Red king crab

Paralithodes camtschaticus

©Monterey Bay Aquarium

Norway, Barents Sea

Pots

August 31, 2015

Seafood Watch Consulting Researcher

Disclaimer
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Seafood Watch Standard used in this assessment: Standard for Fisheries vF2
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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 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**

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.

Based on this principle, Seafood Watch had developed four sustainability criteria for evaluating wildcatch 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 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.

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\(^1\) “Fish” is used throughout this document to refer to finfish, shellfish and other invertebrates
Summary

The red king crab is a large crustacean that was intentionally introduced into the Barents Sea in the 1960s by Soviet scientists seeking to establish a valuable pot fishery. Initially the principal countries of Norway and Russia set cooperative management measures to encourage the stock’s further westward expansion and to increase densities in the area in which it was released. After initiation of a commercial fishery, and confirmation that Norwegian management had no effect on Russian stock size, Norway and Russia agreed to manage the stock separately, each pursuing its own goals and objectives. Since the advent of the commercial fishery, Russian landings have dominated Norwegian landings and imports into the US.

Because of its status as a nonnative species with harmful ecosystem impacts, abundance, fishing mortality, and vulnerability are not of concern. The use of trap gear in both countries for catching red king crab has little impact on bottom habitat because harvesters fish on mud substrates with little structure. Bycatch species are not well known. But this gear type typically has low amounts in other areas of the world; especially when outfitted with biodegradable panels and other management measures to reduce interaction. As such, bycatch and discard rates are also not of concern.

Norwegian managers currently pursue a policy of reducing the stock west of 26°E through an open access fishery, while east of this line, in areas bordering their Russian neighbors, harvest is at MEY (maximum economic yield). This policy is reflected in the higher quotas, allowances on removal of females, and lack of regulation in areas not adjacent to Russia. These practices, while troubling if invoked on a native species, have earned Norway’s fishery a “Best Choice” rating when successfully used on a harmful invasive stock such as red king crab.
Final Seafood Recommendations

<table>
<thead>
<tr>
<th>SPECIES/FISHERY</th>
<th>CRITERION 1: IMPACTS ON THE SPECIES</th>
<th>CRITERION 2: IMPACTS ON OTHER SPECIES</th>
<th>CRITERION 3: MANAGEMENT EFFECTIVENESS</th>
<th>CRITERION 4: HABITAT AND ECOSYSTEM</th>
<th>OVERALL RECOMMENDATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red King crab Norway Barents Sea, Pots, Norway</td>
<td>Green (5.00)</td>
<td>Yellow (2.51)</td>
<td>Yellow (3.00)</td>
<td>Green (3.61)</td>
<td>(3.41)</td>
</tr>
</tbody>
</table>

Summary

The red king crab is a large crustacean that was intentionally introduced into the Barrens Sea in the 1960’s by then Soviet scientists seeking to establish a valuable pot fishery. Both Norway and Russia currently harvest this nonnative.

The **Best Choice** rating for the red king crab fishery in Norway reflects that country’s current policies of keeping a low biomass to prevent further spread and eradication of the stock in most of its territorial seas.

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 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).
Introduction

Scope of the analysis and ensuing recommendation

This report covers recommendations for the Barents Sea red king crab (*Paralithodes camtschaticus*) landed by Norway and caught using crab pot gear.

Species Overview

The large bodied red king crab was intentionally introduced into the Barents Sea, near Kola Bay, by Soviet researchers in the 1960s (Hjelset 2013)(Hjelset et al. 2009)(Jørgensen & Nilssen 2011)(Jørgensen 2013). The goal was to increase economic opportunities for communities in this part of the Barents Sea. The species started to grow and spread.

![Generalized spread of Red king crab.](Figure_1.png)


During operation of the research fishery, both countries agreed to keep landing levels conservative to increase the population. This was relaxed in 2002 with the advent of the commercial fishery. Until 2007, Norway and Russia agreed to a single quota via the Mixed Russian-Norwegian Fishery Commission. This ended in 2007 when both countries pursued management of the stock separately (Jørgensen and Nilssen 2011). Fishery management goals, quotas, assessment methodologies, and management are now independent, but cooperative research still continues.

Production Statistics

Norway landings of red king crab have recently hovered around 1,000t.
While prior to that, in 2008 and 2009, landings were much higher; at approximately 5,000 t. Coincidentally, 2008 and 2007 landing levels increased directly after joint management with Russia ceased. (Jørgensen and Nilssen 2011).

**Importance to the US/North American market.**

As documented in a recent World Wildlife Fund report, (WWF 2014) import/export statistics and analysis of king crab is complicated by market name/species ambiguity, trade data discrepancies, and illegal activity. Despite this, some inferences can be drawn.

The majority of red king crab caught in Norway is destined for the export market. Of the 1,000 t average yearly landings, approximately 30%–35% (300-350 t) of that is destined for US markets. While Norway may not appear to be major source of red king crab on US markets from all areas, it accounts for 20% of the imports from the Barents Sea into the US. Also, with reductions in world-wide red king crab quotas, its importance is expected to rise.

Figure 2: Catch (blue bars), Value (red line), and Avg. price (green line) of Norwegian Red king crab (From Anonymous 2014 [Translated]). Note 2014 preliminary.
<table>
<thead>
<tr>
<th>Year</th>
<th>Tons imported</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>56</td>
</tr>
<tr>
<td>2003</td>
<td>48</td>
</tr>
<tr>
<td>2004</td>
<td>173</td>
</tr>
<tr>
<td>2005</td>
<td>201</td>
</tr>
<tr>
<td>2006</td>
<td>87</td>
</tr>
<tr>
<td>2007</td>
<td>66</td>
</tr>
<tr>
<td>2008</td>
<td>242</td>
</tr>
<tr>
<td>2009</td>
<td>278</td>
</tr>
<tr>
<td>2010</td>
<td>156</td>
</tr>
<tr>
<td>2011</td>
<td>96</td>
</tr>
<tr>
<td>2012</td>
<td>358</td>
</tr>
<tr>
<td>2013</td>
<td>342</td>
</tr>
</tbody>
</table>

Figure 3 Tons of King crab (as frozen) imported into the US from Norway (Data from http://www.st.nmfs.noaa.gov/commercial-fisheries/index)

**Common and market names.**

Red crab is commonly referred to by that name or simply as king crab. It may also appear as Kani (especially for sushi) Kamchatka king crab or Alaskan king crab when mislabeled.

**Primary product forms**

Common product include fresh, frozen (whole or part), canned, and a growing live market.
Assessment

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

Criterion 1: Impacts on the species under assessment

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

The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

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

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

Criterion 1 Summary

<table>
<thead>
<tr>
<th>RED KING CRAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
</tr>
<tr>
<td>Norway/Barents Sea Pots</td>
</tr>
</tbody>
</table>

As an intentionally introduced nonnative species, with harmful ecological impacts, fishing mortality and stock abundance are of very low concern. Given moderate vulnerability, and low concerns of fishing mortality and abundance, the impacts to this stock warrant a green rating.

Criterion 1 Assessment

SCORING GUIDELINES

Factor 1.1 - Inherent Vulnerability

- Low—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing).
- Medium—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).
- High—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make it particularly vulnerable to fishing, (e.g., long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator). Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling, aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.
**Factor 1.2 - Abundance**

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

**Factor 1.3 - Fishing Mortality**

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

**RED KING CRAB**

**Factor 1.1 - Inherent Vulnerability**

<table>
<thead>
<tr>
<th>NORWAY/BARENTS SEA, POTS, NORWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medium</strong></td>
</tr>
</tbody>
</table>

Red king crabs spawn yearly after females molt. While highly fecund, sexual maturity is not achieved until 60-110 mm carapace width (Hjelset et al. 2009)(Falk-Petersen, J. et al. 2011) or at about 5-7 years of age (Danner 2007)(Falk-Petersen, J. et al. 2011). Maximum age is 20-30 years. Red king crabs form pods by sex and size (Jørgensen 2013) making them more vulnerable to fishing pressure.

**Factor 1.2 - Abundance**

<table>
<thead>
<tr>
<th>NORWAY/BARENTS SEA, POTS, NORWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Low Concern</strong></td>
</tr>
</tbody>
</table>

Red king crabs in the Barents Sea are an intentionally introduced exotic species that has been shown to have caused some harmful ecological impacts (Jørgensen & Nilssen 2011)(Jørgensen & Spiridonov 2014)(Jørgensen 2013)(Falk-Petersen, J. et al. 2011). As such, potential depletion of the stock's abundance through fishing is not a conservation concern.
Factor 1.3 - Fishing Mortality

NORWAY/BARENTS SEA, POTS, NORWAY

Very Low Concern

Because red king crab in the Barents Sea is an intentionally introduced nonnative species, fishing mortality is of very low 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 to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing.

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

- 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 Critical

Criterion 2 Summary

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

<table>
<thead>
<tr>
<th>Species</th>
<th>Inherent Vulnerability</th>
<th>Abundance</th>
<th>Fishing Mortality</th>
<th>Subscore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benthic inverts</td>
<td>2.00:Medium</td>
<td>3.00:Moderate Concern</td>
<td>2.33:Moderate Concern</td>
<td>Yellow (2.64)</td>
</tr>
<tr>
<td>Finfish</td>
<td>2.00:Medium</td>
<td>3.00:Moderate Concern</td>
<td>2.33:Moderate Concern</td>
<td>Yellow (2.64)</td>
</tr>
</tbody>
</table>

The bycatch and retained species caught in the Barents Sea Crab pot Fishery are generally unknown. Bycatch is scored according to the Seafood Watch unknown bycatch matrix, based on a synthesis of peer reviewed literature and expert opinion on the bycatch impacts of each gear type. More information is available in Appendix 3 of the Seafood Watch criteria.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Inherent Vulnerability
(same as Factor 1.1 above)

Factor 2.2 - Abundance
(same as Factor 1.2 above)
### Factor 2.3 - Fishing Mortality
*(same as Factor 1.3 above)*

**BENTHIC INVERTS**

### Factor 2.1 - Inherent Vulnerability

<table>
<thead>
<tr>
<th>Area</th>
<th>Vulnerability</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NORWAY/BARENTS SEA, POTS, NORWAY</strong></td>
<td>Medium</td>
<td>Crab pots are likely to interact with benthic invertebrates, but the species of benthic invertebrates affected is unknown. Unknown species of benthic invertebrates are considered to be of medium inherent vulnerability according to the Seafood Watch criteria.</td>
</tr>
</tbody>
</table>

### Factor 2.2 - Abundance

<table>
<thead>
<tr>
<th>Area</th>
<th>Concern</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NORWAY/BARENTS SEA, POTS, NORWAY</strong></td>
<td>Moderate Concern</td>
<td>The stock status of unknown species of benthic invertebrates is considered to be of moderate concern according to the Seafood Watch criteria.</td>
</tr>
</tbody>
</table>

### Factor 2.3 - Fishing Mortality

<table>
<thead>
<tr>
<th>Area</th>
<th>Concern</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NORWAY/BARENTS SEA, POTS, NORWAY</strong></td>
<td>Moderate Concern</td>
<td>The impact of pot fisheries on unknown species of benthic invertebrates is considered to be of moderate concern according to the Seafood Watch Unknown Bycatch matrix, based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type.</td>
</tr>
</tbody>
</table>

### Factor 2.4 - Discard Rate

<table>
<thead>
<tr>
<th>Area</th>
<th>Rate</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NORWAY/BARENTS SEA, POTS, NORWAY</strong></td>
<td>20-40%</td>
<td>Because discard and bait use is not reported, a moderate value was used. Both discard and bait usage in this fishery are not known. Therefore a bait usage rate of 20% is assumed as specified in the Seafood Watch guidelines. Likewise a 0%-20% discard rate (including undersize red crab) was also used. A 20%-40% bait and discard rate in a fishery is considered a moderate value.</td>
</tr>
</tbody>
</table>

**FINFISH**

### Factor 2.1 - Inherent Vulnerability

<table>
<thead>
<tr>
<th>Area</th>
<th>Vulnerability</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NORWAY/BARENTS SEA, POTS, NORWAY</strong></td>
<td>Medium</td>
<td>Crab pots are likely to interact with unidentified fish species, but the species affected is unknown. Unknown</td>
</tr>
</tbody>
</table>
species fish are considered to be of medium inherent vulnerability according to the Seafood Watch criteria.

**Factor 2.2 - Abundance**

NORWAY/BARENTS SEA, POTS, NORWAY  
Moderate Concern  
The stock status of unknown species of finfish are considered to be of moderate concern according to the Seafood Watch criteria.

**Factor 2.3 - Fishing Mortality**

NORWAY/BARENTS SEA, POTS, NORWAY  
Moderate Concern  
The fishing mortality of unknown species of finfish is considered to be of moderate concern according to the Seafood Watch unknown bycatch matrix, based on a synthesis of peer reviewed literature and expert opinion on the bycatch impacts of each gear type.

**Factor 2.4 - Discard Rate**

NORWAY/BARENTS SEA, POTS, NORWAY  
20-40%  
Because discard and bait use is not reported, a moderate value was used. Both discard and bait usage in this fishery are not known. Therefore a bait usage rate of 20% is assumed as specified in the Seafood Watch guidelines. Likewise a 0%–20% discard rate (including undersize red crab) was also used. A 20%–40% bait and discard rate in a fishery is considered a moderate value.
**Criterion 3: Management Effectiveness**

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

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

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

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

**Criterion 3 Summary**

<table>
<thead>
<tr>
<th>Region / Method</th>
<th>Harvest Strategy</th>
<th>Bycatch Strategy</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway / Barents Sea / Pots / Norway</td>
<td>3.00</td>
<td>3.00</td>
<td>Yellow (3.00)</td>
</tr>
</tbody>
</table>

Red king crab in the Barents is managed by Norway and Russia. Until 2005 both countries jointly managed the stock with a goal of maximizing economic output. Since then, each country has managed this invasive species differently with different goals. Norway sets quotas maximum economic yield near the Russian border but a policy of eradication outside this zone. Russian fishery managers set quotas to increase abundance and density for maximum long-term economic output and spread. Russia additionally has released larval crabs and has further documented the spread of the species eastward.

**Criterion 3 Assessment**

**SCORING GUIDELINES**

**Factor 3.1 - Harvest Strategy**

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

- 5 (Very Low Concern)—Rated as ‘highly effective’ for all seven subfactors considered
- 4 (Low Concern)—Management Strategy and Recovery of Species of Concern rated ‘highly effective’ and all other subfactors rated at least ‘moderately effective.’
- 3 (Moderate Concern)—All subfactors rated at least ‘moderately effective.’
- 2 (High Concern)—At minimum, meets standards for ‘moderately effective’ for Management Strategy and Recovery of Species of Concern, but at least one other subfactor rated ‘ineffective.’
- 1 (Very High Concern)—Management exists, but Management Strategy and/or Recovery of Species of Concern rated ‘ineffective.’
- 0 (Critical)—No management exists when there is a clear need for management (i.e., fishery catches threatened, endangered, or high concern species), OR there is a high level of Illegal, unregulated, and unreported fishing occurring.
Factor 3.1 Summary

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.

NORWAY / BARENTS SEA, POTS, NORWAY

Moderately Effective

Quotas are set at maximum economic yield (MEY) in the quota managed zone. Quotas within this zone are set to allow for consistent high yields for maximum economic benefit. In the open access area west of this zone, catch is completely unregulated and not subject to quotas, size limits, or other measures.

Justification:

Norway manages Red king crab using two zones; a quota zone and a non-quota zone.

Figure 4 Current distribution of Red king crab in Norwegian and adjacent waters. Area east of 26° is the quota fishing area (from Hjelset 2013: their Figure 1).
Within the quota zone quotas, minimum sizes, and gear restrictions are used to keep the population and harvest at maximum economical yield (Hjelset 2013)(Hjelset et al. 2009)(IMR 2012)(MoF 2014). To the west of this zone, harvest is unregulated and the goal of minimizing the spread of red crab is the driving force in management. This includes a small subsidy to encourage removals. Norway's policy has had some success; population sizes have been stable and westward spread of the species has been halted in recent years (Hjelset 2013)(IMR 2012)(IMR 2013)(Anonymous 2015). This is, in part, due to an additional relaxation of regulations allowing for female crabs to be harvested even within the quota zone.

Subfactor 3.1.2 – Recovery of Species of Concern

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

NORWAY / BARENTS SEA, POTS, NORWAY

N/A

The Norwegian fishery targets only red king crab, an invasive stock in the Barents. Bycatch is not well known, but generally thought to be low. As such, there are no over exploited or threatened species targeted or retained in this fishery.

Subfactor 3.1.3 – Scientific Research and Monitoring

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

NORWAY / BARENTS SEA, POTS, NORWAY

Moderately Effective

Scientific monitoring is in place, but uncertainties in the data, as well as a lack of overall information on impacts make the data uncertain for management use.

Justification:

Norway takes part in the joint IMR-PINRO (Institute of Marine Research-Polar Research Institute of Marine Fisheries and Oceanography), which documents distributions and abundances for several stocks. In addition, Norway conducts their own assessments of the stock in Norwegian waters and monitors distribution of red king crab in their exclusive economic zone (EEZ) (IMR 2012)(IMR 2013). However, data are very uncertain for this stock given its relatively recent introduction, and lack of research on impact to the Barents ecosystem (Hjels 2014)(Hjelset 2013)(IMR 2012)(IMR 2013).

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.
**NORWAY / BARENTS SEA, POTS, NORWAY**

**Moderately Effective**

Norwegian fishery managers follow the scientific advice and set quotas in line with scientists’ suggestions. For example, because of concerns around the ecosystem effects of Barents Sea red crab, managers have set quotas higher and in line with scientific advice to reduce stock size and have initiated exploitation of female crabs (Hjelset 2013)(Jørgensen & Spiridonov 2014). Additionally, since 2010, the Norwegian government has been using a subsidy to increase catch and effort outside of the quota regulated zone. However, the current policy within the quota regulated zone is for maximum sustainable economic yield rather than eradication or declining abundance (Anonymous 2015).

### Subfactor 3.1.5 – 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.*

**NORWAY / BARENTS SEA, POTS, NORWAY**

**Highly Effective**

Norwegian managers use logbooks, dealer reporting, and a newly implemented vessel monitoring system (VMS) to track catch and landings. All vessels must call in at the start and end of a fishing trip (MoF 2014).

### 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.*

**NORWAY / BARENTS SEA, POTS, NORWAY**

**Moderately Effective**

Norwegian managers have only recently instituted female catches and higher quotas (Hjelset 2013)(IMR 2012) (IMR 2013). So the long-term effects of these measures cannot be effectively gauged. While some progress in stabilizing the spread is apparent, the overall goal in the quota managed zone is for MEY, while the goal in the open access zone is to limit the spread of the red crab. As such, only in the open access area is management effective in the goal of minimizing the impact of this invasive species.

### 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.*

**NORWAY / BARENTS SEA, POTS, NORWAY**

**Highly Effective**

Norway has a inclusive process which allows for stockholder notification and participation in management (see: http://www.fiskeridir.no/).
Factor 3.2 - Bycatch 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 rating 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 rated 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

<table>
<thead>
<tr>
<th>Region / Method</th>
<th>All Kept</th>
<th>Critical</th>
<th>Strategy</th>
<th>Research</th>
<th>Advice</th>
<th>Enforce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway / Barents Sea / Pots / Norway</td>
<td>No</td>
<td>No</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Moderately Effective</td>
<td>Highly Effective</td>
</tr>
</tbody>
</table>

Bycatch and discards in the Norwegian fishery are not well known, but is thought to be very small given the type of gear used the location of fishing, and other factors.

Subfactor 3.2.2 – 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.).

<table>
<thead>
<tr>
<th>NORWAY / BARENTS SEA, POTS, NORWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately Effective</td>
</tr>
</tbody>
</table>

There is no known management strategy per se, but the gear used has biodegradable panels to prevent ghostfishing by lost equipment as well as other modifications to reduce bycatch (such as escape vents) (Eno et al. 2001)(Fuller et al. 2008)(IMR 2012).

Subfactor 3.2.3 – Scientific Research and Monitoring

Considerations: Is bycatch in the fishery recorded/document 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.
Subfactor 3.2.4 – 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.

Subfactor 3.2.5 – Enforcement of Management Regulations

Considerations: Is there a monitoring/enforcement system in place to ensure fishermen follow management regulations and what is the level of fishermen’s compliance with regulations? To achieve a Highly Effective rating, there must be consistent enforcement of regulations and verification of compliance.

No specific enforcement practices or policies are available for bycatch species. As such, the default values from Score 3.1.5 are used.
**Criterion 4: Impacts on the habitat and ecosystem**

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

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

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

Rating cannot be Critical for Criterion 4.

**Criterion 4 Summary**

<table>
<thead>
<tr>
<th>Region / Method</th>
<th>Gear Type and Substrate</th>
<th>Mitigation of Gear Impacts</th>
<th>EBFM</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway / Barents Sea / Pots / Norway</td>
<td>3.00: Low Concern</td>
<td>0.25: Minimal Mitigation</td>
<td>4.00: Low Concern</td>
<td>Green (3.61)</td>
</tr>
</tbody>
</table>

**Criterion 4 Assessment**

**SCORING GUIDELINES**

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

- 5 (None) - Fishing gear does not contact the bottom
- 4 (Very Low) - Vertical line gear
- 3 (Low)—Gear that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Bottom seine on resilient mud/sand habitats. Midwater trawl that is known to contact bottom occasionally (2)
- 2 (Moderate)—Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Bottom seine except on mud/sand
- 1 (High)—Hydraulic clam dredge. Dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)
- 0 (Very High)—Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)  
  Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

**Factor 4.2 - Mitigation of Gear Impacts**

- +1 (Strong Mitigation)—Examples include large proportion of habitat protected from fishing (>50%) with gear, fishing intensity low/limited, gear specifically modified to reduce damage to seafloor and modifications shown to be effective at reducing damage, or an effective combination of ‘moderate’ mitigation measures.
- +0.5 (Moderate Mitigation)—20% of habitat protected from fishing with gear or other measures in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing.
- +0.25 (Low Mitigation)—A few measures are in place (e.g., vulnerable habitats protected but other habitats not protected); there are 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

Factor 4.3 - Ecosystem-Based Fisheries Management

- 5 (Very Low Concern)—Substantial efforts have been made to protect species’ ecological roles and ensure fishing practices do not have negative ecological effects (e.g., large proportion of fishery area is protected with marine reserves, and 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. Measures are in place to minimize potentially negative ecological effect if hatchery supplementation or fish aggregating devices (FADs) are used.
- 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)—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)—Use of hatchery supplementation or fish aggregating devices (FADs) in the fishery is having serious negative ecological or genetic consequences, OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.

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

<table>
<thead>
<tr>
<th>NORWAY / BARENTS SEA, POTS, NORWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Concern</strong></td>
</tr>
<tr>
<td>Bottom impacts by this gear type are thought to be quite low. The fishery normally occurs on soft sediments moderately far from shore (FSUE 2014)(IMR 2012)(IMR 2013). Given that crab traps tend to have minimal impact on soft sediment communities (Eno et al. 2001), the impact of this fairly small fishery is thought to be low.</td>
</tr>
</tbody>
</table>

Factor 4.2 - Mitigation of Gear Impacts

<table>
<thead>
<tr>
<th>NORWAY / BARENTS SEA, POTS, NORWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimal Mitigation</strong></td>
</tr>
<tr>
<td>Norwegian fishery managers utilize satellite-based vessel monitoring, closed areas, and other measures to reduce impact of this gear on the sea floor and associated habitat (MoF 2014). However, managers have been taking measures to increase effort in this fishery to prevent the spread of the species, which may inadvertently increase habitat impacts.</td>
</tr>
</tbody>
</table>

Factor 4.3 - Ecosystem-Based Fisheries Management

<table>
<thead>
<tr>
<th>NORWAY / BARENTS SEA, POTS, NORWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Concern</strong></td>
</tr>
<tr>
<td>Policies put in place to control the spread of red king crab by Norwegian managers have little impact on the</td>
</tr>
</tbody>
</table>
ecosystem in terms of bycatch or habitat damage. As such, ecosystem impacts from removing this nonnative species and the associated fishery is of low concern.
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.

Seafood Watch would like to thank the consulting researcher and author of this report, Matt Cieri, as well as several anonymous reviewers for graciously reviewing this report for scientific accuracy.
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Appendix A: Review Schedule

Assessments are generally updated yearly or every two years depending on funding. Given the market changes, an update within 5 years is desirable.