and

Pacific Rock Crabs: Brown, Red and Yellow

Cancer antennarius, Cancer productus, and *Cancer anthonyi*

Image © Monterey Bay Aquarium

California and Oregon

Trap

May 12, 2014

The Safina Center Seafood Analysts

About The Safina Center

The Safina Center (formerly Blue Ocean Institute) translates scientific information into language people can understand and serves as a unique voice of hope, guidance, and encouragement. The Safina Center (TSC) works through science, art, and literature to inspire solutions and a deeper connection with nature, especially the sea. Our mission is to inspire more people to actively engage as well-informed and highly motivated constituents for conservation.

Led by conservation pioneer and MacArthur fellow, Dr. Carl Safina, we show how nature, community, the economy and prospects for peace are all intertwined. Through Safina's books, essays, public speaking, PBS television series, our Fellows program and Sustainable Seafood program, we seek to inspire people to make better choices.

The Safina Center was founded in 2003 by Dr. Carl Safina and was built on three decades of research, writing and policy work by Dr. Safina.

The Safina Center's Sustainable Seafood Program
The Center's founders created the first seafood guide in 1998. Our online seafood guide now encompasses over 160-wild-caught species. All peer-reviewed seafood reports are transparent, authoritative, easy to understand and use. Seafood ratings and full reports are available on our website under Seafood Choices. TSC's Sustainable Seafood Program helps consumers, retailers, chefs and health professionals discover the connection between human health, a healthy ocean, fishing and sustainable seafood.

- Our online guide to sustainable seafood is based on scientific ratings for more than 160 wild-caught seafood species and provides simple guidelines. Through our expanded partnership with the Monterey Bay Aquarium, our guide now includes seafood ratings from both The Safina Center and the Seafood Watch® program.
- We partner with Whole Foods Market (WFM) to help educate their seafood suppliers and staff, and provide our scientific seafood ratings for WFM stores in the US and UK.
- Through our partnership with Chefs Collaborative, we created Green Chefs/Blue Ocean, a free, interactive, online sustainable seafood course for chefs and culinary professionals.
- Our website features tutorials, videos, blogs, links and discussions of the key issues such as mercury in seafood, bycatch, overfishing, etc.

Check out our Fellows Program, learn more about our Sustainable Seafood Program and Carl Safina's current work at www.safinacenter.org .

The Safina Center is a 501 (c) (3) nonprofit organization based in the School of Marine & Atmospheric Sciences at Stony Brook University, Long Island, NY. www.safinacenter.org admin@safinacenter.org | 631.632.3763

About Seafood Watch®

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

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch®'s sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

Guiding Principles

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

Based on this principle, Seafood Watch and the Safina Center have developed four sustainability **criteria** for evaluating wild-catch fisheries for consumers and businesses. These criteria are:

- How does fishing affect the species under assessment?
- How does the fishing affect other, target and non-target species?
- How effective is the fishery's management?
- How does the fishing affect habitats and the stability of the ecosystem?

Each criterion includes:

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

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

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

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

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

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

Summary

Rock crabs are found along the Pacific coast of North America from Alaska to Mexico on rocky reefs and soft substrate. They are short-lived and fast growing animals. This report evaluates the Oregon and California rock crab fisheries for three species: red, brown, and yellow (California only) rock crabs.

Abundance of rock crabs is unknown because population assessments have not been conducted by either state. Annual catches in California exceed 1,000,000 pounds, while catches in Oregon average less than 3,000 pounds. The commercial rock crab fisheries are managed by California Department of Fish and Game and Oregon Department of Fish and Wildlife. Some management regulations are in place, but in the California fishery there is very limited monitoring of rock crabs to ensure their sustainability.

Baited trap gears are used in both fisheries, but Oregon uses a smaller light weight crab ring, while California uses traditional crab traps. The overall impact on the habitat and ecosystem by these fisheries is low to moderate. In the Oregon fishery, there are minimal bycatch concerns. In the California fishery, there are some concerns about the catches of kellet's whelk, but new regulations were recently implemented to reduce fishing on this species.

Final Seafood Recommendation

Species/ Fishery	Impacts on the Species Under Assessment	Impacts on other Species	Management Effectiveness	Impacts on Habitat and Ecosystem	Overall Recommendation
Brown rock crab Oregon Northwest Pacific - Crab ring	Green (3.32)	Yellow (2.64)	Yellow (3.00)	Yellow (3.16)	**Yellow/Good Alternative (3.020)**
Brown rock crab California Northwest Pacific - Trap	Yellow (2.64)	Yellow (2.51)	Red (2.00)	Yellow (2.74)	**Yellow/Good Alternative (2.456)**
Red rock crab Oregon Northwest Pacific - Crab ring	Yellow (2.64)	Green (3.32)	Yellow (3.00)	Yellow (3.16)	**Yellow/Good Alternative (3.020)**
Red rock crab California Northwest Pacific - Trap	Yellow (2.64)	Yellow (2.51)	Red (2.00)	Yellow (2.74)	**Yellow/Good Alternative (2.456)**
Yellow Rock crab California Northwest Pacific - Trap	Yellow (2.64)	Yellow (2.51)	Red (2.00)	Yellow (2.74)	**Yellow/Good Alternative (2.456)**

Scoring Guide

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

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

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

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

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Introduction

Scope of the analysis and ensuing recommendation

This report evaluates the sustainability of rock crab trap fisheries in California and Oregon, USA. In the California fishery, three rock crab species are targeted: brown rock crab (*Cancer antennarius*), red rock crab (*Cancer productus*), and yellow rock crab (*Cancer anthonyi*). In the much smaller Oregon fishery, red rock crab in the main target species, but the brown rock crab may be caught too. The yellow rock crab is not found in Oregon.

Overview of the species and management bodies

Red, yellow and brown rock crabs are found along the Pacific coast of North America in rocky and sandy substrates (Rudy et al. 1983)(Carroll and Winn 1989). Each species' distribution and habitat preferences are unique, but species can coexist in some areas. Rock crabs do not appear to migrate and movements tend to be short distances, thus, multiple populations likely exist throughout their range (Carroll and Winn 1989). Seasonal movements are possible but data is limited (Rudy et al. 1983)(Carroll and Winn 1989).

			Habitat Preference						
			Gravel	Rocky substrate	Rocky reefs	Coarse sand	Silty sand	Mud	Bays and estuaries
Species	**Distribution**	**Range**							
Red rock crab	AK to Baja California, Mexico	Low intertidal to > 91 m	•	•	•	•		•	•
Brown rock crab	WA to Baja California, Mexico	Low intertidal to > 100 m		•	•	•	•		
Yellow rock crab	CA to Baja California, Mexico	Low intertidal to 140 m			•		•	•	•

Figure 1: Distribution, range and habitat preference of three species of rock crabs: red, brown, and yellow

Rock crabs are short-lived, with a maximum age of 5-7 years, and reach sexual maturity by 1.5 to 2 years of age (Carroll 1982)(Carroll and Winn 1989)(CDFG 2004a). Rock crabs are sexually dimorphic in size with males being larger than females. They can grow to a maximum size of 17-20 cm (7- 8in) (Parker et al. 1986)(CDFG 2010).

Rock crabs are fished using baited traps or pots and can be set singly or hooked together in series (NREFHSC 2002)(Morgan and Chuenpagdee 2003) (CDFG 2013a)(ODFW 2013a). Traps rest on the ocean floor for several days before fishermen retrieve the live catch. In Oregon, rock crabs are caught with a type of trap called crab rings. These small traps lay collapsed and flat on the ocean floor until the fisherman pull the gear up, only then does the animal become enclosed in the net-like gear. The Oregon fishery is managed by the Oregon Department of Fish and Wildlife and the northern and southern

California fisheries are managed by California Department of Fish and Game.

Production Statistics

Annual catches of rock crabs in California have ranged from 1 to 1.74 million pounds since 2000, with an average of 1.26 million pounds (NMFS 2013). Within California there are two rock crab fisheries, one in Northern California (north of 36ºN lat) and one in Southern California (south of 36ºN lat). Since 2005, a location specific permit is required to catch rock crabs, and the number of available permits is limited in the southern fishery (CDFG 2013a). Most of the California rock crab catch is taken in the southern fishery. The fishery in Oregon is much smaller, with only 5 vessels participating, and annual catches have ranged from 1,600 to 4,400 pounds since 2003 with an average of 2,900 pounds (NMFS 2013)(ODFW 2013d). In both fisheries it is common for catches to be lumped under a general category of "rock crabs", thus determining the threat of commercial fishing on each species is nearly impossible.

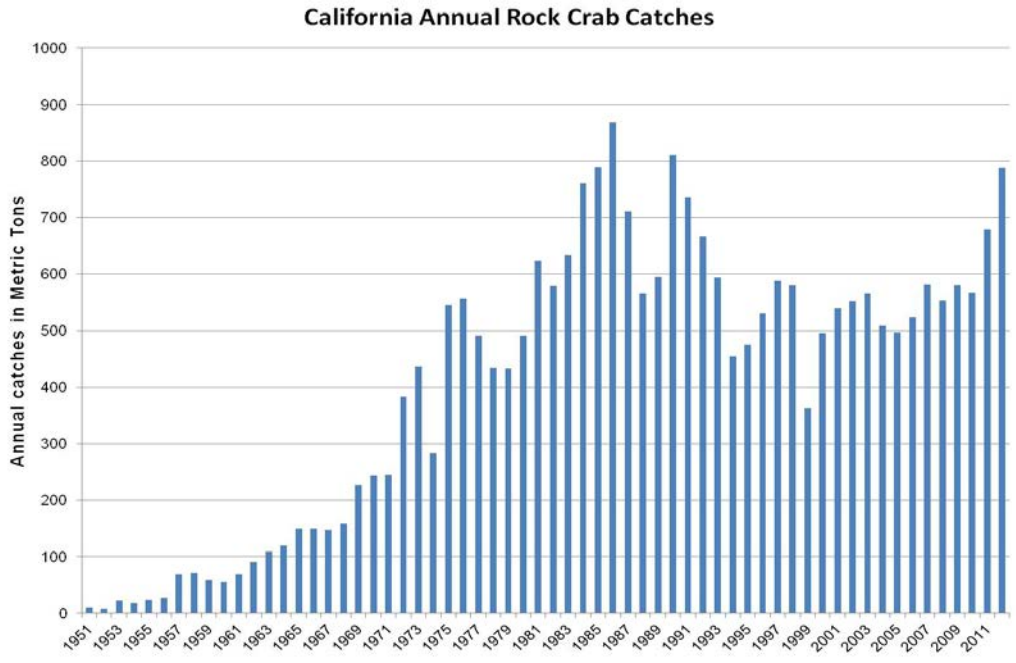

Figure 2: Reported annual catches of rock crabs in California

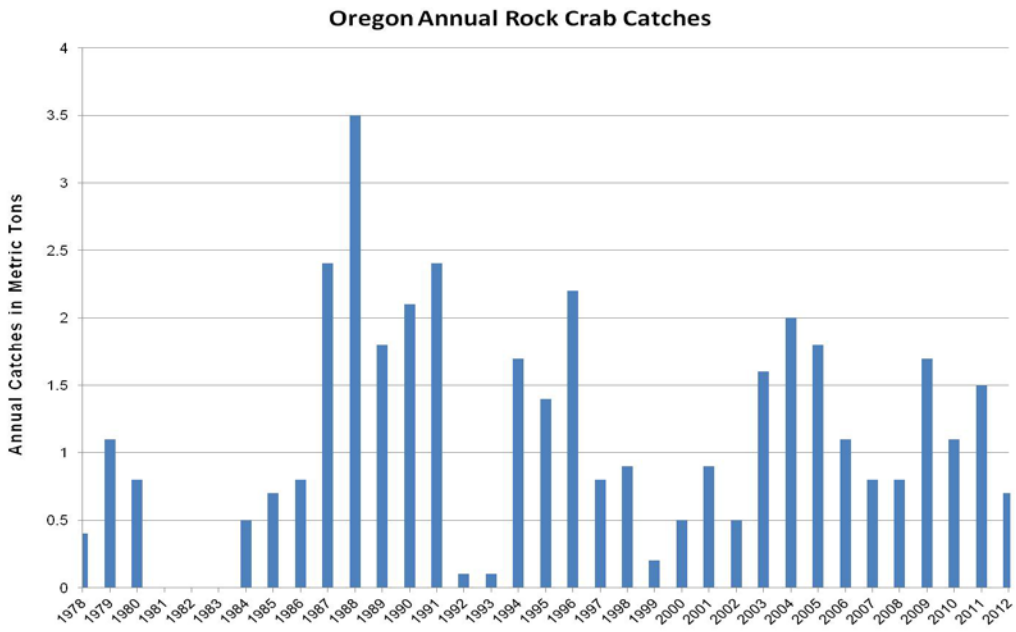

Figure 3: Reported annual catches of rock crabs in Oregon

Importance to the US/North American market

In the United States rock crabs are caught in Washington, Oregon and California. Catches in California make up more than 99% of all US rock crab catches (NMFS 2013). Commercial catches in California are primarily for human consumption. The small catches of rock crab in Oregon are currently used as a food source for the aquarium industry. Overall, rock crabs contribute very little, less than 1%, to the overall US crab market. Rock crabs are not specifically identified on US import and export lists and would fall under the "other crab" listing (NMFS 2013).

Common and market names

Red rock crab: red crab, rock crab
Brown rock crab: Pacific rock crab, California rock crab, spot-bellied rock crab, rock crab, red rock crab
Yellow rock crab: rock crab, gold crab, yellow crab

Primary product forms

Live, fresh, and frozen for human and animal (octopus) consumption.

Assessment

This section presents relevant information on the fishery and details how the fishery is scored relative to the Seafood Watch Fisheries Criteria, available at http://www.seafoodwatch.org. All scores result in a zero to five final score for the criterion and the overall final rank. A zero score indicates poor performance, while a score of five indicates high performance.

Criterion 1: Impacts on the species under assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. The inherent vulnerability to fishing rating influences how abundance is scored, when abundance is unknown.

The final Criterion 1 Score is determined by taking the geometric mean of the abundance and fishing mortality scores. Rating is based on the score as follows: >3.2=Green or Low Concern, >2.2 and <=3.2=Yellow or Moderate Concern, <=2.2=Red or High Concern. Rating is Critical if Factor 1.3 (Fishing Mortality) is Critical.

Criterion 1 Summary

BROWN ROCK CRAB				
Region / Method	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Criterion 1 Score**
California Northwest Pacific Trap	Low Vulnerability	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**
Oregon Northwest Pacific Crab ring	Low Vulnerability	3.00:Moderate Concern	3.67:Low Concern	**Green (3.318)**

RED ROCK CRAB				
Region / Method	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Criterion 1 Score**
California Northwest Pacific Trap	Low Vulnerability	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**
Oregon Northwest Pacific Crab ring	Low Vulnerability	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**

YELLOW ROCK CRAB				
Region / Method	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Criterion 1 Score**
California Northwest Pacific Trap	Low Vulnerability	3.00:Moderate Concern	2.33:Moderate Concern	**Yellow (2.644)**

Criterion 1 Assessment

BROWN ROCK CRAB

Factor 1.1 - Inherent Vulnerability to Fishing

Scoring guidelines

- *Low = FishBase vulnerability score for species 0-35 OR species exhibits life history characteristics that make it resilient to fishing, e.g., early maturing (<5 years), short lived (< 10 years), small maximum size, and low on food chain.*
- *Medium = FishBase vulnerability score for species 36-55 OR life history characteristics that make it neither particularly vulnerable or resilient to fishing, e.g. moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain.*
- *High = FishBase vulnerability score for species 56-100 OR life history characteristics that make is particularly vulnerable to fishing, e.g. long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator.*

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

California Northwest Pacific, Trap
Oregon Northwest Pacific, Crab ring

Low Vulnerability

Rock crabs have a lifespan of 5-7 years and reach sexual maturity by 1.5 to 2 years of age (Carroll 1982)(Carroll and Winn 1989). Like all crustaceans, they grow in stages by molting (shedding their shell). Molting frequency and growth increments vary by sex and decrease as the animal ages (Carroll 1982)(CDFG 2004a). Females are smaller than males, with maximum size between 14.5 and 16.5 cm carapace width for brown and yellow rock crabs (Carroll 1982)(Carroll and Winn 1989). Red rock crabs are the largest and have a maximum carapace width of 17 and 20 cm for females and males, respectively (Parker et al. 1986)(Carroll and Winn 1989). Rock crabs are brooders and can carry over 1 million eggs externally on their shells (Carroll 1982). Yellow rock crabs produce the highest number of eggs, at up to 4 million (Carroll and Winn 1989). Brown rock crabs typically carry eggs during fall and winter, and yellow rock crabs are seen with eggs in spring and summer (Reilly 1987). Given these life history characteristics, all three rock crab species are considered to have a 'low vulnerability' to fishing.

Rationale:
Table 1: Results from Seafood Watch invertebrate vulnerability rubric (SFW criteria document, pg. 4):

Vulnerability attribute	Category	Score (can range from 1-3; higher scores signify more resilient life history attributes)
Average age at maturity	< 5 years	3
Average maximum age	< 10 years	3
Fecundity	N/A	N/A
Reproductive strategy	Demersal egg brooder	2
Density dependence	No depensatory or compensatory dynamics demonstrated or likely	2
Average Score		2.5

Species with average attribute scores between 2.46 and 3 are deemed to have a ‘low vulnerability'.

Factor 1.2 – Abundance

Scoring guidelines

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

California Northwest Pacific, Trap

3.00 **Moderate Concern**

All three rock crab species can be found throughout California, but red rock crabs have the highest densities in northern California, brown rock crabs have the highest densities in central California, and yellow rock crabs have the highest densities in southern California (Carroll and Winn 1989)(CDFG 2004a). Brown rock crabs are more abundant in shallow habitats, while yellow rock crabs increase with depth (Reilly 1987). Population abundance surveys have not been conducted for any of the three rock crab species and there is very limited information on their abundance. Since abundance is unknown and brown rock crabs have a low vulnerability to fishing, abundance is rated 'moderate concern'.

Oregon Northwest Pacific, Crab ring

3.00 **Moderate Concern**

Brown rock crabs are less common in Oregon compared to red rock crabs, but can be found in estuaries and rocky outer coasts (Rudy et al. 1983)(ODFW 2006). Populations often overlap with red rock crabs and dungeness crabs (ODFW 2006). There are no population surveys for this species. Since abundance is unknown for brown rock crabs and they have a 'low vulnerability' to fishing, abundance is rated 'moderate concern'.

Factor 1.3 - Fishing Mortality

Scoring guidelines

- *5 (Very Low Concern) = Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY) OR fishery does not target species and its contribution to the mortality of species is negligible (≤ 5% of a sustainable level of fishing mortality)*
- *3.67 (Low Concern) = Probable (>50% chance) that fishing mortality is at or below a sustainable level, but some uncertainty OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught)*
- *2.33 (Moderate Concern) = Fishing mortality is fluctuating around sustainable levels OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery, and if species is depleted, reasonable management is in place.*
- *1 (High Concern) = Overfishing is occurring, but management is in place to curtail overfishing OR fishing mortality is unknown, species is depleted and no management is in place*
- *0 (Critical) = Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

California Northwest Pacific, Trap

2.33 **Moderate Concern**

Fishing mortality on brown rock crabs, red rock crabs, and yellow rock crabs in California is unknown because population assessments have not been performed. Catches of these species are commonly lumped together under a general category of "rock crabs", thus making it difficult to determine the threat of commercial fishing on each species. Experimental catches of rock crabs near Santa Monica Bay revealed that areas closed to commercial fishing had more crabs, larger crabs, and a greater variety of sizes when compared to areas frequently fished by the commercial rock crab fishery (CDFG 2001)(CDFG 2004a). This suggests that fishing pressures negatively affects rock crab abundance and growth.

However, due to a lack of further information, fishing mortality is rated 'moderate concern'.

Oregon Northwest Pacific, Crab ring

3.67 **Low Concern**

The fishing mortality on brown rock crabs is unknown because a population assessment has not been performed; however, there are no reports that brown rock crabs are depleted. Overall, brown rock crabs are less abundant in Oregon than red rock crabs (Rudy et al. 1983). Brown rock crabs are caught less frequently than red rock crabs and none were retained in 2012 (Ainsworth 2013, personal communication). The Oregon Department of Fish and Wildlife does not have any specific research, management, or monitoring specifically for brown rock crabs. Although there is limited information on brown rock crabs, because they are caught infrequently, we have awarded a 'low concern' score for fishing mortality.

RED ROCK CRAB

Factor 1.1 - Inherent Vulnerability to Fishing

Scoring guidelines – same as above

California Northwest Pacific, Trap
Oregon Northwest Pacific, Crab ring

Low Vulnerability

Rock crabs have a lifespan of 5-7 years and reach sexual maturity by 1.5 to 2 years of age (Carroll 1982)(Carroll and Winn 1989). Like all crustaceans, they grow in stages by molting (shedding their shell). Molting frequency and growth increments vary by sex and decrease as the animal ages (Carroll 1982)(CDFG 2004a). Females are smaller than males, with maximum size between 14.5 and 16.5 cm carapace width for brown and yellow rock crabs (Carroll 1982)(Carroll and Winn 1989). Red rock crabs are the largest and have a maximum carapace width of 17 and 20 cm for females and males, respectively (Parker et al. 1986)(Carroll and Winn 1989). Rock crabs are brooders and can carry over 1 million eggs externally on their shells (Carroll 1982). Yellow rock crabs produce the highest number of eggs, at up to 4 million (Carroll and Winn 1989). Brown rock crabs typically carry eggs during fall and winter, and yellow rock crabs are seen with eggs in spring and summer (Reilly 1987). Given these life history characteristics, all the rock crab species are considered to have a 'low vulnerability' to fishing.

Rationale:
Table 1: Results from Seafood Watch invertebrate vulnerability rubric (SFW criteria document, pg. 4):

Vulnerability attribute	Category	Score (can range from 1-3; higher scores signify more resilient life history attributes)
Average age at maturity	< 5 years	3
Average maximum age	< 10 years	3
Fecundity	N/A	N/A
Reproductive strategy	Demersal egg brooder	2
Density dependence	No depensatory or compensatory dynamics demonstrated or likely	2
Average Score		2.5

Species with average attribute scores between 2.46 and 3 are deemed to have a ‘low vulnerability'.

Factor 1.2 – Abundance

Scoring guidelines – same as above

California Northwest Pacific, Trap

3.00 **Moderate Concern**

All three rock crab species can be found throughout California, but red rock crabs have the highest densities in northern California, brown rock crabs have the highest densities in central California, and yellow rock crabs have the highest densities in southern California (Carroll and Winn 1989)(CDFG 2004a). Brown rock crabs are more abundant in shallow habitats, while yellow rock crabs increase with depth (Reilly 1987). Population abundance surveys have not been conducted for any of the three rock crab species and there is very limited information on their abundance. Since abundance is unknown and red rock crabs have a low vulnerability to fishing, abundance is rated 'moderate concern'.

Oregon Northwest Pacific, Crab ring

3.00 **Moderate Concern**

Red rock crabs are common throughout Oregon in estuaries and rocky shores (Rudy et al. 1983). Population abundance surveys are not available, but research is underway to better understand the population including demographics, movement, and fishing mortality (ODFW 2012b). Since current abundance for red rock crabs is unknown and they have a low vulnerability to fishing, abundance is rated 'moderate concern'.

Factor 1.3 - Fishing Mortality

Scoring guidelines – same as above

California Northwest Pacific, Trap

2.33 **Moderate Concern**

Fishing mortality on brown rock crabs, red rock crabs, and yellow rock crabs in California is unknown because population assessments have not been performed. Catches of these species are commonly lumped together under a general category of "rock crabs", thus making it difficult to determine the threat of commercial fishing on each species. Experimental catches of rock crabs near Santa Monica Bay revealed that areas closed to commercial fishing had more crabs, larger crabs, and a greater variety of sizes when compared to areas frequently fished by the commercial rock crab fishery (CDFG 2001)(CDFG 2004a). This suggests that fishing pressures negatively affects rock crab abundance and growth. However, due to a lack of further information, fishing mortality is rated 'moderate concern'.

Oregon Northwest Pacific, Crab ring

2.33 **Moderate Concern**

The fishing mortality on red rock crabs in Oregon is unknown because a population assessment has not been performed; however, there are no reports that red rock crabs are depleted. In 2000, red rock crabs were declared a "developing fishery" meaning the species is underutilized (ODFW 2001). In 2006, the Oregon Department of Fish and Wildlife (ODFW) identified the red rock crab population as important to nearshore habitats and placed them on the "watch list" meaning the species doesn't require immediate management but could in the future. Since being added to the "watch list" biologists have been collecting information on the impact of catches on the population, but no changes in regulations have occurred (ODFW 2006)(ODFW 2012c)(ODFW 2013a). Due to insufficient information on current fishing mortality of red rock crabs, we have awarded a score of 'moderate concern'.

YELLOW ROCK CRAB

Factor 1.1 - Inherent Vulnerability to Fishing

Scoring guidelines – same as above

California Northwest Pacific, Trap

Low vulnerability

Rock crabs have a lifespan of 5-7 years and reach sexual maturity by 1.5 to 2 years of age (Carroll

1982)(Carroll and Winn 1989). Like all crustaceans, they grow in stages by molting (shedding their shell). Molting frequency and growth increments vary by sex and decrease as the animal ages (Carroll 1982)(CDFG 2004a). Females are smaller than males, with maximum size between 14.5 and 16.5 cm carapace width for brown and yellow rock crabs (Carroll 1982)(Carroll and Winn 1989). Red rock crabs are the largest and have a maximum carapace width of 17 and 20 cm for females and males, respectively (Parker et al. 1986)(Carroll and Winn 1989). Rock crabs are brooders and can carry over 1 million eggs externally on their shells (Carroll 1982). Yellow rock crabs produce the highest number of eggs, at up to 4 million (Carroll and Winn 1989). Brown rock crabs typically carry eggs during fall and winter, and yellow rock crabs are seen with eggs in spring and summer (Reilly 1987). Given these life history characteristics, rock crabs are considered to have a 'low vulnerability' to fishing.

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Table 1: Results from Seafood Watch invertebrate vulnerability rubric (SFW criteria document, pg. 4):

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Density dependence	No depensatory or compensatory dynamics demonstrated or likely	2
Average Score		2.5

Species with average attribute scores between 2.46 and 3 are deemed to have a ‘low vulnerability'.

Factor 1.2 – Abundance

Scoring guidelines – same as above

California Northwest Pacific, Trap

3.00 **Moderate Concern**

All three rock crab species can be found throughout California, but red rock crabs have the highest densities in northern California, brown rock crabs have the highest densities in central California, and yellow rock crabs have the highest densities in southern California (Carroll and Winn 1989)(CDFG 2004a). Brown rock crabs are more abundant in shallow habitats, while yellow rock crabs increase with depth (Reilly 1987). Population abundance surveys have not been conducted for any of the three rock crab species and there is very limited information on their abundance. Since abundance is unknown and

yellow rock crabs have a low vulnerability to fishing, abundance is rated 'moderate concern'.

Factor 1.3 - Fishing Mortality

Scoring guidelines – same as above

California Northwest Pacific, Trap

2.33 **Moderate Concern**

Fishing mortality on brown rock crabs, red rock crabs, and yellow rock crabs in California is unknown because population assessments have not been performed. Catches of these species are commonly lumped together under a general category of "rock crabs", thus making it difficult to determine the threat of commercial fishing on each species. Experimental catches of rock crabs near Santa Monica Bay revealed that areas closed to commercial fishing had more crabs, larger crabs, and a greater variety of sizes when compared to areas frequently fished by the commercial rock crab fishery (CDFG 2001)(CDFG 2004a). This suggests that fishing pressures negatively affects rock crab abundance and growth. However, due to lack of further information, fishing mortality is rated 'moderate concern'.

Criterion 2: Impacts on other species

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

To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard rate score (ranges from 0-1), which evaluates the amount of non-retained catch (discards) and bait use relative to the retained catch. Rating is based on the score as follows: >3.2=Green or Low Concern, >2.2 and <=3.2=Yellow or Moderate Concern, <=2.2=Red or High Concern. Rating is Critical if Factor 2.3 (Fishing Mortality) is Critical.

Criterion 2 Summary

Brown Rock Crab				
Region / Method	**Lowest Scoring of Other Species**	**Lowest Species Subscore**	**Discard Rate Modifying Score ((Discards+ Bait)/Retained Catch)**	**Criterion 2 Score**
California Northwest Pacific, Trap	Red Rock Crab and Yellow Rock Crab	2.644	0.95 (20-40%)	Yellow (2.512)
Oregon Northwest Pacific, Crab Ring	Red Rock Crab	2.644	1.00 (<20%)	Yellow (2.644)

Red Rock Crab				
Region / Method	**Lowest Scoring of Other Species**	**Lowest Species Subscore**	**Discard Rate Modifying Score ((Discards+ Bait)/Retained Catch)**	**Criterion 2 Score**
California Northwest Pacific, Trap	Brown Rock Crab and Yellow Rock Crab	2.644	0.95 (20-40%)	Yellow (2.512)
Oregon Northwest Pacific, Crab Ring	Brown Rock Crab	3.318	1.00 (<20%)	Green (2.644)

Yellow Rock Crab				
Region / Method	**Lowest Scoring of Other Species**	**Lowest Species Subscore**	**Discard Rate Modifying Score ((Discards+ Bait)/Retained Catch)**	**Criterion 2 Score**
California Northwest Pacific, Trap	Brown Rock Crab and Red Rock Crab	2.644	0.95 (20-40%)	Yellow (2.512)

Information on non-target or bycatch species caught in the California rock crab fisheries is not available. The traps used to catch rock crabs are selective for small animals and their stationary open-mesh design allows for some bycatch to escape and others to be released by the fishermen with minimal harm. Finfish and benthic invertebrates are likely impacted by this fishery. Species that can be retained in the California rock crab fishery include: Kellet's whelk, octopus, and crabs (other than the genus *Cancer*). Significant catches of Kellet's whelk are known to occur in the fishery, so we have assessed this species in this report. There is some concern about the abundance of Kellet's whelk, but managers recently implemented new measures to limit fishing on this species. Due to limited information on catches of other species we have assessed the species groups 'finfish' and 'benthic invertebrates' using the Seafood Watch unknown bycatch matrix, which is based on a synthesis of peer reviewed literature and expert opinion on the bycatch impacts of each gear type (see appendix 3 in the Seafood Watch Wild Fisheries Assessment Criteria). Overall, impacts on bycatch species are of moderate concern in this fishery. For each of the rock crab species in California, the lowest scoring species were the other rock crabs.

Within the Oregon rock crab fishery, there are considered to be no other main species caught. The Oregon fishery uses crab rings that lie flat and only actively fish when the gear is pulled up by the fishermen. Because of the gear design, most non-target catch is likely able to be released alive. Non-targeted catch such as groundfish, salmon, and dungeness crab must be returned unless a separate dungeness crab permit is held. Since no other main species are caught in this fishery, the lowest scoring species for Oregon brown rock crab was the red rock crab and vice versa.

Criterion 2 Assessment

A full list of the main species assessed in this report can be found in Appendix B. See criterion 1 for assessments of brown, red, and yellow rock crabs.

BENTHIC INVERTEBRATES

Factor 2.1 - Inherent Vulnerability to Fishing

Scoring Guidelines - same as Factor 1.1 above

California Northwest Pacific, Trap

Medium Vulnerability

The species of benthic invertebrates affected by the rock crab fishery is unknown (apart from the Kellet's whelk which is assessed separately). Most benthic invertebrates have a 'medium' inherent vulnerability to fishing.

Factor 2.2 – Abundance

Scoring Guidelines - same as Factor 1.2 above

California Northwest Pacific, Trap

3.00 **Moderate Concern**

Because the specific species of benthic invertebrates caught in the rock crab fishery is unknown, the population status of benthic invertebrates is unknown and considered to be of 'moderate concern'.

Factor 2.3 - Fishing Mortality

Scoring Guidelines - same as Factor 1.3 above

California Northwest Pacific, Trap

3.67 **Low Concern**

The amount and species of benthic invertebrates caught in the rock crab trap fishery is unknown. However, in general traps are considered to have a low impact on other species, and most non-target species are likely able to be released unharmed (Morgan and Chuenpagdee 2003)(Kelleher 2005). Fishing mortality for unknown benthic invertebrates caught with trap gear is considered a 'low concern' (see appendix 3 in the Seafood Watch Wild Fisheries Assessment Criteria).

FINFISH

Factor 2.1 - Inherent Vulnerability to Fishing

Scoring Guidelines - same as Factor 1.1 above

California Northwest Pacific, Trap

Medium Vulnerability

The species of finfish affected by the rock crab fishery is unknown, but most finfish have a 'medium' inherent vulnerability to fishing.

Factor 2.2 – Abundance

Scoring Guidelines - same as Factor 1.2 above

California Northwest Pacific, Trap

3.00 **Moderate Concern**

The specific species on finfish caught in the rock crab fishery is unknown. Therefore the population status of finfish is considered unknown and a 'moderate concern'.

Factor 2.3 - Fishing Mortality

Scoring Guidelines - same as Factor 1.3 above

California Northwest Pacific, Trap

3.67 **Low Concern**

The amount and species of finfish caught in the rock crab fishery is unknown. However, in general traps are considered to have a low impact on non-target species, and most species are likely able to be released unharmed (Morgan and Chuenpagdee 2003)(Kelleher 2005). Fishing mortality for unknown finfish caught with trap gear is considered a 'low concern' (see appendix 3 in the Seafood Watch Wild Fisheries Assessment Criteria).

WHELK

Factor 2.1 - Inherent Vulnerability to Fishing

Scoring Guidelines - same as Factor 1.1 above

California Northwest Pacific, Trap

High Vulnerability

Kellet's whelk are slow growing animals with long life spans. Maximum size is 17.5 cm (7 in) in shell length with females being larger than males (SIMON 2009)(CDFG 2010). Female kellet's whelk are sexually mature at 6.5 - 7 cm (2.6 - 2.8 in) in length. Males mature at slightly smaller sizes (CDFG 2010). Maximum age and age at maturity are unknown, but growth rates allow for estimation. Reported growth rates are between 0.76 - 1.0 cm (0.3 - 0.4 in) per year until mature and growth is thought to slow once mature (CDFG 2010). Therefore, sexually maturity likely occurs between 6.5 - 9 years. Maximum lifespan is believed to far exceed 20 years (CDFG 2010). Adults form spawning aggregations and fertilization occurs internally. Females deposit fertilized egg masses on hard substrate (SIMON 2009)(CDFG 2010). Each egg mass typically contains 400 - 1200 eggs, but can contain as many as 2200 eggs (CDFG 2010). Given these life history characteristics kellet's whelk have a 'high' inherent vulnerability.

Rationale:

Table 1: Results from Seafood Watch invertebrate vulnerability rubric (SFW criteria document, pg. 4):

Vulnerability attribute	Category	Score (range from 1-3; higher scores signify more resilient life history attributes)
Average age at maturity	5-10 years	2
Average maximum age	>25 years	1
Fecundity	N/A	N/A
Reproductive strategy	Demersal egg layer	2
Density dependence	No depensatory or compensatory dynamics demonstrated or likely	2
Average Score		1.75

Species with average attribute scores between 1-1.84 are deemed to have a 'high vulnerability.'

Factor 2.2 – Abundance

Scoring Guidelines - same as Factor 1.2 above

California Northwest Pacific, Trap

2.00 **High Concern**

Density of kellet's whelk appears to vary throughout their range in California, but the overall population abundance is not known. The geographic range of kellet's whelk has spread further north in the last 40 years to include Monterey Bay, California (Zacherl et al. 2003)(SIMON 2009)(CDFG 2010). Field studies show higher density of whelks in their historical range (0.78 whelks per square meter) versus their new northern range (0.06 whelks per square meter) (Zacherl et al. 2003). Since abundance of kellet's whelk is unknown and their vulnerability to fishing is high, abundance is scored as 'high concern'.

Factor 2.3 - Fishing Mortality

Scoring Guidelines - same as Factor 1.3 above

California Northwest Pacific, Trap

3.67 **Low Concern**

Fishing mortality for kellet's whelk is unknown because a population assessment has not been

performed. Kellet's whelk is caught using two methods, by hand (diving) or incidentally in traps. Ninety eight percent of the annual catches occur in the lobster and rock crab trap fisheries, with the vast majority (~99%) being caught in southern California (CDFG 2009)(CDFG 2013d). The rock crab fishery and lobster fishery contribute equally (50/50) to the catch of kellet's whelk. Catches of kellet's whelk began increasing in the mid 1990's and peaked in 2006 with 87 mt (191,800 lbs) (CDFG 2011a). From 2006 to 2010 annual catches averaged 78.8 mt (173,724 lbs) (CDFG 2011a). In 2011 the fishery was designated an "emerging fishery" by the California Department of Fish and Game (CDFG); this classification means that catches are increasing such that “the existing regulations are not sufficient to ensure a stable, sustainable fishery” (CDFG 2011a). As a result, in 2012, regulations were put in place to limit annual catches to around half of historic catch levels (100,000 lbs. or 45 mt) and close the fishery during the spawning season (March-July) (CDFG 2012a). Catches of kellet's whelk in 2012 were well below the total allowable catch, with only 52,000 lbs recorded (CDFG 2013e). Because the new management regulations for kellet's whelk seem to effectively limit fishing mortality on this species, we have rated this factor 'low concern'.

Factor 2.4 – Discards and Bait Use

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 2.4 score*
< 20%	*1*
20–40%	*0.95*
40–60%	*0.9*
60–80%	*0.85*
80–100%	*0.8*
>100%	*0.75*

California Northwest Pacific, Trap

0.95 **20-40%**

The amount of discards, fish thrown back to the ocean, in the California rock crab fishery is unknown. Bycatch in not reported in the rock crab fisheries, however, regulations restrict the species of bycatch that can be retained in this fishery and require all other species or undersized rock crabs to be released (CDFG 2013a). Rock crabs are caught using baited traps (fish, chicken, or crab parts) and typically constructed from wire mesh. The mesh must be at least 4.76 cm (1.875 inches) by 9.84 cm (3.875 inches) and have at least one circular opening of 8.25 cm (3.25 in) (CDFG 2013a). Any trap constructed of mesh other than wire must have two circular openings (CDFG 2013a). Mesh size is used to control the

size of animal that is caught in each trap, allowing smaller animals to escape, but is not species specific. The gear is set on the ocean floor for 2-4 days, allowing crabs and other animals to become attracted to the bait and trapped in the gear. Since this gear fishes passively (when fishermen aren't there) bycatch would remain trapped and endure stress until the gear is pulled up onto the fishing vessel. To ensure survival of the trapped animals, the gear must be checked on a regular basis (Morgan and Chuenpagdee 2003)(Kelleher 2005). Trap fishermen in California are only required to check the gear every 4 days or 96 hours (CDFG 2013a). Ghost fishing, gear that is lost or left in the ocean and continues to catch animals, is also a problem in trap fisheries (Eno et al. 2001). Ghost fishing can have detrimental effects on numerous animals and will continue to be a problem until the gear is pulled out of the water or it biodegrades completely (Morgan and Chuenpagdee 2003)(SeaDoc Society 2009). Currently the trap gear used in California rock crab fisheries is not required to be constructed entirely of biodegradable material, but escape openings are required to destruct easily (CDFG 2013a). A hotline is available to report lost or abandoned gear, but it is unclear whether rock crab fishermen are required to report lost gear.

A global review of commercial marine fishing reported low bycatch and discards in trap-style fisheries (Kelleher 2005). They reported an average discard rate of 23.2% with a range from 0-60%. Based on California's bycatch regulations, survivability of bycatch in trap fisheries, use of bait, and the global report we estimate the discard plus bait to retained catch ratio to be 20-40%.

Oregon Northwest Pacific, Crab ring

1.00 **< 20%**

Baited crab rings are the dominate gear used in the Oregon rock crab fishery (Ainsworth 2013, personal communication). Because this gear lies collapsed and flat, animals cannot become trapped in the gear until the fishermen pulls the trap up, turning the gear into a small cone-shaped bag (Ainsworth 2013, personal communication). While the gear is not selective, the survivability of bycatch is very good because of the gear design (Morgan and Chuenpagdee 2003, Ainsworth 2013, personal communication). A global review of commercial marine fishing reported low bycatch and discards in trap-style fisheries (Kelleher 2005). They reported an average discard rate of 23.2% with a range from 0-60%. Bait in this fishery includes chicken parts or fish carcasses from processing plants (Ainsworth 2013, personal communication). Because the survivability of bycatch in this fishery is likely very good and the fish bait used in the fishery comes from byproducts, we consider the dead discard plus bait to retained catch ratio to be <20%.

Criterion 3: Management effectiveness

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

The final score for this criterion is the geometric mean of the two scores. Rating is based on the score as follows: >3.2=Green or Low Concern, >2.2 and <=3.2 =Yellow or Moderate Concern, <=2.2 or either the Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern. Rating is Critical if either or both of Harvest Strategy (Factor 3.1) and Bycatch Management Strategy (Factor 3.2) are Critical.

Criterion 3 Summary

Region / Method	Harvest Strategy	Bycatch Strategy	Criterion 3 Score
California Northwest Pacific Trap	2.00: High Concern	2.00: High Concern	Red(2.000)
Oregon Northwest Pacific Crab ring	3.00: Moderate Concern	All Species Retained	Yellow(3.000)

In both California and Oregon, some management regulations are in place for rock crabs. However in the California fishery research and monitoring of rock crabs is very poor. In the Oregon fishery, some research and monitoring of rock crabs is being conducted.

In the California fishery there are some bycatch regulations in place for the rock crab fishery, but there is no monitoring of bycatch species. In the Oregon fishery, rock crabs are caught with "crab rings", a type of trap, and survivability of bycatch caught in the crab rings is considered very high (Ainsworth 2013, personal communication). Since bycatch is not a problem in the Oregon fishery, we consider "all species retained" and have not assessed bycatch management.

Criterion 3 Assessment

Factor 3.1: Harvest Strategy

Scoring Guidelines

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

- *5 (Very Low Concern) = Rated as 'highly effective' for all seven subfactors considered*
- *4 (Low Concern) = Management Strategy and Recovery of Species of Concern rated 'highly effective' and all other subfactors rated at least 'moderately effective'.*

- *3 (Moderate Concern) = All subfactors rated at least 'moderately effective'.*
- *2 (High Concern) = At minimum meets standards for 'moderately effective' for Management Strategy and Recovery of Species of Concern, but at least one other subfactor rated 'ineffective'.*
- *1 (Very High Concern) = Management exists, but Management Strategy and/or Recovery of Species of Concern rated 'ineffective'*
- *O (Critical) = No management exists when a clear need for management exists (i.e., fishery catches threatened, endangered, or high concern species) OR there is a high level of Illegal, Unregulated, and Unreported Fishing occurring.*

Factor 3.1: Harvest Strategy								
Region / Method	**Management Strategy and Impl.**	**Recovery of Species of Concern**	**Scientific Research & Monitoring**	**Record of Following Scientific Advice**	**Enforcement of Regs.**	**Track Record**	**Stakeholder Inclusion**	**Factor 3.1 Score**
California Northwest Pacific Trap	Moderately Effective	N/A	Ineffective	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	2.00: High Concern
Oregon Northwest Pacific Crab ring	Moderately Effective	N/A	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	3.00: Moderate Concern

Subfactor 3.1.1 - Management Strategy and Implementation

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

California Northwest Pacific, Trap

Moderately Effective

Brown, yellow, and red rock crabs have been commercially fished with baited traps in California since 1928 (CDFG 2004a). In 2002 a law was passed giving the California Fish and Game Commission authority to manage the commercial rock crab fishery (CDFG 2004a)(CDFG 2004b). The management was intended to align with the broader Marine Life Management Act (1998) which was designed to conserve and sustainably use California's marine resources (CDFG 2004a)(CDFG 2004b).

Within California there are two rock crab fisheries, one in Northern California (north of 36ºN lat) and one in Southern California (south of 36ºN lat), and the majority of catches occur in southern California. Location specific permits have been required to catch rock crabs since 2005. In the northern fishery permits can be obtained by anyone with commerical and trap permits; however, the southern fishery

has limited entry which restricts who can obtain permits (CDFG 2013a). Only fishermen that held permits for the southern fishery in the previous year are allowed to apply for permitting in the next year and no new permits can be issued. Each year five permits can be transferred to individuals not currently permitted (CDFG 2011b)(CDFG 2013a). Additionally, a control date of January 1, 2003 was established if further restriction for permit regulation is needed in the future (CDFG 2013a).

Since the 1990's overall rock crab catches have declined, but catches have been fairly consistent in the 2000's (CDFG 2004a)(CDFG 2010) (CDFG 2012b). Only crabs measuring 10.8 cm (4.25 in) or larger can be caught; all undersized crabs must be released (CDFG 2013a). Currently there are no restrictions on the number of commercial catches, no seasonal closures, and no restrictions for collecting egg bearing females (CDFG 2013a).

Kellet's whelk is a non-targeted but retained catch in the rock crab fishery. The vast majority of Kellet's whelk catches occur in the rock crab and lobster trap fisheries. Since the 1990's catches have greatly increased. In 2011, California's Fish and Game Commission named Kellet's whelk an "emerging fishery" and in 2012 seasonal closures (March-July) and catch limits (100,000 lbs) were implemented (CDFG 2011a)(CDFG 2012a).

While some management is in place for rock crabs and whelk, the effectiveness of these management strategies remains uncertain due to the lack of population assessments. We have therefore rated the management strategy 'moderately effective'.

Oregon Northwest Pacific, Crab ring

Moderately Effective

Rock crabs caught in Oregon's bays and Pacific Ocean are managed by Oregon Department of Fish and Wildlife. Several commercially important species of crabs are fished in the same areas, including dungeness crabs and box crabs. Since rock crabs overlap with dungeness crabs, fishermen must abide by some of the dungeness crab fishery regulations, including seasonal closures and obtaining an "ocean dungeness crab permit" (ODFW 2013a). Overall, management aims to maintain catches in the commercial rock crab fishery while ensuring sustainability of dungeness crabs. Currently there are no limits on the number or size of rock crabs that can be caught, but there are limits to the number of traps that can be used (ODFW 2012a)(ODFW 2013a). No population surveys have been performed for rock crabs, but in 2012, the Oregon Department of Fish and Wildlife began a tagging project to learn about fishing mortality, life history characteristics, and movements of rock crabs (ODFW 2012b). In 2006 red rock crabs were listed as a species to closely monitor due to fishing pressures (ODFW 2006). The goal of "watch list species" is to identify if increased management is needed (ODFW 2006). No new measures have been put in place, but currently the Oregon fishery is small and does not have a human consumption market. Since some management policies are in place and fishing mortality is being closely monitored, we have rated management as 'moderately effective'.

Subfactor 3.1.2 - Recovery of Species of Concern

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

California Northwest Pacific, Trap

N/A

The abundance of rock crabs in California is unknown because abundance surveys have not been performed, but rock crabs are not considered depleted or overfished (CDFG 2013a). The commercial rock crab fishery also catches and retains kellet's whelk. Abundance of kellet's whelk is unknown, but the California Department of Fish and Game is concerned about kellet's whelk populations. However, kellet's whelk has not been designated as overfished or depleted, and in 2012 regulations were put in place to limit fishing mortality on this species (CDFG 2012a). Since no species in this fishery are considered depleted, we have rated recovery as 'n/a'.

Oregon Northwest Pacific, Crab ring

N/A

The abundance of rock crabs in the Oregon fishery is unknown because population surveys have not been performed. Since rock crabs are not currently considered overfished or depleted, we have rated this factor as 'n/a'.

Subfactor 3.1.3 - Scientific Research and Monitoring

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

California Northwest Pacific, Trap

Ineffective

Poor design of catch reporting requirements has resulted in the inability to track historical catches of each rock crab species in California (CDFG 2001)(CDFG 2004a)(CDFG 2004b). From 1950 - 1985 crab catches were reported into two groups: dungeness or rock crab based on location of capture and not true species identification (northern catches= Dungeness; southern catches= rock crab) (CDFG 2004b). In 1994 commercial reporting allowed for species designation of rock crabs, but the Commission continued

to consolidate brown, yellow, and red rock crab into one annual catch value until 2003 (CDFG 2004b). Today, fisherman are not required to designate species (brown, yellow, or red) of rock crab caught and often only ‘rock crab’ is reported (CDFG 2004b). Until regulation requires species designation of catches it is nearly impossible to determine fishing effort and effects on each rock crab population.

Research performed near Santa Monica Bay revealed that areas closed to commercial fishing caught more crabs, larger crabs, and a greater variety of sizes when compared to areas frequently fished by the commercial rock crab fishery, suggesting that fishing pressures negatively affect the abundance and size of rock crabs (CDFG 2001)(CDFG 2004a). Unfortunately, no surveys have been performed to assess abundance or to determine sustainable fishing limits (CDFG 2001)(CDFG 2004a).

Scientists, managers, and fishermen recognize that the data collected on rock crabs is insufficent to provide adequate management (Culver et al. 2010). A study conducted in 2008 evaluated new sampling and data collection methods which involved collaborative data collection by fisherman at-sea and at-port. They found that at-sea sampling was critical to understand rock crab populations because significant discarding of live rock crabs (30-50%) was occuring and thus at-port data was less informative. The study concluded that the feasibility of collaborative data collection would be dependent on designing efficent collection protocols, proper compilation and distribution of collected data, and maintaining effective realtionships between scientists, fishermen, and managers (Culver et al. 2010). Currently, there are no plans to implement collaborative data collection in California's rock crab fishery (Juhasz 2014, personal communication).

Since research on the rock crab fishery is limited, it has been rated ‘ineffective’.

Oregon Northwest Pacific, Crab ring

Moderately Effective

Rock crabs are minimally managed by the Oregon Department of Fish and Wildlife and thus research and monitoring is somewhat limited for the fishery. In 2006 red rock crabs were put on a "watch list" as an ecologically important species that may need additional management in the future (ODFW 2012c). Commercial rock crab fishermen must fill out logbooks to document their catches and annual submission of the logbook to the Oregon Department of Fish and Wildlife is required to obtain the next year's permit (ODFW 2013a). Sales records must also be documented (ODFW 2013a). As of 2012, a tagging program was implemented to monitor rock crabs and gain information on the fishery, abundance of rock crabs, and movement of the species, but data is not yet available (ODFW 2012b). Overall research is limited for the rock crab fishery, but efforts are in place and more data should be available in the future, thus we have rated this factor 'moderately effective'.

Subfactor 3.1.4 - Management Record of Following Scientific Advice

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

California Northwest Pacific, Trap

Moderately Effective

The California Department of Fish and Wildlife only sometimes follows scientific advice. In 2003, scientists recommended monitoring bycatch and exploring gear modifications in the rock crab fishery, restricting access in the fishery, and establishing a better understanding of rock crab populations (size, recruitment, etc.) (CDFG 2004a). Managers did restrict access to the fishery in 2005, but have not undertaken studies to monitor rock crab populations or bycatch (CDFG 2013a). For Kellet's whelk, a species that is retained in the rock crab fishery, scientists recommended that because the species is vulnerable to overfishing, preliminary regulations be implemented until a population assessment could be performed (CDFG 2009)(CDFG 2011a). They suggested implementing restrictions to benefit reproduction, including minimum catch size and seasonal closures, and proposed gear and depth restrictions, along with catch limits (CDFG 2010)(CDFG 2011a). Managers did implement a a seasonal spawning closure and catch limits for Kellet's whelk in 2012 (CDFG 2012a)(CDFG 2013a). Since scientific advice is only sometimes followed, we have rated this factor 'moderately effective'.

Oregon Northwest Pacific, Crab ring

Moderately Effective

Oregon Department of Fish and Wildlife actively seeks external input in the form of advisory panels, committee groups, peer-review, public comment, and open forum meetings. While multiple formal documents credit the scientific input and advice from various stakeholders, it is not clear how much or how often advice is implemented (ODFW 2006)(ODFW 2012c)(ODFW 2013c). The nearshore management strategy incorporates scientific advice and lists red rock crabs as a species to "watch", and recently managers have begun to monitor red rock crab populations (ODFW 2006). Since expert advice is regularly sought but information is limited on the use of scientific advice, we have rated this factor 'moderately effective'.

Subfactor 3.1.5 - Enforcement of Management Regulations

Considerations: Is there a monitoring/enforcement system in place to ensure fishermen follow management regulations? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

California Northwest Pacific, Trap

Moderately Effective

Within the California Department of Fish and Game (CDFG) there is a law enforcement division whose sole function is to protect California's natural resources. The CDFG has strict regulations for the type and design of gear that can be used to catch rock crabs, and when and where they can be fished (CDFG 2013a). There are clear descriptions of the types of permits needed to participate in the commercial fishery, including vessel, commercial fishing licenses, and limited entry permits, as well as clear descriptions of fines for violations (JCC 2011)(CDFG 2013a). It is unclear how active enforcement and monitoring is in the rock crab fishery. We have therefore rated enforcement 'moderately effective'.

Oregon Northwest Pacific, Crab ring

Moderately Effective

The Oregon State Police (OSP) fish and wildlife division is responsible for enforcing and ensuring compliance of regulations. In 2012, only 8.5% of encountered shellfish fishermen were not in compliance (Samuels 2013). Logbook and dockside checks are performed; however, it is unclear how often these checks occur in the commercial rock crab fishery. Since some enforcement is in place for the fishery we have rated this factor 'moderately effective'.

Subfactor 3.1.6 – Management Track Record

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

California Northwest Pacific, Trap

Moderately Effective

Rock crabs have been commercially fished in California since 1928 (CDFG 2004a). During this time, annual catches have fluctuated, with the highest catches in the 1990's (NMFS 2013). Catches in the 2000's have been somewhat constant, but have increased since 2010 (NMFS 2013)(CDFG 2012b). While there are some regulations in place to protect rock crab populations, such as size restrictions, there are no regulations on the quantity of rock crabs that can be caught. Additionally, there have not been population surveys performed to understand fishing pressure on the rock crab populations.
Since management of the fishery is minimal, but the population appears to support the commercial fishery, we have rated the management track record ‘moderately effective’.

Oregon Northwest Pacific, Crab ring

Moderately Effective

The majority of the management in place for rock crabs is designed to avoid threats towards dungeness crab populations and their associated fishery (ODFW 2013a). While there has been limited management and research specific to rock crabs(ODFW 2013a), the Oregon Department of Fish and Wildlife is taking a precautionary approach by placing red rock crabs on the nearshore "watch list" to prevent unwanted decline in the population (ODFW 2006). This designation demands Oregon Department of Fish and Wildlife to monitor the fishery and threats to the population, and monitoring efforts are underway (ODFW 2012b). Since the population has not been designated as depleted and management is monitoring the population for future management needs, we have rated this factor 'moderately effective'.

Subfactor 3.1.7 - Stakeholder Inclusion

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

California Northwest Pacific, Trap

Highly Effective

The Marine Life Management Act (MLMA) and Marine Life Protection Act (MLPA) have goals of conserving and sustainably using California's marine resources while improving the management process. Additionally, they require California Department of Fish and Game (CDFG) to involve interested parties in the regulatory-planning and decision-making processes (Hilborn et al. 2006)(CDFG 2013b). Involvement is often achieved through public meetings and development of advisory groups(CDFG 2013b). There are numerous projects within CDFG that have review panels, advisory groups, or technical committees that are comprised of stakeholders. Stakeholders in the rock crab fishery include commercial and recreational fishermen, agencies, marine conservation organizations, scientists, and local citizens. Managers clearly define scientific advisory roles, outline review processes, and make comments and outcomes from meetings publicly available (CDFG 2002)(LAC 2012a)(LAC 2012b)(CDFG 2013c). Therefore stakeholder participation is deemed 'highly effective'.

Oregon Northwest Pacific, Crab ring

Highly Effective

Stakeholder involvement with the regulations, policies, and management plans that impact commercial and recreational fisheries in Oregon appears high. Involvement ranges from attendance at public

meetings, participation in solicited surveys, submission of public comments, to formal review and revisions of management plans, and participation in advisory groups (ODFW 2006)(ODFW 2013b)(ODFW 2013c). Multiple formal management plans and conservation initiatives developed by the Oregon Department of Fish and Wildlife credit the input and feedback from an array of stakeholders (ODFW 2006)(ODFW 2013c). Inclusion of red rock crabs on the "nearshore species watch list" involved feedback from scientists, fisherman, conservation organizations, agencies, and concerned public citizens (ODFW 2006). Since stakeholder involvement is active and diverse, we rate stakeholder inclusion as 'highly effective'.

Factor 3.2: Bycatch Management Strategy

Scoring Guidelines

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

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

Factor 3.2: Bycatch Management Strategy					
Region / Method	**Management Strategy and Impl.**	**Scientific Research and Monitoring**	**Record of Following Scientific Advice**	**Enforcement of Regs.**	**3.2 Score**
California Northwest Pacific Trap	Moderately Effective	Ineffective	Moderately Effective	Moderately Effective	2:00: High Concern
Oregon Northwest Pacific Crab ring	All Species Retained – N/A				

Subfactor 3.2.1 - Management Strategy and Implementation

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

California Northwest Pacific, Trap

Moderately Effective

Bycatch in the rock crab fishery is not reported by California's Department of Fish and Wildlife. Regulations restrict the species of bycatch that can be retained to octopus, kellet's whelk, and crabs (other than *Cancer* species). All other species or undersized rock crabs must be released (CDFG 2013a). Mesh size is used to control the size of animal that is caught in each trap, and while mesh and opening size have changed over the years to be as selective as possible, the gear is not species specific (CDFG 2013a). To ensure bycatch is released alive, frequent gear checks are necessary (Morgan and Chuenpagdee 2003). Typically crab traps are left in the water to fish for 2-4 days before being pulled in (CDFG 2004a). California requires the trap gear to be checked every 96 hours (CDFG 2013a). Since bycatch is not reported it is difficult to determine whether the current bycatch regulations in place have limited bycatch or not. We have therefore rated management of bycatch as 'moderately effective'.

Subfactor 3.2.2 - Scientific Research and Monitoring

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

California Northwest Pacific, Trap

Ineffective

Research on non-retained species or bycatch is not regularly performed or reported in the California rock crab fishery. Logbooks, which typically report retained and non-retained catches, are not required in the rock crab fishery (CDFG 2013a). Instead, landing receipts are used to report the catch of rock crabs, but do not report bycatch. Additionally, there are no reports of observer or dock checks in this fishery. Since research and monitoring programs do not exist for this fishery, we have rated this factor 'ineffective'.

Subfactor 3.2.3 - Management Record of Following Scientific Advice

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

California Northwest Pacific, Trap

Moderately Effective

Fishery managers with the California Department of Fish and Game only sometimes follow scientific advice (see Factor 3.1. Harvest Strategy). Therefore this factor is rated 'moderately effective'.

Subfactor 3.2.4 - Enforcement of Management Regulations

Considerations: Is there a monitoring/enforcement system in place to ensure fishermen follow management regulations? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

California Northwest Pacific, Trap

Moderately Effective

California Department of Fish and Game is responsible for enforcing regulations in the rock crab fishery. There is no information on enforcement specific to bycatch in the rock crab fishery, but overall enforcement for the fishery is considered 'moderately effective' (see Factor 3.1 Harvest Strategy).

Criterion 4: Impacts on the habitat and ecosystem

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

The final score is the geometric mean of the impact of fishing gear on habitat score (plus the mitigation of gear impacts score) and the Ecosystem Based Fishery Management score. Rating is based on the score as follows: >3.2=Green or Low Concern, >2.2 and <=3.2=Yellow or Moderate Concern, <=2.2=Red or High Concern. Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region / Method	Impacts of gear on the habitat	Mitigation of Gear Impacts	Ecosystem Based Fisheries Management	Criterion 4 Score
California Northwest Pacific Trap	2.00:Moderate Concern	0.50:Moderate Mitigation	3.00:Moderate Concern	**Yellow (2.739)**
Oregon Northwest Pacific Crab ring	2.00:Moderate Concern	0.50:Moderate Mitigation	4.00:Low Concern	**Yellow (3.162)**

Criterion 4 Assessment

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

Scoring Guidelines

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

California Northwest Pacific, Trap

2.00 **Moderate Concern**

Rock crabs are fished in northern and southern California using a trap or pot design. These traps are baited with food and set on the ocean floor to attract crabs. Traps remain in the water for 2-4 days before they are hauled up to retrieve the catch; during this process the traps can cause scraping along the ocean floor (Eno et al. 2001)(NREFHSC 2002)(Morgan and Chuenpagdee 2003). Paired and single traps are common in the Rock Crab fishery (CDFG 2004a). Traps hooked together have a larger "footprint" of potential damage because the chain can rub along the bottom (NREFHSC 2002)(Morgan and Chuenpagdee 2003). Traps are known to disturb plants and animals that live on the ocean floor including sea fans, algae, kelp, clams, sponges, and worms (Eno et al. 2001)(Morgan and Chuenpagdee 2003). Rock crabs live in diverse habitat including soft sand/mud areas and on hard bottom substrates or rocky reefs (Carroll and Winn 1989). Rocky reef habitats are typically less resilient (take longer to recover) to damage caused by fishing gears compared to soft bottom habitats (NREFHSC 2002). How, where, and when traps are used can alter the environmental impacts of the gear; for example, traps left for longer periods of time and replaced to the same location would cause longer lasting destruction to the area than a trap checked daily and moved to different locations (Eno et al. 2001)(NREFHSC 2002). Unfortunately, fishermen are not required to document trap set locations, therefore determining the cumulative effects that this trap fishery has on the habitat is difficult. Because rock crabs may be found and fished on hard bottom substrates or rocky reefs, the impact to the bottom habitat by trap fishing is considered a 'moderate concern'.

Oregon Northwest Pacific, Crab ring

2.00 **Moderate Concern**

Rock crabs are primarily caught in Oregon bays, but can be caught along the rocky Pacific Ocean coast (Rudy et al. 1983)(ODFW 2013a). Permitted gear includes baited crab rings and baited crab traps, but currently rock crabs are only reported to be caught in crab rings (Ainsworth 2013, personal communication)(ODFW 2013a). Habitat for rock crabs range from shallow rocky reefs and kelp beds to artificial substrate (jetties) and soft bottom (mud/sand) sub-tidal areas (ODFW 2006). Rocky or reef habitats are typically less resilient (take longer to recover) to damage caused by fishing gears compared to soft bottom habitats (NREFHSC 2002). Traditionally trap gear is set on the bottom and left for several days before it is pulled up to retrieve the catch, and damage to substrate can occur when the traps are set, when they are pulled in, or during the resting period. Disturbance of boulders, corals, plants (kelp, algae, seagrass, etc.), and animals (crabs, clams, worms, etc.) that live on the bottom has been shown in marine trap fisheries (Eno et al. 2001)(NREFHSC 2002)(Morgan and Chuenpagdee 2003). However, crab rings are the primary gear used in this fishery and this gear is small, lightweight, and only actively catches when the trap is pulled up, making crab rings less destructive than other trap gears (Ainsworth

2013, personal communication). Since the gear comes in contact with slow recovering rocky habitat we have rated the impact of trap gear as 'moderate concern'.

Factor 4.2 - Mitigation of Gear Impacts

Scoring Guidelines

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

California Northwest Pacific, Trap

0.50 **Moderate Mitigation**

Some efforts are being made to protect habitats from fishing gear impacts in California. There are 124 marine protected areas (MPAs) in California, which do not allow any commercial rock crab fishing (CDFG 2013a). These MPAs cover 852 sq mi or 16.12% of California's waters (CDFG 2014). In addition to these MPAs, there are other nearshore areas where commercial rock crab fishing is prohibited in Humboldt, San Pedro and San Diego bays and the broader Santa Monica Bay, as well as the leeward side of Santa Catalina Island (CDFG 2013a). In southern California, where the majority of rock crab fishing occurs, the total protected areas covers 22% of this region's waters (CDFG 2014)(Juhasz 2014, personal communication). Additionally, the southern California fishery has restricted access which limits the number of commercial fishermen licensed to catch rock crabs and helps limits overall habitat damage (CDFG 2013a). Gear lost or abandoned are at sea can continue to impact the habitat as it scrapes or tumbles along the ocean floor; fortunately a hotline is available to report lost gear and removal efforts are being made (SeaDoc Society 2009). We have awarded a score of "moderate mitigation" since a substantial proportion of the area is protected from rock crab fishing and managers have made efforts to limit the number of fishing participants.

Oregon Northwest Pacific, Crab ring

0.50 **Moderate Mitigation**

The rock crab fishery is small, with only 5 vessels participating (Ainsworth 2013, personal communication). Permitted gear includes crab traps and crab rings. Oregon Department of Fish and Wildlife (ODFW) minimizes the impact of the rock crab fishery on the ecosystem by regulating the number of traps or rings that can be used, the weight of the gear, monitoring lost or abandoned gear, and encouraging the removal of abandoned gear (ODFW 2013a). Crab trap size must be 13 cubic feet or less and must contain a panel made from biodegradable twine (ODFW 2013a). In bays and estuaries only crab rings are allowed and not more than 15 rings can be used per vessel (ODFW 2013a). Crab rings are smaller and lighter weight than crab traps, and are the only current method used to catch rock crabs (Ainsworth 2013, personal communication). Many of these regulations were implemented to protect the dungeness crab fishery, but because they share habitat, red rock crab fishermen must follow the same regulations (ODFW 2013a). Since light weight gear is used and some efforts are in place, a score of 'moderate mitigation' is awarded.

Factor 4.3 – Ecosystem-Based Fisheries Management

Scoring Guidelines

- *5 (Very Low Concern) = Substantial efforts have been made to protect species' ecological roles and ensure fishing practices do not have negative ecological effects (e.g., large proportion of fishery area protected with marine reserves, abundance is maintained at sufficient levels to provide food to predators).*
- *4 (Low Concern) = Studies are underway to assess the ecological role of species and measures are in place to protect the ecological role of any species that plays an exceptionally large role in the ecosystem. If hatchery supplementation or fish aggregating devices (FADs) are used, measures are in place to minimize potential negative ecological effects.*
- *3 (Moderate Concern) = Fishery does not catch species that play an exceptionally large role in the ecosystem, or if it does, studies are underway to determine how to protect the ecological role of these species. OR negative ecological effects from hatchery supplementation or FADs are possible and management is not place to mitigate these impacts.*
- *2 (High Concern) = The fishery catches species that play an exceptionally large role in the ecosystem and no efforts are being made to incorporate their ecological role into management.*
- *1 (Very High Concern) = The use of hatchery supplementation or FADs in the fishery is having serious negative ecological or genetic consequences. OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.*

California Northwest Pacific, Trap

3.00 **Moderate Concern**

Rock Crabs prey on invertebrates (e.g., snails, abalone, clams, crabs, oysters), but also forage on dead material (CDFG 2001)(CDFG 2004a). They are an important food source for many groups of animals including: birds (willet), marine mammals (sea otters), fish (Cabezon, rockfish, barred sand bass, sharks) and invertebrates (octopus) (Stenzel et al. 1976)(Carroll and Winn 1989)(Roberts et al. 1984)(CDFG 2001)(CDFG 2004a).

Currently there is limited management in place for rock crabs and no environmental surveys to address potential impacts to the food web or ecosystem (CDFG 2013a). However, California does have 124 marine protected areas (MPAs) to protect marine life, habitats, and ecosystems. These MPAs cover 16% of the state's waters (CDFG 2014). MPAs have different levels of protection, but none allow commercial rock crab fishing to occur (CDFG 2013a). In areas where commercial crab fishing was closed, rock crabs were larger and more abundant than surrounding fished areas (CDFG 2004a).

Because the rock crab fishery is not considered to catch any species of "exceptional ecological importance", the areas protected in MPA's cover less than 20% of California's coastal waters, and no other efforts to address ecosystem impacts are in place, we have rated this factor 'moderate concern'.

Oregon Northwest Pacific, Crab ring

4.00 **Low Concern**

Rock crabs are scavengers and carnivores, eating barnacles, crabs, clams, and snails (Rudy et al. 1983). They are an important food item for many sea birds, octopus, and large fishing, including salmon and herring (Rudy et al. 1983). In 2006 red rock crabs were listed as an important nearshore species. Scientists reported that the species did not require management action, but could in the future, and thus recommended it for the "watch list" (ODFW 2006). The goal of this project is to evaluate the importance of species in the nearshore habitat and increase their sustainability through increased or modified regulations (ODFW 2006). Since 2006, red rock crabs have remained on the "watch list" and continue to be monitored by The Shellfish Program (ODFW 2012c). Additionally, the Oregon rock crab fishery does not catch species of “exceptional ecological importance”. Since studies are underway to evaluate the ecological role of rock crabs, we have scored this factor 'low concern'.

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

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Appendix A: List of All Species Assessed in the Fishery

Summary of all main species considered in the assessment

Rock crab: California Northwest Pacific, Trap				
Species	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Subscore**
BROWN ROCK CRAB	Low Vulnerability	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
RED ROCK CRAB	Low Vulnerability	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
YELLOW ROCK CRAB	Low Vulnerability	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
KELLET'S WHELK	High Vulnerability	2.00: High Concern	3.67: Low Concern	**2.709**
BENTHIC INVERTS	Medium Vulnerability	3.00: Moderate Concern	3.67: Low Concern	**3.318**
FINFISH	Medium Vulnerability	3.00: Moderate Concern	3.67: Low Concern	**3.318**

Rock crab: Oregon Northwest Pacific, Crab ring				
Species	**Inherent Vulnerability**	**Abundance**	**Fishing Mortality**	**Subscore**
RED ROCK CRAB	Low Vulnerability	3.00: Moderate Concern	2.33: Moderate Concern	**2.644**
BROWN ROCK CRAB	Low Vulnerability	3.00: Moderate Concern	3.67: Low Concern	**3.318**