



Monterey Bay Aquarium Seafood Watch

Environmental sustainability assessment of wild-caught Orange-footed sea cucumber (*Cucumaria frondosa*) from Canada (Quebec) caught using towed dredges



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Species: Orange-footed sea cucumber (*Cucumaria frondosa*)
Location: Canada: Quebec (Northwest Atlantic)
Gear: Towed dredges
Type: Wild Caught
Author: Seafood Watch
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Assessed using [Seafood Watch Fisheries Standard v3](#)

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About Seafood Watch

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

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

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Watch assessments in any way they find useful.

Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished¹ or farmed that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following guiding principles illustrate the qualities that fisheries must possess to be considered sustainable by the Seafood Watch program (these are explained further in the Seafood Watch Standard for Fisheries):

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

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

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

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

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

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

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

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

Summary

This report assesses the sustainability of the orange-footed sea cucumber (*Cucumaria frondosa*) fishery in Quebec, Canada. The fishery is currently in an exploratory phase and harvesting occurs in specific management areas on the Gaspé Peninsula, as well as on the north shore of the Gulf of St Lawrence, using drag nets (i.e., dredging).

C. frondosa has an extensive range around the Arctic and north Atlantic Oceans, and is found at a range of depths, moving deeper as it gets older and larger. They are found on complex rocky bottoms or hard substrates and are unusual for sea cucumbers in that they are selective suspension feeders. Sea cucumbers function as organic nutrient recyclers. They are gonochoric and exhibit broadcast spawning.

The fishery in Quebec has existed since 2008, but is still in the exploratory stages and therefore not yet fully commercial. It is managed by Fisheries and Oceans Canada (DFO) and is currently restricted to five areas, each with specific restrictions. For most of the fishery's development, fishers have found more productive areas to target and CPUE, along with landings, has increased. The most recent assessment in 2014 showed that landings on the Gaspé Peninsula (Zones B and C) in 2013 were over 90% of the total allowable catch (TAC); however, a decline in CPUE was observed in 2014, resulting in reduced TAC and landings from 2015.

The fishery is managed with a precautionary approach under an interim management plan published in 2015, with drag fishing only permitted as a temporary measure for the fishery's exploration; diving is ultimately preferred as a more environmentally sustainable method. Exploitation rates are restricted to 10% of the calculated available biomass in each area, and protected areas prohibit fishing in 15% of the fishing zones. Other strengths of the fishery include a comprehensive monitoring strategy, including at-sea observers and VMS, as well as an inclusive relationship with stakeholders.

Bycatch is a concern, totaling between 5% and 11% by number of sea cucumbers in landings over the 2011 to 2013 period and 20.2% in 2014. Several benthic invertebrates are caught and the DFO require gear modifications to reduce it. Similar concerns exist for the impact of the drag net on habitat; again, modifications are required to reduce impact. Yet, measures have not been in place long enough to measure effectiveness for either bycatch or habitat impact.

Overall, the fishery is managed conservatively, and although *C. frondosa* is a relatively vulnerable species, there are no current concerns over stocks. The impact of dredging is of some concern, due to impact on habitat and bycatch species, although it is unlikely to continue to be permitted as the fishery becomes fully commercial.

Final Seafood Recommendations

SPECIES FISHERY	CRITERION 1: Impacts on the Species	CRITERION 2: Impacts on Other Species	CRITERION 3: Management Effectiveness	CRITERION 4: Habitat and Ecosystem	OVERALL RECOMMENDATION
Orange-footed sea cucumber Quebec/Northwest Atlantic Towed dredges Canada	Yellow (2.640)	Yellow (2.640)	Green (4.000)	Red (1.730)	(2.635)

Scoring Guide

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

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

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

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 assesses the sustainability of the sea cucumber (*Cucumaria frondosa*) fishery in Quebec, Canada. Harvesting occurs only in specific permitted management areas of the Quebec coast and is done by drag net (i.e, dredging). Experimental dive fishing has taken place since 2015, but this is not considered in the assessment.

Species Overview

C. frondosa has an extensive range, and is considered to be almost circumpolar in the northern hemisphere (DFO 2009). In its early years, the sea cucumber is found at depths less than 10 m then later migrates slowly to depths of up to 60 m, although individuals have been found as deep as 400 m (DFO 2014a). The species is a highly selective suspension feeder (Hamel and Mercier 1996a) and prefers complex rocky bottoms or mixed hard substrates as a habitat (DFO 2014a). Sexes are separate, with reproduction involving aggregation and external fertilization; resultant larvae spend 48 hours in the water column before settling (DFO 2014a). *C. frondosa* in Quebec spawns in mid-June, which is later than in other parts of the North American east coast; similarly, the species in this region reaches maturity between 80 mm and 102 mm, which is larger than in Newfoundland (DFO 2014a).

The fishery in Quebec has been in development since 2004, with four stakeholders from the processing sector successively acting as project lead, and has existed as a fishery since 2008 (DFO 2015). It is managed by Fisheries and Oceans Canada (DFO) and is currently in stage II (Exploratory)—the commercial and stock assessment stage—in accordance with the DFO's New Emerging Fisheries Policy (DFO 2001). This means that it has demonstrated feasibility and is now undergoing research to determine whether the stock can sustain a commercial harvest, as well as to gather biological data on stock abundance and investigate dredging impacts on sea cucumbers, other species, and habitats. Two assessments have been conducted, reporting on the exploratory fishing from 2008 to 2010 and 2011 to 2013 across four areas: areas A, B, and C on the north shore of Gaspé Peninsula, and Unit HSP/3 on the North Shore of the St. Lawrence Estuary (DFO 2011) (DFO 2014a) (Fig. 1).

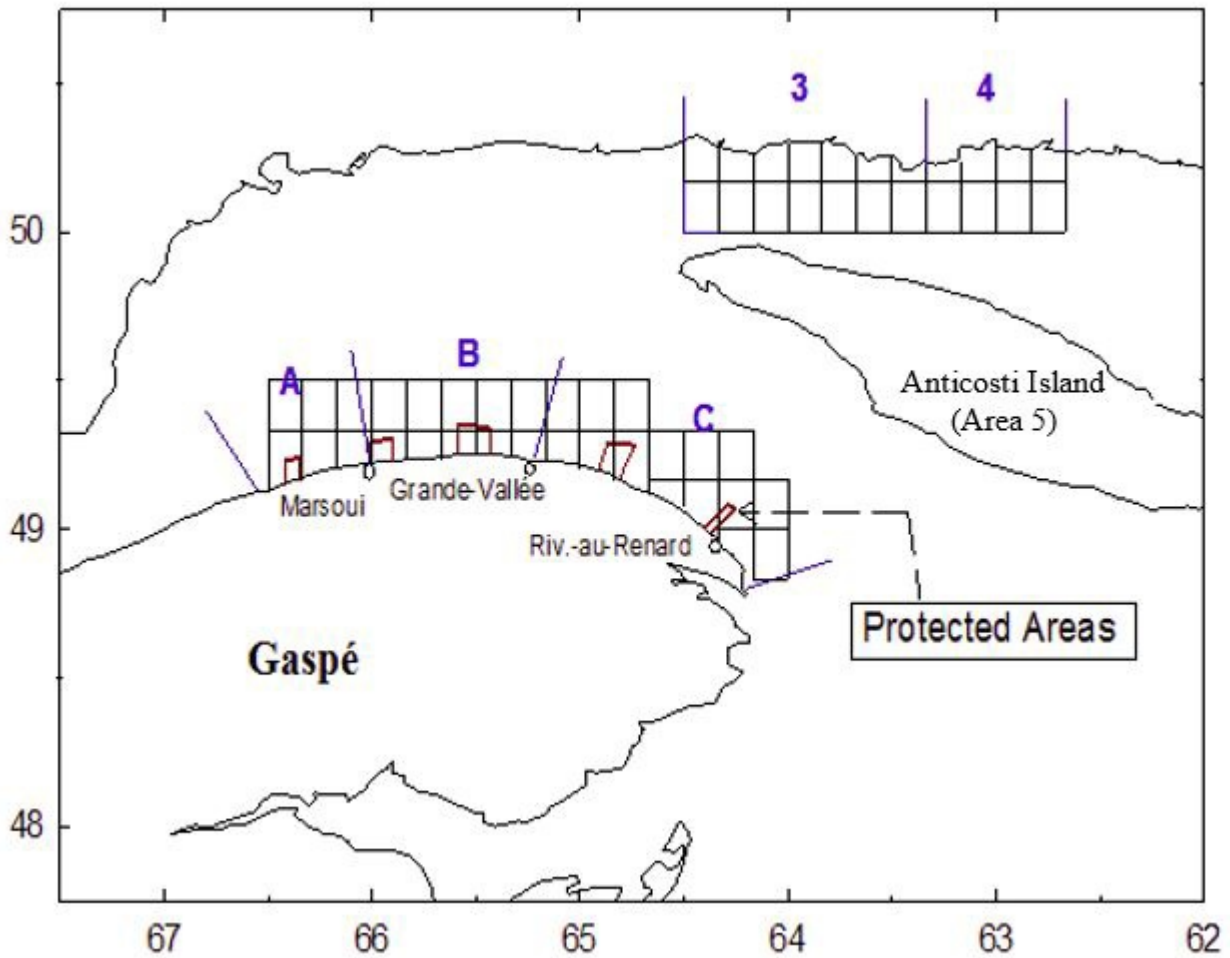


Figure 1 Sea Cucumber Management Areas in the St. Lawrence Estuary. Area 5 is the north side of Anticosti Island. Source: DFO 2014a

The fishery currently operates on both sides of the estuary. On the North Shore, two exploratory and two experimental licenses are available, one of each in areas 3 and 5 (DFO 2016) (Fig. 1). Experimental licenses are to determine if there is stock in a particular area and whether it can be caught by particular gear; exploratory licenses are to determine if the stock can maintain a commercially viable operation (DFO 2001). On the Gaspé side, there are a total of four exploratory licenses, with two issued for both zones B and C. In each, one license is a community license for Aboriginal First Nations and the other is issued to non-aboriginals (DFO 2014b). Harvesting of First Nations in the fishery under a community license is conducted in the same manner and under the same regulations as non-aboriginals, i.e., for profit, instead of for food, social, and ceremonial (FSC) purposes as in many other fisheries. Given the destructive nature of the gear, the DFO intend that the use of dredging by drag net is only a temporary aspect of the exploratory fishery. Beginning in 2015, license holders are required to ensure that an independent protocol is developed and implemented to establish the viability of dive fishing in areas B and C (DFO 2015).

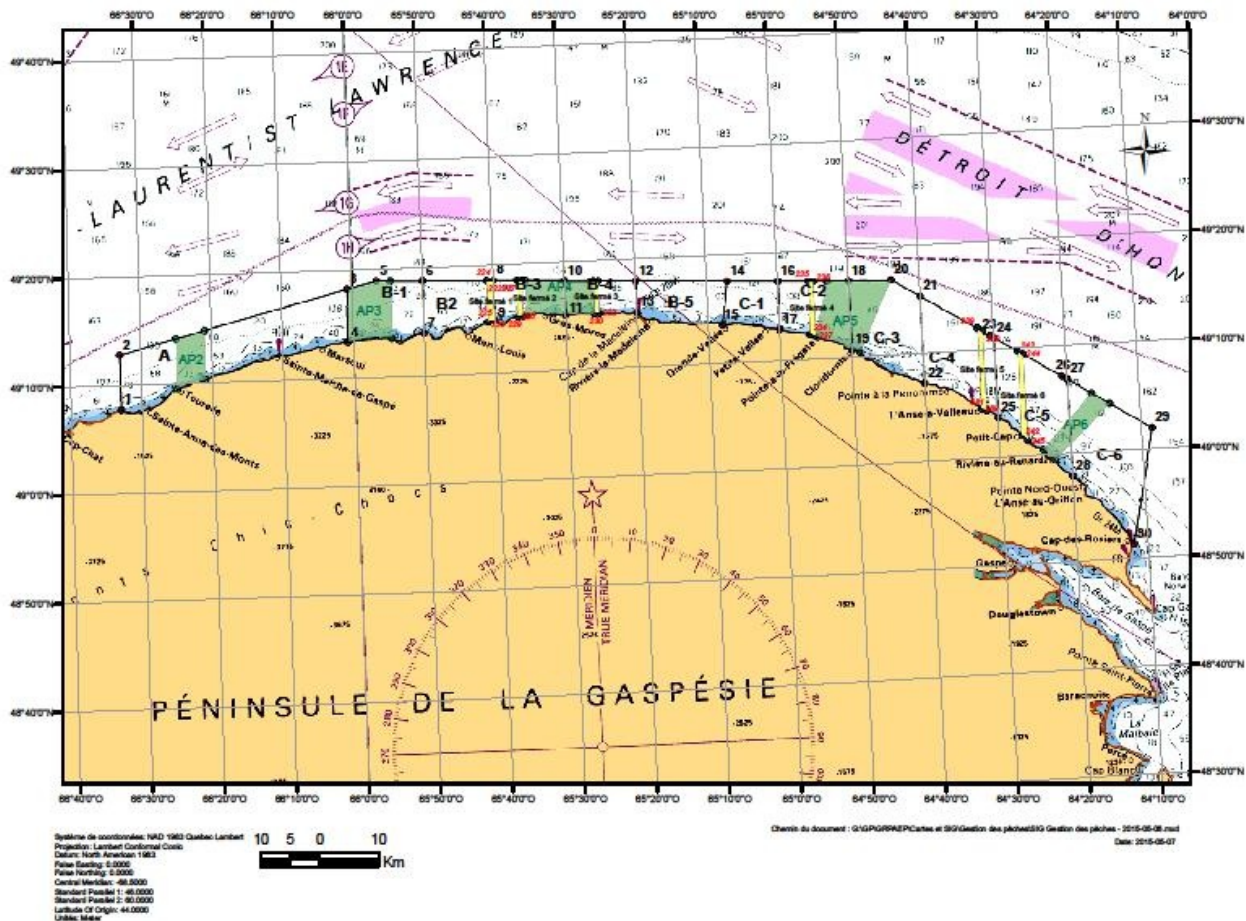


Figure 2 Sea cucumber fishing areas A, B and C. Protected areas are highlighted in green. Source: DFO 2015

Production Statistics

Production has increased throughout most of the fishery's development, as fishers discover areas with higher yields. Until the last assessment in 2014, landings had not yet reached the total allowable catch (TAC) in any unit, though they were 90% in Zone B in 2013 and reached nearly 92% in Zone C in both 2012 and 2013 (DFO 2014a). The increase in CPUE is shown in Figure 3. But, since the assessment, a strong decline in CPUE has been observed in some sub-areas, leading to a TAC reduction in 2015 (pers. comm., DFO 2016).

There is little domestic market for sea cucumbers in North America, other than within Asian communities. The vast majority of *C. frondosa* is exported; however, determining specific quantities is difficult, because Canada does not nationally report sea cucumber exports at the species level, instead grouping them along with other shellfish (DFO 2017).

Year	Unit B		Unit C		Unit 3		
	TAC (t)	CPUE (kg/hm)	TAC (t)	CPUE (kg/hm)	Quota (day)	Effort (day)	CPUE (kg/hm)
2008			200	392			
2009	200+400	296	300+500	433	35	23	234
2010	200+400	172	300+500	379	35+35	68	249
2011	200+400	276	300+500	381	35+35	64	241
2012	200+400	351	300+500	408	35+35	67	233
2013	200+400	648	300+500	507	70	43	205
Average		349		417		53	232

Figure 3 Total allowable catch (TAC in t), quota (day), effort (day) and catch per unit effort (CPUE in kg/hm) in the Quebec commercial sea cucumber drag net fishery from 2008 to 2013. Source: DFO 2014a

Importance to the US/North American market.

There is currently no domestic market in North America for *C. frondosa*, other than within Asian communities. Sea cucumber products are processed and shipped to Asia, primarily China (DFO 2014a).

Common and market names.

Orange-footed sea cucumber; Northern sea cucumber (Nelson et al. 2012); Sea pumpkin (Hamel and Mercier 2008).

Primary product forms

Sea cucumbers are processed in Quebec and Maine (DFO 2014a), generally boiled and dried, and sold as "bêche-de-mer" or dried skin—also called trepang—an important medicinal product in Asia (Purcell 2010).

Assessment

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

Criterion 1: Impacts on the Species Under Assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species' inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

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

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

Guiding Principles

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

Criterion 1 Summary

ORANGE-FOOTED SEA CUCUMBER			
Region Method	Abundance	Fishing Mortality	Score
Quebec/Northwest Atlantic Towed dredges Canada	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.640)

Criterion 1 Assessment

SCORING GUIDELINES

Factor 1.1 - Abundance

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

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

Factor 1.2 - Fishing Mortality

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

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

ORANGE-FOOTED SEA CUCUMBER

Factor 1.1 - Abundance

QUEBEC/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

Two initial abundance assessments were conducted, for zones A, B, and C (Campagna et al. 2005) and for the North Shore (Hamel et al. 2013). Since harvesting began, two fishery assessments have also been published in 2011 and 2014 (DFO 2011 2014a). As an emerging fishery, however, stock status is still unknown and therefore no reference points have been defined. Given this, and that the species is not highly vulnerable (see Productivity-Susceptibility Analysis below), abundance is deemed a "moderate" concern.

Justification:

DFO has conducted two abundance assessments for sea cucumbers in Quebec, the first in Gaspé in 2004 (Campagna et al. 2005) and a second in 2010 (Hamel et al. 2013) for the North Shore area that corresponds to zones 3 to 4. DFO has also conducted two assessments of the Quebec sea cucumber fishery itself. The first, assessing 2008 to 2010 (DFO 2011), included an abundance assessment for a portion of the region conducted in 2010. This, however, was part of a special study in partnership with the industry and no similar study has taken place since (pers. comm., J-P. Dallaire, DFO 2016). The second assessment (DFO 2014a) reported on landings, sizes, and CPUE from 2011 to 2013 and acknowledged that the fishery was still too new to have enough knowledge to determine acceptable exploitation rates. Therefore, as an emerging fishery still in an exploratory stage, there are currently no reference points set.

Productivity-Susceptibility Analysis

Scoring Guidelines:

1) Productivity score (P) = average of the productivity attribute scores (p1, p2, p3, p4 (finfish only), p5 (finfish only), p6, p7, and p8 (invertebrates only))

2) Susceptibility score (S) = product of the susceptibility attribute scores (s1, s2, s3, s4), rescaled as follows:
 $S = [(s1 * s2 * s3 * s4) - 1/40] + 1$.

3) Vulnerability score (V) = the Euclidean distance of P and S using the following formula: $V = \sqrt{(P^2 + S^2)}$

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	Less than 5 years. <i>C. frondosa</i> sampled in the lower St Lawrence Estuary and found maturity occurs more rapidly in deeper waters, at ca. 3.8 years at 15 m and 2.8 years at 20 m (Hamel and Mercier 1996a).	1
Average maximum age	Between 10 to 25 years. Actual maximum age is unknown. Some field studies suggest it takes a minimum of 10 years to reach max. size (Hamel and Mercier 1996a), although lab studies indicate 25 years (So et al. 2010 2010).	2
Fecundity	Up to 12,000 mature oocytes per individual (Hamel and Mercier 1996b).	2
Reproductive strategy	Broadcast spawner (DFO 2014a).	1
Trophic level	<2.75. <i>C. frondosa</i> is a suspension feeder (DFO 2014a).	1
Density dependence	Depensatory. Sea cucumbers demonstrate depensatory effects at low densities (Nelson et al. 2012).	3
Productivity Score		1.67

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Protected areas and limited fishing depths ensure concentrations of <i>C. frondosa</i> are unfished within the species range. An initial assessment found concentrations outside of the areas currently fished (Campagna et al. 2005); however, with no formal inventory conducted, we are unable to calculate whether >70% of the species concentration is unfished.	3
Vertical overlap (Considers all fisheries)	In the Gaspé area, fishing is only permitted between 32 and 42 m (DFO 2015). Given that the normal depth range of <i>C. frondosa</i> is considered to be 0 to 60 m (DFO 2014a), this represents 17% of the vertical range. On the North Shore, fishing is allowed below 20 m (DFO 2016), representing 40% of the depth range. Overall, a considerable portion of the depth range is unfished.	2
Selectivity of fishery (Specific to fishery under assessment)	Immature individuals are generally found below 19 m (DFO 2011) and the drag net fishery is limited to depths below 32 m, ensuring that virtually all individuals caught are mature.	2

Post-capture mortality (Specific to fishery under assessment)	<i>C. frondosa</i> is the retained target species	3
Susceptibility Score		1.875

Vulnerability Score = 2.51 (low vulnerability)

Factor 1.2 - Fishing Mortality

QUEBEC/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

Exploitation is restricted to a precautionary rate of 10% in each area, which sets a total allowable catch (TAC) based on an initial abundance assessment (Campagna et al. 2005). Capture in 2012 and 2013 was around 90% of the TAC. It is likely that mortality is at or below a sustainable level that is appropriate given the species' ecological role. Nonetheless, given that the abundance estimate is over 10 years old, TACs may not be calculated accurately, and we have deemed fishing mortality a "moderate" concern.

Justification:

In each fishing area, a precautionary exploitation rate of 10% of available biomass has been set. This is based on a 2004 biomass assessment conducted by a private proponent, in collaboration with Fisheries and Oceans Canada (Campagna et al. 2005). After removal of the biomass in each protected area, a TAC has been calculated for each fishing zone. In zones B and C, landings were nearly 90% and 92% for 2013, respectively, although capture in Zone 3 decreased compared to 2012 (DFO 2014a). CPUE markedly increased in 2013, coinciding with the introduction of aboriginal community licenses (Table 1). Since 2014, however, CPUE decreased, resulting in a reduced TAC from 2015. Recreational fishing is not permitted and, although overall mortality is unknown, given the conservative TAC, there are likely no conservation concerns.

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated under Criterion 2. Seafood Watch defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery's potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait score. The Criterion 2 rating is determined as follows:

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

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

Guiding Principles

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

Criterion 2 Summary

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

ORANGE-FOOTED SEA CUCUMBER					
Quebec/Northwest Atlantic Towed Dredges Canada					
Subscore:	2.640	Discard Rate:	1.00	C2 Rate:	2.640
Species Stock	Abundance	Fishing Mortality	Subscore		
Benthic inverts	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.640)		

Due to the dredging action of the drag net fishery, it is unselective and prone to bycatch. The Conservation Harvesting Plan (CHP) reports that a 2010 analysis of the fishery revealed bycatch at 13% by number of the total catch (DFO 2014b). This 2014 assessment reported data for 2011 to 2013, recording main species caught as bycatch. Total bycatch amounted to 5% by number of the total catch in 2011, 8% in 2012, and 9% in 2013 (DFO 2014a). The Fisheries Management Plan (FMP) reports that an additional bycatch study was conducted in 2014 as part of monitoring of the short-, medium-, and long-term impacts of dredging; it recorded a bycatch rate of 20.2% by number of the total catch in the heavily fished areas, though it did not detail species caught, nor which areas were heavily fished (DFO 2015).

The bycatch species include starfish, rock crab, green sea urchin, scallop, and whelk (DFO 2014a) (DFO 2014b) (DFO 2015), but according to the 2014 assessment, each species type averaged only around 1% of the total catch from 2011 to 2013, except starfish (unspecified species), which made up approximately 3.5%.

Although none of the species caught as bycatch are species at risk, or are reported to contribute more than 5% of the total catch, the 20.2% bycatch rate from 2014 (DFO 2015) leaves the possibility that one of the invertebrate species might contribute 5% or more of the catch in the heavily fished areas. Therefore, bycatch in the drag fishery is assessed for "unassessed benthic invertebrates," and the Criterion 2 score is 2.64, a "moderate" concern, due to the low vulnerability of the bycatch taxa and small size of the fishery.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance

(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality

(same as Factor 1.2 above)

BENTHIC INVERTS

Factor 2.1 - Abundance

QUEBEC/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

According to SFW guidelines, unassessed benthic invertebrates that are not from highly vulnerable taxa are scored as "moderate" concern.

Justification:

None of the species listed as bycatch in either the 2014 assessment (DFO 2014a) or the CHP (DFO 2014b) are species at risk.

Factor 2.2 - Fishing Mortality

QUEBEC/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

According to SFW guidelines, unassessed benthic invertebrates are scored using the Unknown Bycatch Matrices (UBM). As benthic inverts interacting with a form of dredge, bycatch for this fishery scores 1, "high" concern. But (also according to SFW guidelines), because it is a small fishery and the species primarily caught are of small concern (DFO 2014a), the UBM score can be overruled and upgraded. Therefore, fishing mortality for the drag net fishery bycatch is deemed to be of "moderate" concern.

Justification:

The scale of the Quebec fishery is small and the most dominant catch taxa, starfish (DFO 2014a), is not a conservation concern.

Factor 2.3 - Modifying Factor: Discards and Bait Use

Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For

fisheries that use bait, bait is used efficiently.

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

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

QUEBEC/NORTHWEST ATLANTIC

Towed Dredges | Canada

< 100%

All bycatch is returned to the water immediately as discards (DFO 2014b). Total discards divided by the sum of the total catch is <100%. Therefore, the factor 2.3 score is 1.

Criterion 3: Management Effectiveness

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

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

The Criterion 3 rating is determined as follows:

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

Rating is Critical if Management Strategy and Implementation is Critical.

GUIDING PRINCIPLE

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

Criterion 3 Summary

Fishery	Management Strategy	Bycatch Strategy	Research and Monitoring	Enforcement	Stakeholder Inclusion	Score
Fishery 1: Quebec/Northwest Atlantic Towed dredges Canada	Highly Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Green (4.000)

Criterion 3 Assessment

Factor 3.1 - Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do managers follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

QUEBEC/NORTHWEST ATLANTIC
Towed Dredges | Canada

Highly Effective

Several precautionary management measures are in place, including controls on effort, catch, and minimum landing size (MLS). Sea cucumber harvesting is also managed by limiting minimum and maximum depths, fishing seasons, and protected areas. Most of these measures have been in place since the start of the fishery in 2008, with protected areas introduced in 2010 and a MLS in 2013 (DFO 2014b). It is likely that many of these are effective, particularly MLS and restrictions on fishing areas, which will protect juvenile sea cucumbers; however, TAC is based on biomass estimates over 10 years old and may not be up to date. Even so, management measures are flexible enough to respond to changes, with the TAC being reduced in response to decreased CPUE in 2014. Given the precautionary adaptive management measures, which cover all of the target stock, and the small size of the fishery, we deemed the management strategy and implementation to be "highly effective."

Justification:

The DFO first published a management plan for areas A, B, and C in 2009. The plan became a Conservation Harvesting Plan (CHP) in 2013 (revised in 2014), covering 2013 to 2016 (DFO 2014b); in 2015 an interim Fisheries Management Plan (FMP) was developed to address management concerns raised by the industry (DFO 2015). For the North Shore, a CHP was published in 2016 (DFO 2016). Both plans include several management measures intended to limit catch to a sustainable level, minimize impact on other fisheries, and reduce bycatch.

Fishing on the Gaspé peninsula is restricted to three fishing management areas (FMA; A, B, and C), with different measures for each, depending on their characteristics. A precautionary TAC has also been set in each FMA, both for diving (0 to 18 m) and drag net (32 to 42 m), calculated using a conservative exploitation rate of 10%, applied to the available biomass determined in a 2004 assessment (Campagna et al. 2005). The TAC in each area remained the same between 2009 and 2014 (DFO 2011) (DFO 2014a), but the TAC was reduced by around 50% for areas A, B, and C in 2015 after management observed a reduction in CPUE (DFO 2015). Areas B and C are further divided into 5 and 6 subareas, respectively, each with its own TAC set out in the FMP. If TACs are exceeded, quota will be reduced the following year (DFO 2015). Yet, the exploitation rate used to calculate the TAC is applied to biomass data that is over ten years old and may no longer be accurate.

Also, a minimum landing size (MLS) of 114 mm has been set by the FMP (a decrease from 116 mm in the CHP) well above the size of maturity (100 mm) to allow for uncertainty, and should avoid the retention of juveniles (DFO 2014b) (DFO 2015). To further reduce catch of juveniles by dredging, drag net harvesting was limited to depths where only mature individuals are found, below 20 m. There has been some conflict with other fisheries, and since 2015, the fishing depth has been further restricted to depths below 32 m, to avoid dredge impacts on fixed gear and damage to other species, such as rock crab, lobster, and whelk (DFO 2015).

Fishery openings are also staggered to ensure that dredging avoids the sea cucumber spawning period when they are most vulnerable. Sea cucumbers are also protected by areas that ban fishing in 15% of the available fishing area, a restriction that applies to the harvesting of a few other species, including Atlantic rock crab and scallops (DFO 2015) (pers. comm., J-P. Dallaire 2017).

In the North Shore area, the CHP limits the fishery to four licenses, two exploratory and two experimental, each limited to its own area (DFO 2016). There are no TACs, but each license is restricted by effort in terms of fishing days and can only fish below 20 m. The season only lasts for 6 months, from April to October, and there is a MLS of 114 mm.

All of these management measures are conservative and designed to avoid negative impacts on the stock, but they have not been in place long enough to determine their effectiveness.

Factor 3.2 - Bycatch Strategy

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

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Moderately Effective

Bycatch in the fishery is high enough to be of concern to the DFO, and management measures have been put into place in attempts to reduce bycatch. Yet, measures have not been in place long enough to evaluate their effectiveness. Therefore, we deem the score for bycatch strategy to be "moderately effective."

Justification:

Bycatch risks in Area A are such that no dredging is permitted at all (Hamel et al., 2013). Only towed gear mounted on runners are permitted in the other fishing areas and, based on a DFO Science Advisory Report (SAR) in 2009, the CHP recommends gear modifications to improve efficiency, selectiveness, and reduce impact on the habitat. These include the development of gear that produces an audible sound to scare away moving animals and a simplification of the deck process that allows smaller sea cucumbers and more bycatch to escape (DFO 2014b).

Nonetheless, the gear used by fishers in this fishery is significantly heavier than the gear on which the 2009 SAR was based, and a new SAR was requested in 2015 (DFO 2015). Until the new advisory is published, the DFO requires specific modifications to reduce bycatch and improve post-selection survival. In particular, in response to high reported bycatch in 2013 and 2014, mesh size of the net must be a minimum of 80 mm for a length of at least a meter. Also, dredging speed is restricted to 3 knots to allow non-target species to flee and smaller organisms to escape (DFO 2015). The CHP also requires that bycatch be returned immediately at the exact point of capture and recorded, and warns that if bycatch is consistently too high, the fishery may be closed immediately (DFO 2014b).

Despite the likelihood of these measures having a cumulative positive effect, they have not been in place long enough to evaluate their effectiveness.

Factor 3.3 - Scientific Research and Monitoring

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

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Moderately Effective

Fishery-dependent data is collected from logbooks, purchase-slips, and through an at-sea observer program that covers at least 30% of trips. Bycatch is monitored through scientific protocol applied by the at-sea observers. Also, the CHP requires that license holders participate in post-season monitoring of fishery impacts. Investigations into the effects of dredging on sea cucumbers and benthic communities as well as the spawning

period of *C. frondosa* on the Gaspé coast are ongoing, with results hoped to contribute to the next stock assessment in 2017.

Although there is robust and thorough monitoring in places, results from fishery-independent data are yet to be published and management decisions for quotas are still based on biomass results from 2004. Therefore, this criterion is deemed to be "moderately effective."

Justification:

The most recent assessment of the Quebec fishery was of the exploratory fishery between 2011 and 2013, which relied largely on fishery-dependent data sourced from logbooks and purchase slips obtained at the dock (DFO 2014a). Since 2013, however, license holders have been required to participate in additional post-season monitoring of the medium- and long-term impacts of dredge fishing. These surveys are conducted according to a protocol outlined in the CHP and will assess the impacts on sea cucumbers and the benthos, though it will not assess the sea cucumber population (DFO 2014b) (DFO 2015). The industry is responsible for all data analysis (DFO 2015), but no results have yet been published.

Also, as outlined by the 2015 FMP, license holders will collaborate with the DFO and ISMER (Institut des Sciences de la mer de Rimouski, an academic research institute part of Université du Québec à Rimouski), in a study initiated and funded by Mi'gmaq Maliseet Aboriginal Fisheries Management Association (MMAFMA) to investigate spawning and size of maturity in the fishing areas. License holders are also responsible for establishing protocol that demonstrates the viability of dive fishing and, if dive-fishing is not viable, develops alternative methods with less negative impacts than the current dredges (DFO 2015).

Industry also funds an at-sea observer program, which covers a minimum of 30% of fishing trips. Bycatch is required to be reported in logbooks when species at risk are caught and a scientific monitoring protocol for bycatch is applied by at-sea observers (DFO 2014a).

Factor 3.4 - Enforcement of Management Regulations

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

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Highly Effective

The fishery has a comprehensive monitoring system in place and there are no current reported issues with compliance; therefore, this criterion is scored "highly effective."

Justification:

The fishery operates with a comprehensive program of monitoring, including dockside monitoring and a vessel monitoring system (VMS). At-sea observers, funded by industry, are in place for 30% of trips; they will collect data on the size of sea cucumbers caught and apply a bycatch monitoring protocol (DFO 2014b) (DFO 2015). Through the CMP and FMP, the DFO has adequate capacity in place to ensure compliance and take appropriate steps in case of breach (DFO 2014b) (DFO 2015). VMS is also mandatory (DFO 2014b) (DFO 2016).

Not yet permanent "commercial permits," licensing is appropriate to the exploitation stage. The DFO limits the number of fishers and has a close relationship with license holders through the post-season monitoring. Due to compliance issues, management measures were revised in 2015, and there are currently no reports of license breaches or problems with enforcement.

Factor 3.5 - Stakeholder Inclusion

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

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Highly Effective

The fishery conducts a series of regular meetings where relevant stakeholders have the opportunity to contribute to knowledge of the fishery as well as address conflict. Therefore, we deem stakeholder inclusion to be "highly effective."

Justification:

The fishery has regular peer-review meetings where scientists, fishers, and relevant organizations are invited to contribute to knowledge of the fishery. Also, regional meetings are held to engage local fishers and provide a forum for addressing conflict (pers. comm., J.P. Dallaire 2016). These engagements contribute to management decisions, given that the 2015 FMP developed out of a workshop specifically requested by license holders and other coastal stakeholders.

It appears that all stakeholder groups are represented, evident in a 2014 meeting to address the findings of the 2011 to 2013 assessment including representatives from the DFO, fishermen, fish sellers, the non-profit sector, and First Nations (DFO 2014c).

Criterion 4: Impacts on the Habitat and Ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment. The final score is the geometric mean of the impact of fishing gear on habitat score (factor 4.1 + factor 4.2) and the Ecosystem Based Fishery Management score. The Criterion 4 rating is determined as follows:

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

GUIDING PRINCIPLES

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

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Score
Quebec/Northwest Atlantic Towed dredges Canada	1	0	Moderate Concern	Red (1.730)

Criterion 4 Assessment

SCORING GUIDELINES

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

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

- *5 - Fishing gear does not contact the bottom*
- *4 - Vertical line gear*
- *3 - Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 - Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is*

known trampling of coral reef habitat.

- *1 - Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 - Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*
Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

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

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

Factor 4.3 - Ecosystem-Based Fisheries Management

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

- *5 — Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.*
- *4 — Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.*
- *3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 — Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 — Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

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

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1

The drag net fishery takes place over mostly rock and boulder substrates (Hamel and Mercier 1996a) (pers. comm., J-P. Dallaire 2016). Therefore, it is deemed a score of 1.

Justification:

As determined in the initial abundance assessment (Campagna et al. 2005), dredging is not permitted in Area A, due to the high levels of bycatch and low potential CPUE. In Areas B and C, however, drag netting takes place where the primary substrate up to 60 m depth is bedrock and boulder (Hamel and Mercier 1996a) (pers. comm., J-P. Dallaire 2016). The dredge gear works by dragging a net on runners over the substrate, impacting the habitat.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

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0

Around 15% of the accessible fishing area in Areas B and C has been protected from fishing. Management restrictions also limit sea cucumber fishing to certain depths within the habitat, although the impact on the habitat from other fisheries outside these depths is unclear. Furthermore, although some gear modifications are required to reduce habitat impact (DFO 2015), there is no evidence yet that they are effective. The score modification is therefore 0.

Justification:

Five protected areas throughout Zones A, B, and C have been established, prohibiting sea cucumber fishing as well as fishing for several other species, such as scallop, rock crab and sea urchins (Fig. 2) (DFO 2015). These do not, however, cover a significant portion of the available fishing area, totaling only 15% (DFO 2015). The DFO acknowledges that the use of mobile gear on benthic targets should be prohibited, especially in coastal areas, and should only be considered once the viability of diving or less-destructive gear has been ruled out. Nonetheless, in the development of the *C. frondosa* fishery, dredging is temporarily permitted (DFO 2015).

In addition to the protected areas, in Areas B and C, and on the North Shore, dredging is restricted to specific depth ranges (DFO 2014a) (DFO 2016). For Areas B and C, these depths were limited further by the FMP (DFO 2015) to avoid conflict with other commercial fisheries such as whelk. One of the stated additional benefits is the protection of photic area habitats and most of the other fisheries mentioned in the CHP and FMP (sea urchin, whelk, lobster, and crab) and are operating in the other depth ranges and are either dive fisheries or primarily use low impact gear such as pots. Fisheries using more damaging gear, such as fishing for urchins with whelk cages or scallop dredging, are reported to be rare in the sea cucumber habitats (pers. comm., V. Remillard, DFO statistical analyst 2017); however, the degree of habitat impact is unknown. Therefore, although some habitat protection may occur through management restrictions, it is difficult to determine the extent.

The DFO reports that initial investigation into the effects of such dredging had reversible effects in the short term, but more research into medium- and long-term impacts was necessary (DFO 2015). The DFO Science Advisory Reports (SARs) were for LGS gear weighing 227 kg; this is much lighter than gear currently used by fishers in the sea cucumber fishery, which might invalidate these findings (DFO 2015). Therefore, impact could

be much greater, and in 2015 the DFO requested a Science Advisory regarding dredges over 227 kg.

While awaiting the results of the Advisory, several gear modifications are required of fishers to minimize habitat impacts. These including banning additions that increase mouth penetration, a requirement that the dredge is attached to smooth runners, and ensuring that the basket clasp does not come into contact with the substrate (DFO 2015); however, these modifications have not been required for long enough to determine whether they are effective or not.

Factor 4.3 - Ecosystem-Based Fisheries Management

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Moderate Concern

The ecological importance of the sea cucumber is poorly known. Although some spatial planning is in place, it is not with any particular regard to the species' ecological importance; however, detrimental food-web impacts are unlikely. Therefore, this criterion scores a "moderate" conservation concern.

Justification:

Sea cucumbers are generally considered to be nutrient recyclers, though their contribution to wider food webs is poorly known. *C. frondosa* are very selective suspension feeders and have a limited number of predators, primarily the sea star *Solaster endeca* and the sea urchin *Strongylocentrotus droebachiensis* (Hamel and Mercier 1996a), but further ecological functions in the wider food web are largely unknown.

Some spatial planning exists in the form of protected areas, which prohibits fishing of sea cucumbers in 15% of the available area (Fig. 2), as well as a few other species. This will likely have a spillover effect into adjacent areas; however, these have not been made with reference to the sea cucumber's particular ecological importance, although detrimental food-web impacts are unlikely.

Acknowledgements

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

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Appendix A: Updates to Sea Cucumber Report

This report was reviewed for any significant stock status and management updates to the fishery on December 10, 2019. None were found that would indicate the final rating is no longer accurate.

Appendix B: Review Schedule

- Report on viability of dive fishing – sometime after 2017.
- SAR on gear over 227kg – requested in 2015. To be published sometime after 2017.