2008 U.S. West Coast Bottom Trawl Surveys of Groundfish Resources off Washington, Oregon, and California: Estimates of Distribution, Abundance, Length, and Age Composition. NOAA Technical Memorandum NMFS-NWFSC-114

Breen, P. A. 1990. A review of ghost fishing by traps and gillnets. In Proceedings of the Second International Conference on Marine Debris, R. S. Shomura and M. L. Godfrey, eds. pp. 571-599. Commerce, NOAA Technical Memo. NMFS-SWFSC-154.

Butler, T.H. 1961. Growth and age distribution of the Pacific edible crab Cancer magister Dana. J. Fish. Res. Bd. Can. 18(5): 873-891.

California Legislature. 2018a. Fisheries Omnibus Bill of 2018, S. 1309. Available at: http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1309

California Legislature. 2018b. S. 1310. Available at: http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1310

Carretta JV, Moore JE and KA Forney. 2017c. Regression tree and ratio estimates of marine mammal, sea turtle, and seabird bycatch in the California drift gillnet fishery: 1990-2015. NOAA-TM-NMFS-SWFSC-568

Carretta, JV, SM Wilkin, MM Muto, and K Wilkinson. 2017b. Sources of human-related injury and mortality for U.S. Pacific west coast marine mammal stock assessments, 2011-2015. U.S Dep Commer, NOAA Tech. Memo. NMFS-SWFSC-579, 129 p.

Carretta J, K. Forney, E. Oleson, D. Weller, A. Lang, J. Baker, M. Muto, B. Hanson, A. Orr, H. Huber, M. Lowry, J. Barlow, J. Moore, D. Lynch, L. Carswell, and R. Brownell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. NOAA-TM-NMFS-SWFSC-617

California Dungeness Crab Fishing Gear Working Group (CDCFGWG). 2016. California Dungeness Crab Fishing 2016-17 Best Practices Guide to Minimize Whale Entanglement Risk.

California Dungeness Crab Fishing Gear Working Group (CDCFGWG). 2019a. California Dungeness Crab Fishing Gear Working Group March 19, 2019 Convenings. Evaluation Team Advisory 2018-19 Whale Entanglement Risk Assessment & Mitigation Program (RAMP).

California Dungeness Crab Fishing Gear Working Group (CDCFGWG). 2019a. California Dungeness Crab Fishing Gear Working Group Statement March 29, 2019. Available at: http://www.opc.ca.gov/webmaster/_media_library/2019/03/RAMP_WGStatement_March262019.pdf

California Department of Fish and Wildlife (CDFW). 2014. Review of selected California fisheries for 2013: coastal pelagic finfish, market squid, groundfish, highly migratory species, Dungeness crab, basses, surfperch, ablone, kelp and edible algae, and marine aquaculture. CalCOFI Rep v 55

California Department of Fish and Wildlife (CDFW). 2016. 2016 California Legislative Fisheries Forum. Department of Fish and Game Annual Marine Fisheries Report.

California Department of Fish and Wildlife (CDFW). 2018. California commercial Dungeness crab catch by season and area (pounds and metric tons), 1915-2017. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=136632&inline

Center for Biological Diversity plaintiff) vs. Charlton H. Bonham, in his official capacity as Director of the California Department of Fish and Wildlife (defendant) and Pacific Coast Federation of Fishermen's Associations and Institute for Fisheries Resources (intervenor-defendants). Stipulation and [Proposed] Order Staying Case. Case No. 3:.17-cv-05685-MMC. Document 71. Filed 03/26/2019

Chavez F., C. Costello, D. Aseltine-Neilson, H. Doremus, J. Field, S. Gaines, M. Hall-Arber, N. Manuta, B. McCovey, C. Pomeroy, L. Sievanen, W. Sydeman, S. Wheeler. (California Ocean Protection Council Science Advisory Team Working Group) 2017. Readying California fisheries for climate change. California Ocean Science Trust, Oakland, California, USA.

Curtis K.A., J.E. Moore, S.R. Benson. 2015. Estimating limit reference points for Western Pacific leatherback turtles (Dermochelys coriacea) in the U.S. West Coast EEZ. PLoS ONE 10(9): e0136452.

Demory, D. 1990. History and status of the Oregon Dungeness crab fishery. ODFW. 13 pp.

Fisheries and Oceans Canada (DFO). 2019. Pacific Region Integrated Fisheries Management Plan, Crab by Trap, April 1, 2019 to March 31, 2020.

Diamond, N. and D.G. Hankin. 1985. Movements of adult female Dungeness crabs (Cancer magister) in Northern California based on tag recoveries. Can. J. Fish. Aquat. Sci. 42: 919-926.

Drinkwin, J. 2015. Puget Sound Lost Crab Pot Prevention Plan: Prepared for Northwest Straits Foundation.

Dunn, PH and AL Shanks. 2012. Mating success of female Dungeness crabs (Cancer magister) in Oregon coastal waters. J Shellfish Res 31(3):835-839

Curtis C. Ebbesmeyer CC, Ingraham WJ, Jones JA and MJ Donohue. 2012. Marine debris from the Oregon Dungeness crab fishery recovered in the Northwestern Hawaiian Islands: Identification and oceanic drift paths. Marine Pollution Bulletin 65:69-75

Garth, J.S. D.P. Abbott 1980. Brachyura: The true crabs. In: Morris, H., D.P Abbott and E.C. Haderlie (Eds.), Intertidal Invertebrates of California. Stanford University Press, Stanford, California. pp 594–630

Hankin, D.G. and R.W. Warner. 2001. Dungeness crab. In: Leet, W.S., C.M. Dewees, R. Klingbeil, and E.J. Larson(eds). California's Living Marine Resources: A Status Report. Sacramento: California Department of Fish and Game. p 107-11.

Hankin, D.G., T.H. Butler, P.W. Wild, and Q.L. Xue. 1997. Does intense fishing on males impair mating success of female Dungeness crabs? Can. J. Fish. Aquat. Sci. 54:655-669

Hoopes, D.R. 1973. Alaska's fishery resources - the Dungeness crab. Fishery Facts-6. Commerce, National Oceanic and Atmospheric Administration(NOAA), National Marine Fisheries Service(NMFS).

IACP. 2008. Enforcement program staffing requirements. Study report presented to the Washington Department of Fish and Wildlife.

Jensen, P.C. and P. Bentzen. 2012. A molecular dissection of the mating system of the Dungeness crab, Metacarcinus magister (Brachyura: Cancridae). J. Crust. Biol. 32(3): 443-456

Kelleher, K. 2005. Discards in the world's marine fisheries: an update. FAO Fisheries Technical Paper 470.

Kelley S., D. Hart, S. Heinl, S. Dressel, W. Davidson, G. Oliver. 2011. A program for improving management and research of fisheries in the Southeast region. ADFG Regional Information Report 1J11-14.

Lang AR, Calambokidis J, Scordino J, Pease VL, Klimek A, Burkanov VN, Gearin P, Litovka D, Robertson K, Mate B, Jacobsen JK and BL Taylor. 2017. Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds. Mar Mamm Sci. 2014;30(4):1473–93.

Maselko, J., G. Bishop, P. Murphy. 2013. Ghost fishing in the southeast Alaska commercial Dungeness crab fishery. N. Am. J. of Fish. Manage. 33(2):422-431

Melcher, Curt. 2019. "Letter of intent to apply for incidental take permit" 12 April 2019 Available at: https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/ODFW%20Intent%20Letter_041219.pdf

Messmer, A., G. Bishop, C. Siddon, J. Stratman. 2011. 2012 Report to the Alaska Board of Fisheries on Southeast Alaska/Yakutat Dungeness crab fisheries. ADFG, Fishery Management Report No. 11-62.

Muto, M. M., V. T. Helker, R. P. Angliss, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2019. Alaska marine mammal stock assessments, 2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-393, 390 p. Document available at: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-393.pdf

Neilson, J.L., J.M. Straley, C.M. Gabriele, S. Hills. 2009. Non-lethal entanglement of humpback whales (Megaptera novaeangliae) in fishing gear in northern Southeast Alaska. J. Biogeogr. 36: 452-464.

NOAA. 2017. 2016 West Coast Entanglement Summary. US Dept of Commerce.

National Oceanic and Atmospheric Administration (NOAA). 2018b. Cumulative trade data by product. National Marine Fisheries Service, Fisheries Statistics and Economics Division. Accessed April 2018. http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/applications/trade-by-product

NOAA. 2018c. 2017 West Coast Entanglement Summary. US Dept of Commerce.

NOAA. 2019. 2018 West Coast Entanglement Summary. US Dept of Commerce. Available at: https://s3-us-west-2.amazonaws.com/sfwart/comments/70224/6.10.2019_WCR_2018_Entanglement_Report_508.pdf

National Oceanic and Atmospheric Administration (NOAA). 2018a. National Marine Fisheries Service annual commercial landing statistics. Accessed April 2018. http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

Natural Resources Consultants (NRC). 2006. Derelict fishing gear identification and removal project Port Susan. 13 pp

Northwest Straits Foundation Natural Resources Consultants (NSF NRC). 2011. British Columbia survey and removal project. 17 pp.

Oregon Department of Fish and Wildlife (ODFW). 2012. Oregon Fishing Industry Partnership to Restore Marine Habitat Final Report. NOAA Fisheries Habitat Conservation Program Office Grant Award NA09NMF4630325.

Oregon Department of Fish and Wildlife (ODFW). 2014. Oregon Dungeness Crab Research and Monitoring Plan

ODFW. 2014b. Commercial Ocean Dungeness Crab Fishery Logbook CPUE Preliminary Assessment – 3rd iteration. Oregon Department of Fish and Wildlife Marine Resources Program March, 2014

ODFW. 2014b. Commercial Ocean Dungeness Crab Fishery Logbook CPUE Preliminary Assessment – 3rd iteration Oregon Department of Fish and Wildlife Marine Resources Program March, 2014. Available at: https://s3-us-west-2.amazonaws.com/sfwart/comments/70410/ODFW%20Crab%20Logbook%20CPUE_sent030414.pdf

Oregon Department of Fish and Wildlife (ODFW). 2015. Commercial Fisheries Division 005 Commercial Shellfish and Marine Invertebrate Fisheries General Regulations. Accessed May 2015 at: http://www.dfw.state.or.us/OARs/05.pdf

ODFW. 2019c. Oregon Commercial Dungeness Crab Fishing 2018 - 2019 Directive to Minimize Whale Entanglement Risk Recommended by the Oregon Whale Entanglement Working Group. Available at: https://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/owewg_2018-2019_bestpracticesdirective.pdf

ODFW. 2019a. ODFW Reducing the Risk of Whale Entanglements in Oregon Dungeness Crab Gear. Presentation from October 2018 Industry Meetings. Available at: https://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/4_whaleentanglements_odfw_2018indust

ODFW. 2019b. 10th Annual Oregon Department of Fish and Wildlife Marine Resources Program Dungeness Crab Fishery Newsletter. November 2018. Available at: https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/Crab%20Newsletter_2018_final.pdf

ODFW. 2019d. Whale Entanglement Mitigation Update Industry Notice April 12, 2019. Available at: https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/Industry%20Notice%202019-0412_FINAL.pdf

Oh, S.J. D.G. Hankin. 2004. The sperm plug is a reliable indicator of mating success in female Dungeness crabs, Cancer magister. J. Crust. Biol. 24(2):314-326

O'Malley, K and C Roegner. 2014. Evaluating the population genetic structure of Dungeness crab (Cancer magister) off the Oregon coast. Oregon Wave Energy Trust

Orensanz, J.M., J. Armstrong, D. Armstrong, R. Hilborn. 1998. Crustacean resources are vulnerable to serial depletion - the multifaceted decline of crab and shrimp fisheries in the Greater Gulf of Alaska. Rev. Fish. Biol. Fisher. 8: 117-176

Oregon State Police (OSP). 2015. Oregon State Police - Fish and Wildlife Division Cooperative Enforcement Planning. Accessed May 2015: http://www.oregon.gov/osp/FW/pages/cep.aspx

Oregon Whale Entanglement Working Group (OWEWG). 2017. 2017 - 2018 Directiveto Minimize Whale Entanglement Risk. Available at: http://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/owewg_2017-2018_bestpracticesdirective.pdf

Pauley, G.B., D.K. Armstrong, R. Van Citter, and G.L. Thomas. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--Dungeness crab. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.121). U.S. Army Corps of Engineers, TR EL-82-4. 20 pp.

PSMFC. 2012. Pacific States Marine Fisheries Commission Dungeness crab report 2012.

Saez, L., D. Lawson, M. DeAngelis, E. Petras, S. Wilkin, and C. Fahy. 2013. Understanding the cooccurrence of large whales and commercial fixed gear fisheries off the west coast of the United States. NOAA Technical Memorandum NMFS–SWR–044.

SCS Global Services. 2014. Oregon Dungeness crab 2014 4th MSC surveillance audit report. Certificate Number: SCS-MF-0024

Seafood Business. 2013. Seafood Handbook: Dungeness Crab. Available at: http://media.usfood.com/html/TipsTools/SeafoodHandbook/shellfish/shell01.html

Seafood Watch. 2016. Monterey Bay Aquarium Seafood Watch Standard for Fisheries vF3.2. Available at:

https://www.seafoodwatch.org/-/m/sfw/pdf/criteria/fisheries/mba_seafood%20watch_fisheries%20standard_version%20f3.2.pdf?la=en

Shanks, A.L. 2013. Atmospheric forcing drives recruitment variation in the Dungeness crab (Cancer magister), revisited. Fish. Oceanogr. doi: 10.1111/fog.12020

Shanks, A. 2017. Report on the recruitment of Dungeness crab megalopae during the 2017 recruitment season. Oregon Dungeness Crab Comission.

Shanks, A.L. and G.C. Roegner. 2007. Recruitment limitation in Dungeness crab populations is driven by variation in atmospheric forcing. Ecology 88(7): 1726-1737.

Shanks A., C. Roegner & J. Miller. Using megalopae abundance to predict future commercial catches of Dungeness crabs (Cancer magister) in Oregon. CalCOFI Rep 51

Smith B.D. and G.S. Jamieson. 1989. Exploitation and mortality of male Dungeness Crabs (Cancer magister) near Tofino, British Colombia. Can. J. Fish. Aquat. Sci. 46(9): 1609-1614.

Spear, F and C Babich. 2001. Marine law enforcement. In: Leet, W.S., C.M. Dewees, R. Klingbeil, and E.J. Larson (eds). California's Living Marine Resources: A Status Report. Sacramento: California Department of Fish and Game. P 67-72.

Stevens, B.G., D.A. Armstrong, R. Cusimano. 1982. Feeding habits of the Dungeness crab Cancer magister as determineid by the Index of Relative Importance. Mar. Biol. 72:135-145.

Stratman J., K. Wood and J.A. Messmer. 2017. Annual Management Report for the 2016/2017 Southeast Alaska/Yakutat Dungeness Crab Fisheries. ADFG Fishery Management Report No. 17-55

Swiney, K.M., T.C. Shirley, S.J. Taggar, C.E. O'Clair. 2003. Dungeness crab, Cancer magister, do not extrude eggs annually in southeastern Alaska: an in situ study. J. Crust. Biol. 23(2): 280-288.

Tasto, R.N. 1983. Juvenile Dungeness crab, Cancer magister, studies in the San Francisco Bay area. Pages 135-154 in P.W. Wild and R.N. Tasto, eds. Life history, environment, and mariculture studies of the Dungeness crab, Cancer magister, with emphasis on the central California fishery resource. Calif. Dep. Fish Game Fish Bull. 172.

Trowbridge, C.E. and K.J. Goldman. 2006. 2006 review of Cook Inlet Area commercial fisheries for Dungeness crab, shrimp, and miscellaneous shellfish fisheries: A report to the Alaska Board of Fisheries. ADFG, Special Publication No. 06-09.

U.S. Congress. 1998. To authorize the States of Washington, Oregon, and California to regulate the Dungeness crab fishery in the exclusive economic zone.,105th Cong., 2nd sess., S. 1726.

Washington Administrative Code (WAC). 2007. Washington Administrative Code (WAC) 220-52-041. Coastal Dungeness crab logbook requirements. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=220-52-041

Washington Administrative Code (WAC). 2012b. Washington Administrative Code 220-52-043. Commercial crab fishery – Shellfish pot requirements. Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=220-52-043

Washington Administrative Code (WAC). 2012a. Washington Administrative Code 220-52-040. Commercial crab fishery – Unlawful acts. Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=220-52-040

Washington Department of Fish and Wildlife (WDFW). 2013. Coastal Commercial Dungeness Crab Fishery 2011-2013 Coastal Dungeness Crab Advisory Board. Available at: http://wdfw.wa.gov/fishing/commercial/crab/coastal/advisory_board.html

Washington Department of Fish and Wildlife (WDFW). 2015. Summer crab fishery management measures. Available at: https://wdfw.wa.gov/sites/default/files/2019-03/summer_crab_fishery_management_measures_updated_2015.pdf

Washington Department of Fish and Wildlife (WDFW). 2019. WDFW Whale Entanglement Workshop Handouts and Information. March 19, 2019. Available at: https://wdfw.wa.gov/sites/default/files/2019-03/results.alternatives.presentations.march_.19.meeting.pdf

Washington Department of Fish and Wildlife (WDFW). 2019b. Washington Department of Fish and Wildlife Workshop 2 Regarding Whale Entanglements in the Coastal Dungeness Crab Fishery - Montesano, WA. Available at: https://wdfw.wa.gov/sites/default/files/2019-04/handouts_24apr19_entanglement_meeting.pdf

Washington Department of Fish and Wildlife (WDFW). 2019c. Washington Coastal Dungeness Crab Industry Notice June 4, 2019. Available at: https://wdfw.wa.gov/sites/default/files/2019-06/industry_notice_july_2019l.pdf

Wessel, M., C.E. Trowbridge and C. Russ. 2012. Prince William Sound area management report for Dungeness crab, shrimp, and miscellaneous shellfish fisheries 2011. ADFG, Fishery Management Report No. 12-05.

Yochum N, A Stoner, DB Sampson, C Rose, Al Pazar and R Eder. 2017. Utilizing reflex impairment to assess the role of discard mortality in "Size, Sex, and Season" management for Oregon Dungeness crab (Cancer magister) fisheries. Can. J. Fish. Aquat. Sci. 74: 739–750

Zhang Z. and J. Dunham. 2013. Construction of biological reference points for management of the Dungeness crab, Cancer magister, fishery in the Fraser River Delta, British Columbia, Canada. Fish. Res. 139:18-27.

Appendix A: Extra By Catch Species

LEATHERBACK TURTLE

Factor 2.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

High Concern

The leatherback turtle is listed as "Endangered" throughout its range under the Endangered Species Act (35 FR 8491), and as such abundance is rated as a "high" concern.

Factor 2.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

Moderate Concern

A leatherback turtle mortality in California was attributed to entanglement in Dungeness crab fishery gear in 2016 (WDFW 2016). Genetic stocks are defined according to nesting region, although no DPS subpopulations are officially recognized. Leatherback turtles that feed on the US West Coast are recognized as the Western Pacific population. It is estimated that Western Pacific leatherback turtles in the US West Coast EEZ can withstand mortality rates of 7.7 turtles per five years and prevent further population decline; 4.7 turtles per five years while allowing the population to rebuild to its maximum net productivity level; and mortality of only 0.8 turtles per five years while limiting delay of population rebuilding (Curtis et al. 2015). Cumulative annual fishing mortality in the Western Pacific population is uncertain due to limited observer coverage. It is estimated that total mortality and serious injury of leatherback sea turtles due to interactions with the California drift gillnet fishery from 2011 to 2015 was 1.5 (Carretta et al. 2017c). Due to the recent documented mortality in Dungeness gear, estimated sensitivity of the population to relatively low levels of mortality (4.7 turtles per five years while allowing to rebuild), and uncertainty regarding cumulative fisheries mortality, fishing mortality is rated as a "moderate" concern.

Factor 2.3 - Discard Rate

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

< 100%

Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). The Dungeness crab mortality rate is 1 to 4% for undersize crabs, 1.2% for hard-shell males, 9 to 25% for soft-shell males, and 8% for females (Alverson et al. 1994) (SCS Global Services 2014) (Yochum et al. 2017). Limited research has been conducted on bycatch mortality. Mortality rate can vary temporally, spatially, and with stressors of repeated capture and varied handling time. Using a range of mortality rates of 1 to 25% for all discards, the net dead discard rate is estimated to range from 1.43 to 35.75%. Information on bait use is lacking because it is not quantified in the fishery. The best available estimate is 4.3 to 6.3 lb of crab landed for every pound of bait used in Oregon: approximately a 16 to 23% bait-to-landing ratio (ODFW, personal communication 2015). This is considered an appropriate estimate for the Alaskan region (F. Bowers, ADFG, personal communication 2015).

GRAY WHALE

Factor 2.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America

Low Concern

The minimum population size for the Eastern North Pacific stock of gray whales is 25,849 individuals (Carretta et al. 2019). The population was removed from ESA listing in 1994 and has been considered stable over the past few decades. There are a minimum of 227 individuals in the Pacific Coast Feeding Group (PCFG), a distinct feeding aggregation defined as those feeding between northern California and northern British Columbia in summer and fall. The status of this group as a distinct population stock is uncertain because genetic studies indicate matrilineal fidelity (significant differences in mtDNA haplotype frequencies between groups), but with suggestion of interbreeding with individuals from other feeding grounds (no significant nuclear differences between groups) (Carretta et al. 2019) (Lang et al 2017). The National Marine Fisheries Service considers a stock to be demographically distinct if population dynamics are a consequence of internal dynamics (births and deaths) rather than external dynamics (immigration and emigration). Enough data are not available to determine if the PCFG meets these criteria, since it is plausible that the PCFG is a demographically independent group; however, external immigration into the group may also be taking place. The abundance estimates of the PCFG subpopulation have increased in recent years (2011 to 2015), but population status relative to reference points is unknown. Due to a recent stock assessment with indications that the stock is within range of its optimal sustainable population size, but with some uncertainty regarding the health of the PCFG sub-population, stock status is considered a "low" concern.

Factor 2.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON/ NORTHEAST PACIFIC
Pots | United States Of America
OREGON/ NORTHEAST PACIFIC
Pots | United States Of America

Low Concern

Gray whale entanglements attributed to US West Coast commercial Dungeness crab fisheries have been documented in recent years (2017: 1 in CA and 1 in WA; 2018: 3 in WA and 1 in OR) (NOAA 2017) (NOAA 2018c) (NOAA 2019). These incidents are too recent to be incorporated into the most recent stock assessment and as such, serious injury and mortality designations, if applicable, are unknown. PBR is 801 animals per year for the Eastern North Pacific (ENP) stock and 3.5 animals per year and for the Pacific Coast Feeding Group (PCFG) (Carretta et al. 2019). Total average annual mortality and serious injury for the ENP stock was 8.7 individuals between 2012 and 2016. Of these interactions, 5.8 may have involved Dungeness gear (0.75 CA Dungeness, 0.15 OR Dungeness, 1.9 unidentified pot and trap gear, 3 unidentified fishing gear). Total average annual mortality and serious injury for the PCFG is 0.85 individuals between 2012 and 2016. Of these interactions, 0.7 may have involved Dungeness gear (0.2 CA Dungeness, 0.3 unidentified pot and trap gear, 0.2 unidentified fishing gear). Since average annual serious injury and mortality remains <50% of PBR, and cumulative fishing mortality remains below PBR, fishing mortality is rated as a "low" concern.

Factor 2.3 - Discard Rate

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America
WASHINGTON / NORTHEAST PACIFIC
Pots | United States Of America
OREGON / NORTHEAST PACIFIC
Pots | United States Of America

< 100%

Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). The Dungeness crab mortality rate is 1 to 4% for undersize crabs, 1.2% for hard-shell males, 9 to 25% for soft-shell males, and 8% for females (Alverson et al. 1994) (SCS Global Services 2014) (Yochum et al. 2017). Limited research has been conducted on bycatch mortality. Mortality rate can vary temporally, spatially, and with stressors of repeated capture and varied handling time. Using a range of mortality rates of 1 to 25% for all discards, the net dead discard rate is estimated to range from 1.43 to 35.75%. Information on bait use is lacking because it is not quantified in the fishery. The best available estimate is 4.3 to 6.3 lb of crab landed for every pound of bait used in Oregon: approximately a 16 to 23% bait-to-landing ratio (ODFW, personal communication 2015). This is considered an appropriate estimate for the Alaskan region (F. Bowers, ADFG, personal communication 2015).

KILLER WHALE | TRANSIENT

Factor 2.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

High Concern

The minimum population estimate is 587 individuals for the Eastern North Pacific Gulf of Alaska, Aleutian Islands, Bering Sea Transient killer whale stock and 243 individuals for the West Coast Transient killer whale stock (Muto et al. 2019). Based on preliminary genetic data, stock structure of killer whales needs to be reassessed. Because population trends relative to Optimum Sustainable Production are unknown, and marine mammals are considered highly vulnerable species, abundance is rated a "high" concern.

Factor 2.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

Low Concern

In 2015, a killer whale mortality was attributed to California Dungeness crab gear entanglement (84 Federal Register 118). Based on genetic analysis, the whale was identified as an Alaskan transient but was not identifiable to stock. NMFS intends to assign the mortality to the Gulf of Alaska, Aleutian Islands, Bering Sea Transient stock (PBR = 5.87, annual average serious injury and mortality = 1) and the West Coast Transient stock (PBR = 2.4, annual average serious injury and mortality = 0) in the next revision of stock assessments. Since cumulative fisheries-related annual average mortality and serious injury is <50% PBR for both of these stocks, and would remain so inclusive of this event, fishing mortality is rated a "low" concern.

Factor 2.3 - Discard Rate

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

< 100%

Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). The Dungeness crab mortality rate is 1 to 4% for undersize crabs, 1.2% for hard-shell males, 9 to 25% for soft-shell males, and 8% for females (Alverson et al. 1994) (SCS Global Services 2014) (Yochum et al. 2017). Limited research has been conducted on bycatch mortality. Mortality rate can vary temporally, spatially, and with stressors of repeated capture and varied handling time. Using a range of mortality rates of 1 to 25% for all discards, the net dead discard rate is estimated to range from 1.43 to 35.75%. Information on bait use is lacking because it is not quantified in the fishery. The best available estimate is 4.3 to 6.3 lb of crab landed for every pound of bait used in Oregon: approximately a 16 to 23% bait-to-landing ratio (ODFW, personal communication 2015). This is considered an appropriate estimate for the Alaskan region (F. Bowers, ADFG, personal communication 2015).

BLUE WHALE

Factor 2.1 - Abundance

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

High Concern

The minimum population estimate for Eastern North Pacific (ENP) blue whales is 1,551 individuals (Carretta et al. 2019). Blue whales in the ENP stock are listed as "Endangered" and as such abundance is rated as a "high" concern.

Factor 2.2 - Fishing Mortality

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

Low Concern

During 2012 to 2016, cumulative average annual fisheries mortality (0.96) did not exceed PBR (2.3) (Carretta et al. 2019).Two blue whale serious-injuries (17.4% of PBR) were attributed to interaction with the California Dungeness crab commercial fishery; one was due to unidentified pot-trap gear (8.7% of PBR) and one was due to unidentified fishery gear (13% of PBR). Since the percent of PBR taken by the fishery is less than 50% and cumulative fisheries mortality does not exceed PBR, fishing mortality is rated as a "low" concern.

Factor 2.3 - Discard Rate

CALIFORNIA / EASTERN CENTRAL PACIFIC
Pots | United States Of America

< 100%

Discards are estimated to be 143 crabs for every 100 crabs kept, or 143% of landings (SCS Global Services 2014). The Dungeness crab mortality rate is 1 to 4% for undersize crabs, 1.2% for hard-shell males, 9 to 25% for soft-shell males, and 8% for females (Alverson et al. 1994) (SCS Global Services 2014) (Yochum et al.

2017). Limited research has been conducted on bycatch mortality. Mortality rate can vary temporally, spatially, and with stressors of repeated capture and varied handling time. Using a range of mortality rates of 1 to 25% for all discards, the net dead discard rate is estimated to range from 1.43 to 35.75%. Information on bait use is lacking because it is not quantified in the fishery. The best available estimate is 4.3 to 6.3 lb of crab landed for every pound of bait used in Oregon: approximately a 16 to 23% bait-to-landing ratio (ODFW, personal communication 2015). This is considered an appropriate estimate for the Alaskan region (F. Bowers, ADFG, personal communication 2015).