



Monterey Bay Aquarium Seafood Watch

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



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Species: Orange-footed sea cucumber (*Cucumaria frondosa*)
Location: Canada: New Brunswick, Newfoundland and Labrador, Nova Scotia
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 on the Atlantic coast of Canada. Fishing occurs in three areas across two management regions: Newfoundland and Labrador (NL), Nova Scotia (NS), and New Brunswick (NB) in the Maritimes region. In all three areas, fishing is conducted through the use of a modified drag net.

C. frondosa has an extensive distribution around the Arctic and North Atlantic oceans, preferring hard substrates at a range of depths. Unusually for sea cucumbers, they are selective suspension feeders. Little is known about their life history; however, they are believed to mature at around 5 years and are broadcast spawners.

The fishery in each area is managed by the relevant regional office of Fisheries and Oceans Canada (DFO). The fisheries have existed since the late 1990s in the Maritimes (NS and NB), and the early 2000s in NL. In the Maritimes Region, the fishery converted from exploratory to commercial in 2011, and in NL became fully commercial in 2013 with 19 licenses. In 2019, the Eastern Cucumber Bed in NL was opened to 40 temporary permits, including two commercial permits.

Assessments were conducted for NB and NL in 2009 and 2017, but none of the fishing areas have more recent comprehensive stock assessments or reference points. Instead, quotas are conservatively calculated from the 2009 assessment for NL and from apparently sustainable historical fishing practices in NS and NB. Other management techniques include limiting the number of licenses, restrictive zoning areas, gear modifications to reduce bycatch, and closing the fishery to avoid spawning seasons.

Overall, although quotas are set conservatively, available information is insufficient for any of the stocks to make well-informed management decisions, particularly for a species with high inherent vulnerability. Management strategies are conservative and generally appropriate given the scale of the fisheries, with a range of tools employed and extensive enforcement and stakeholder inclusion. All regions require monitoring of catch and bycatch, but both NS and NB require fishers to perform additional size analysis of samples from each catch to inform upcoming assessments. Although bycatch is low to moderate, the impacts of the drag net on habitat and other species is unknown and of "moderate" concern.

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 Newfoundland and Labrador/Northwest Atlantic Towed dredges Canada	Yellow (2.644)	Yellow (2.644)	Yellow (3.000)	Red (1.732)	Good Alternative (2.454)
Orange-footed sea cucumber New Brunswick/Northwest Atlantic Towed dredges Canada	Red (1.732)	Yellow (2.644)	Yellow (3.000)	Red (1.732)	Avoid (2.208)
Orange-footed sea cucumber Nova Scotia/Northwest Atlantic Towed dredges Canada	Red (1.732)	Yellow (2.644)	Yellow (3.000)	Red (1.732)	Avoid (2.208)

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 orange-footed sea cucumber (*Cucumaria frondosa*) fishery on the Atlantic coast of Canada. It includes three fisheries occurring in two regions: Newfoundland and Labrador (NL), and the Maritimes Region, which includes parts of Nova Scotia (NS) and New Brunswick (NB). In both regions, fishing is conducted through the use of a modified drag net.

Species Overview

Cucumaria frondosa is an echinoderm found in the North Atlantic and Arctic oceans (DFO 2014). It prefers complex rocky bottoms or hard mixed substrates as a habitat (DFO 2014) and is a highly selective suspension feeder (Hamel and Mercier 1996). It is distributed to depths of 100 m in Newfoundland (DFO 2009a), but information on life history for both the Maritimes region (NB and NS) and NL is extremely limited (DFO 2009a) (DFO 2009b). Age of maturity has not been determined, although information from the St. Lawrence estuary in Quebec suggests it is around 5 years, when the sea cucumber is between 80 and 102 mm (DFO 2009b). Nonetheless, there may be some site specific differences in the species. Spawning, for example, occurs from late March to early May in NL, which is earlier than in the Bay of Fundy (NB) and in the St. Lawrence estuary, which occurs from May to June (DFO 2009b) (DFO 2014). *C. frondosa* has separate sexes, with pelagic eggs and larvae that settle after 48 hours (DFO 2014).

Sea cucumber in Atlantic Canada is fished using a mobile drag net, which is a dredge modified for sea cucumber fishing. Dragging occurs in particular zones within the three areas (Fig. 1), all of which are managed by Fisheries and Oceans Canada (DFO). The DFO Maritimes region covers the Scotian Shelf's two fishing areas, one on the Scotia Bank in Nova Scotia (NS) and the other in southwest New Brunswick (NB) areas. Within the Scotian Shelf, fishing is restricted to within designated sea cucumber fishing zones in 4Vs, 4W, and 4X (DFO 2016d). In the Newfoundland and Labrador (NL) region, fishing takes place on the St. Pierre Bank. In the Maritimes region, the sea cucumber fishery was previously an exploratory fishery, but it has been a limited entry commercial fishery since 1 January 2012. The NL fishery was declared fully commercial in 2013 (DFO 2013). The Maritimes region fisheries are managed with Conservation Harvesting Plans (CHPs) (DFO 2016c) (DFO 2016d), although there is currently no integrated management plan for the NL fishery (pers. comm., B. Pilgrim DFO 2016).

Development of the NL fishery began in the early 2000s; in 2003, eight harvesters were given licenses. An assessment was conducted in 2009 (DFO 2009a). Since then, the fishery has increased and became fully commercial in 2013 with 19 licenses available (DFO 2013). The NB fishery began as a Stage I Experimental fishery between 1999 and 2006, becoming a Stage II Exploratory fishery prior to the 2007 season in accordance with the DFO's New Emerging Fisheries Policy (DFO 2001) (DFO 2006) (DFO 2009b) (DFO 2001, 2006, 2009b). An assessment was published in 2009 and catch has remained stable since 2004 (DFO 2009b) (DFO 2016b). In NS, catches have increased since the late 1990s, and currently four licenses are available; however, no assessment has yet been conducted (Hamel and Mercier 2008a) (DFO 2016d).

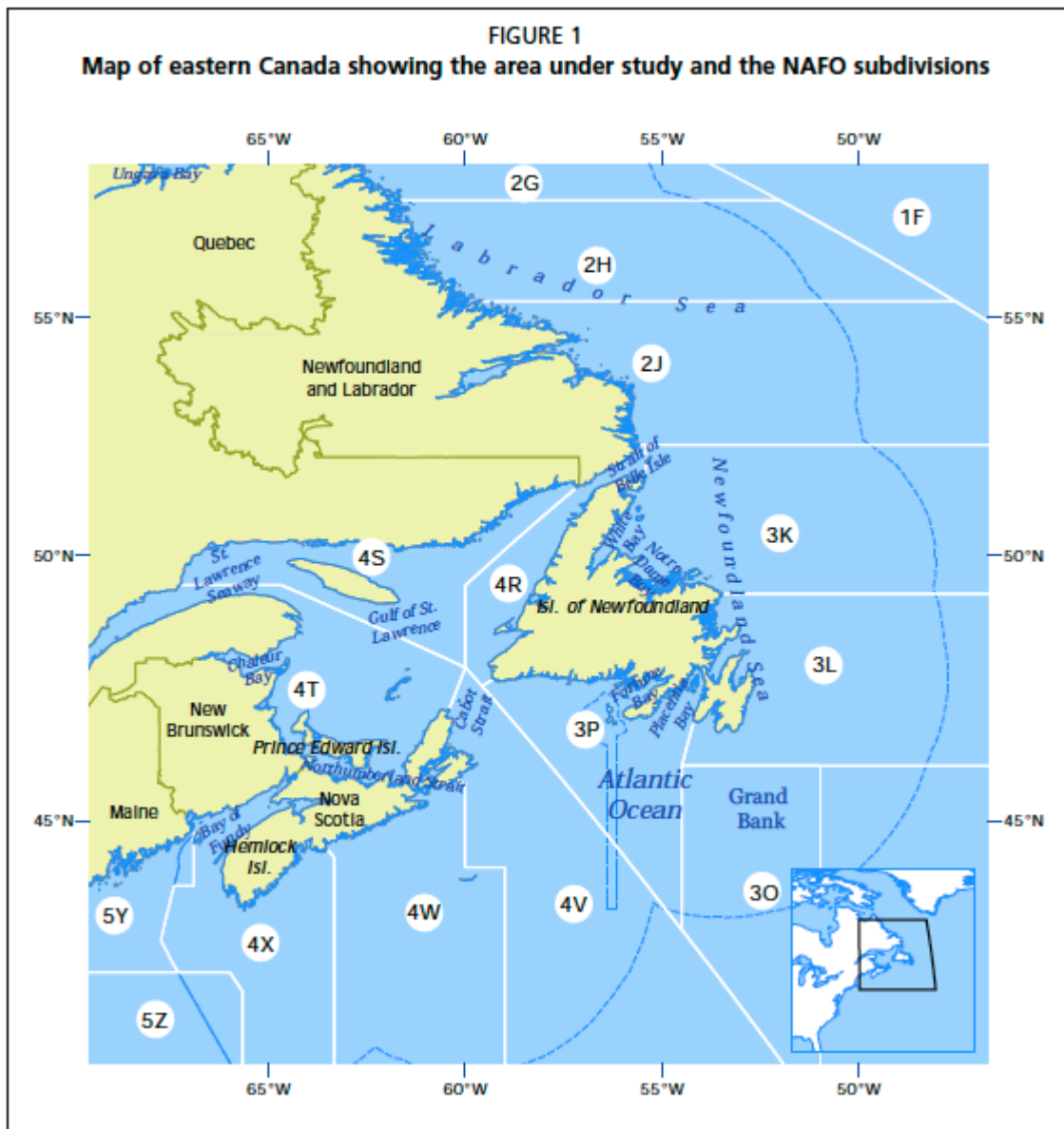


Figure 1 Fisheries management areas in Atlantic Canada. *C. frondosa* fisheries occur in 4VWX (NS), 4X (NB) and 3P (NL). Source: Hamel and Mercier 2008b

Production Statistics

Fishing of *C. frondosa* began in Maine in the 1980s, with a rapidly expanding fishery, and has since spread to Canada (Hamel and Mercier 2008a)(Hamel and Mercier 2008b). In Atlantic Canada, harvesting began in the mid- to late-1990s in the Maritime region and the early 2000s in NL (Fig. 2). There is also a small fishery in Iceland and an unregulated fishery in Russia (So 2009).

The DFO report quantity and value of Canadian landings since 2006 (DFO 2016b). Landings peaked in 2011 at a total 4,500 t, with more than half harvested from Nova Scotia, and have declined since. Yet, despite a dip in 2013, the value of the catch has continued to increase to over C\$5 million in 2014 (Fig. 3).

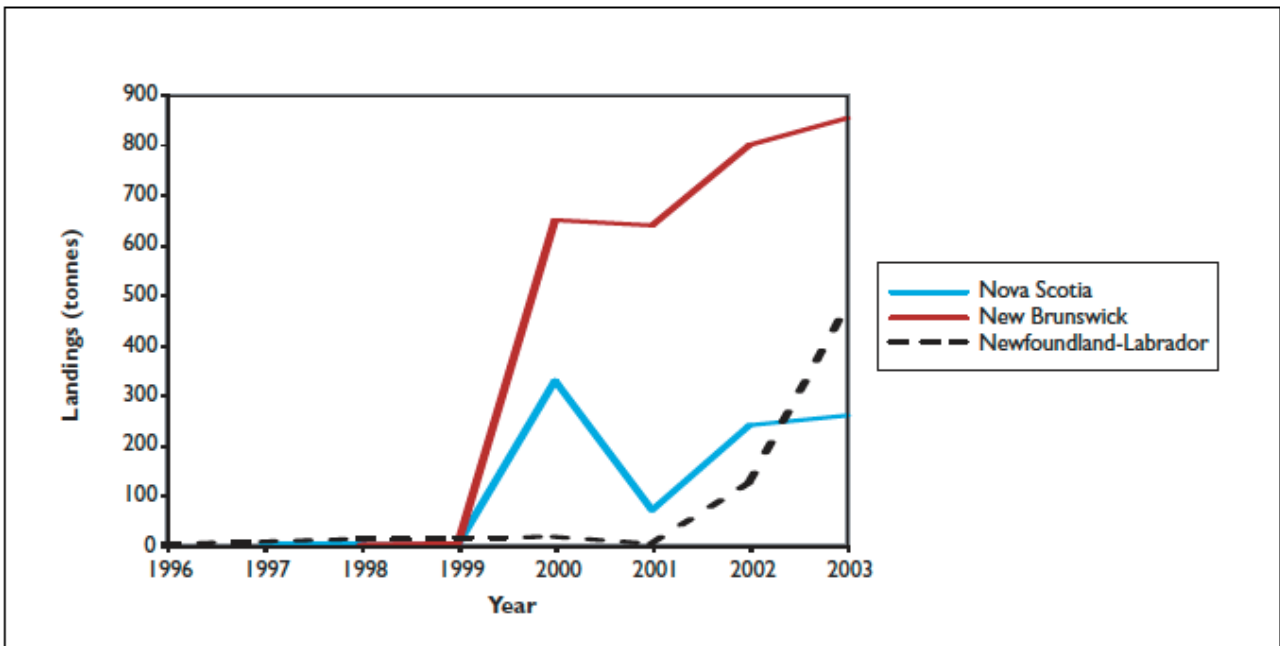


Figure 2 Atlantic Canada landings 1996-2003. Source: Therkildsen and Petersen 2006

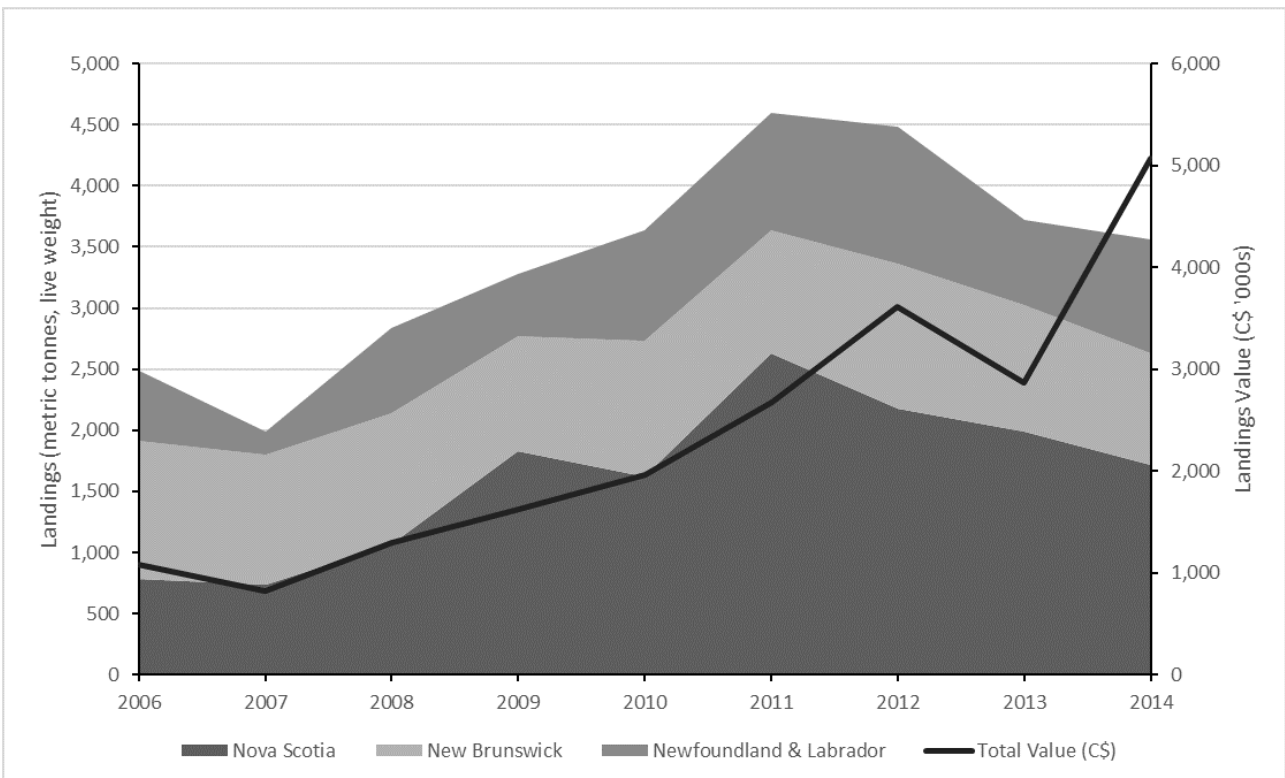


Figure 3 Landings (mt) in Atlantic Canada by fishery. Total value (C\$) for the three fisheries combined. Source data, DFO 2016a

Importance to the US/North American market.

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, it is hard to determine quantities because Canada does not nationally report sea cucumber exports at the species level; instead, it groups them along with other shellfish (DFO 2017).

Common and market names.

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

Primary product forms

The main sea cucumber products are the dried body wall, frozen muscle bands and the flower (aquapharyngeal bulb). Little is discarded, with 90% of the sea cucumber edible (So 2009). Processing occurs locally, with Canadian producers preparing the product for an Asian market (Hamel and Mercier 2008a). Product forms are referred to as "bêche-de-mer," trepang, or iriko and products are primarily exported to Asia. In China, it is sold as a tonic with supposed health benefits and is a delicacy at traditional celebrations such as Chinese New Year (Nelson et al. 2012).

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
New Brunswick/Northwest Atlantic Towed dredges Canada	1.00: High Concern	3.00: Moderate Concern	Red (1.732)
Newfoundland and Labrador/Northwest Atlantic Towed dredges Canada	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
Nova Scotia/Northwest Atlantic Towed dredges Canada	1.00: High Concern	3.00: Moderate Concern	Red (1.732)

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

NEW BRUNSWICK/ NORTHWEST ATLANTIC

Towed Dredges | Canada

High Concern

There is no stock assessment for the SWNB fishery and no reference points have been set. The Productivity-Sustainability Analysis determined a score of high vulnerability; therefore, this criterion scores a "high" concern.

Justification:

The fishery in NB was also assessed in 2009, but the report stated that the patchy distribution and lack of a systematic survey made it impossible to establish any abundance estimates, and that sustainable exploitation rates and reference points were also unknown (DFO 2009b).

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	<5 years. <i>C. frondosa</i> reaches maturity at lengths between 80 and 102 mm, taking 3.3 years to reach 107 mm (DFO 2014).	1
AVERAGE MAXIMUM AGE	Between 10 to 25 years. Actual maximum age is unknown. Some field studies suggest it takes 10 years to reach max size, although lab studies indicate 25 years (Nelson et al. 2012).	2
FECUNDITY	8 to 12,000 eggs per year (Hamel and Mercier 2008b)	2
REPRODUCTIVE STRATEGY	Broadcast spawner (DFO 2014)	1
TROPHIC LEVEL	<2.75. <i>C. frondosa</i> is a suspension feeder (DFO 2014).	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)	No indication that significant concentrations of sea cucumbers exist outside the area fishing effort.	3
VERTICAL OVERLAP (CONSIDERS ALL FISHERIES)	High overlap. <i>C. frondosa</i> are the target species.	3
SELECTIVITY OF FISHERY (SPECIFIC TO FISHERY UNDER ASSESSMENT)	There is no minimum landing size, so all cucumbers are retained, including those below size of maturity (DFO 2016d). DFO require fishers to move away from areas where they encounter large numbers of small individuals; however, license conditions only mandate a minimum of one observer trip per season, which is unlikely to be enough to ensure that this measure is effective.	3

POST-CAPTURE MORTALITY (SPECIFIC TO FISHERY UNDER ASSESSME	<i>C. frondosa</i> is the retained target species.	3
SUSCEPTIBILITY SCORE		3

Vulnerability score: 3.43 (High vulnerability)

NEWFOUNDLAND AND LABRADOR/ NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

The 2017 assessment estimated a biomass index of 187 kt in the southeast area of St. Pierre Bank, but the survey could not estimate the biomass index for the northwest area, which is where the commercial fishery operates (DFO 2017). Overall, the most recent surveys are considered "incomplete and unreliable in providing a biomass index for the northwest area"; therefore, a Productivity-Susceptibility Analysis was conducted according to SFW guidelines, which resulted in a score of medium vulnerability. As the species is not highly vulnerable, this criterion was deemed a "moderate" concern.

Justification:

The 2009 fishery assessment published a biomass index that estimated abundance in both the eastern and western sea cucumber areas; however, the assessment acknowledged that sustainable exploitation rates are unknown and did not set any reference points (DFO 2009a). The more recent assessment in 2017 was still unable to establish reference points.

Productivity-Susceptibility Analysis

Scoring Guidelines:

- 1) Productivity score (P) = average of the productivity attribute scores (p_1, p_2, p_3, p_4 (finfish only), p_5 (finfish only), p_6, p_7 , and p_8 (invertebrates only))
- 2) Susceptibility score (S) = product of the susceptibility attribute scores (s_1, s_2, s_3, s_4), rescaled as follows:

$$S = [(s_1 * s_2 * s_3 * s_4) - 1/40] + 1.$$
- 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	<5 years. <i>C. frondosa</i> reaches maturity at lengths between 80 and 102 mm, taking 3.3 years to reach 107 mm (DFO 2014).	1
AVERAGE MAXIMUM AGE	Between 10 to 25 years. Actual maximum age is unknown. Some field studies suggest it takes 10 years to reach max size, though lab studies indicate 25 years (Nelson et al. 2012).	2
FECUNDITY	8 to 12,000 eggs per year (Hamel and Mercier 2008b).	2
REPRODUCTIVE STRATEGY	Broadcast spawner (DFO 2014)	1
TROPHIC LEVEL	<2.75. <i>C. frondosa</i> is a suspension feeder (DFO 2014).	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)	Significant concentrations exist outside the area of effort. Three times the biomass is found in the protected eastern cucumber area than the fished western cucumber area (DFO 2009a).	2
VERTICAL OVERLAP (CONSIDERS ALL FISHERIES)	High overlap. <i>C. frondosa</i> are the target species.	3
SELECTIVITY OF FISHERY (SPECIFIC TO FISHERY UNDER ASSESSMENT)	There are no minimum landing sizes, so all cucumbers are retained, including immature individuals.	3
POST-CAPTURE MORTALITY (SPECIFIC TO FISHERY UNDER ASSESSMENT)	<i>C. frondosa</i> is the retained target species	3
SUSCEPTIBILITY SCORE		2.325

Vulnerability Score = 2.86 (medium vulnerability)

NOVA SCOTIA / NORTHWEST ATLANTIC

Towed Dredges | Canada

High Concern

No biomass assessment or reference points exist for the Scotia Bank stock. The Productivity-Susceptibility Analysis determined that the species is highly vulnerable, therefore this criterion scores a "high" concern.

Justification:

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	<5 years. <i>C. frondosa</i> reaches maturity at lengths between 80 and 102 mm, taking 3.3 years to reach 107 mm (DFO 2014)	1
AVERAGE MAXIMUM AGE	Between 10 to 25 years. Actual maximum age is unknown. Some field studies suggest it takes 10 years to reach max size, while lab studies indicate 25 years (Nelson et al. 2012).	2
FECUNDITY	8 to 12,000 eggs per year (Hamel and Mercier 2008b).	2
REPRODUCTIVE STRATEGY	Broadcast spawner (DFO 2014).	1
TROPHIC LEVEL	<2.75. <i>C. frondosa</i> is a suspension feeder (DFO 2014).	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)	No indication that significant concentrations of sea cucumbers exist outside area of fishing effort.	3
VERTICAL OVERLAP (CONSIDERS ALL FISHERIES)	High overlap. <i>C. frondosa</i> are the target species.	3
SELECTIVITY OF FISHERY (SPECIFIC TO FISHERY UNDER ASSESSMENT)	There is no minimum landing size, so all sea cucumbers are retained, including those below size of maturity (DFO 2016d). DFO require fishers to move away from areas where they encounter large numbers of small individuals; however, license conditions only mandate a minimum of one observer trip per season, which is unlikely to be enough to ensure that this measure is effective.	3
POST-CAPTURE MORTALITY (SPECIFIC TO FISHERY UNDER ASSESSMENT)	<i>C. frondosa</i> is the retained target species.	3
SUSCEPTIBILITY SCORE		3

Vulnerability score: 3.43 (High Vulnerability)

Factor 1.2 - Fishing Mortality

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

A sustainable exploitation rate is unknown. Quotas are based on apparently sustainable historic fishing practices; this is based on preliminary results that have not yet been peer-reviewed and published. Therefore, it is unknown if fishing mortality is appropriate for the stock and this criterion scores a "moderate" concern.

Justification:

The most recent assessment in NB (DFO 2009b) states that sustainable exploitation rates and other reference points are unknown. The overall TAC in 2016 (DFO 2016c) is the same as it has been every year since it was implemented in 2006 (DFO 2006), when it was based on average landings over the previous 5 years (DFO 2009b). The DFO reports that quotas are largely based on historical practices that appear to be sustainable

(pers. comm., C. Smith 2016) but, although catch rates have remained largely static each year since 2006 (DFO 2016a), with no further stock assessment it remains unclear whether exploitation is at a sustainable rate.

NEWFOUNDLAND AND LABRADOR/ NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

Sustainable exploitation rates have not been determined, catch per unit effort (CPUE) has remained relatively stable, and surveys are unable to provide a reliable biomass index (DFO 2018). The total allowable catch (TAC) was increased from 907 t in 2010 to 2,242 t in 2013, and then increased again to 6,016 t in 2019. The full TAC on the Western Bed was taken in 2015 and 2016 (TAC for those years was 2,242 t), but not in 2017 and 2018 (TAC for those years as 6,016 t) (DFO 2019). The Eastern Bed was opened in 2019 with a quota of 1,000 t (DFO 2019). Without a reliable biomass index, an exploitation rate index cannot be determined, and the sustainability of current fishing mortality is unknown. Therefore, Seafood Watch deems fishing mortality to be of "moderate" concern.

Justification:

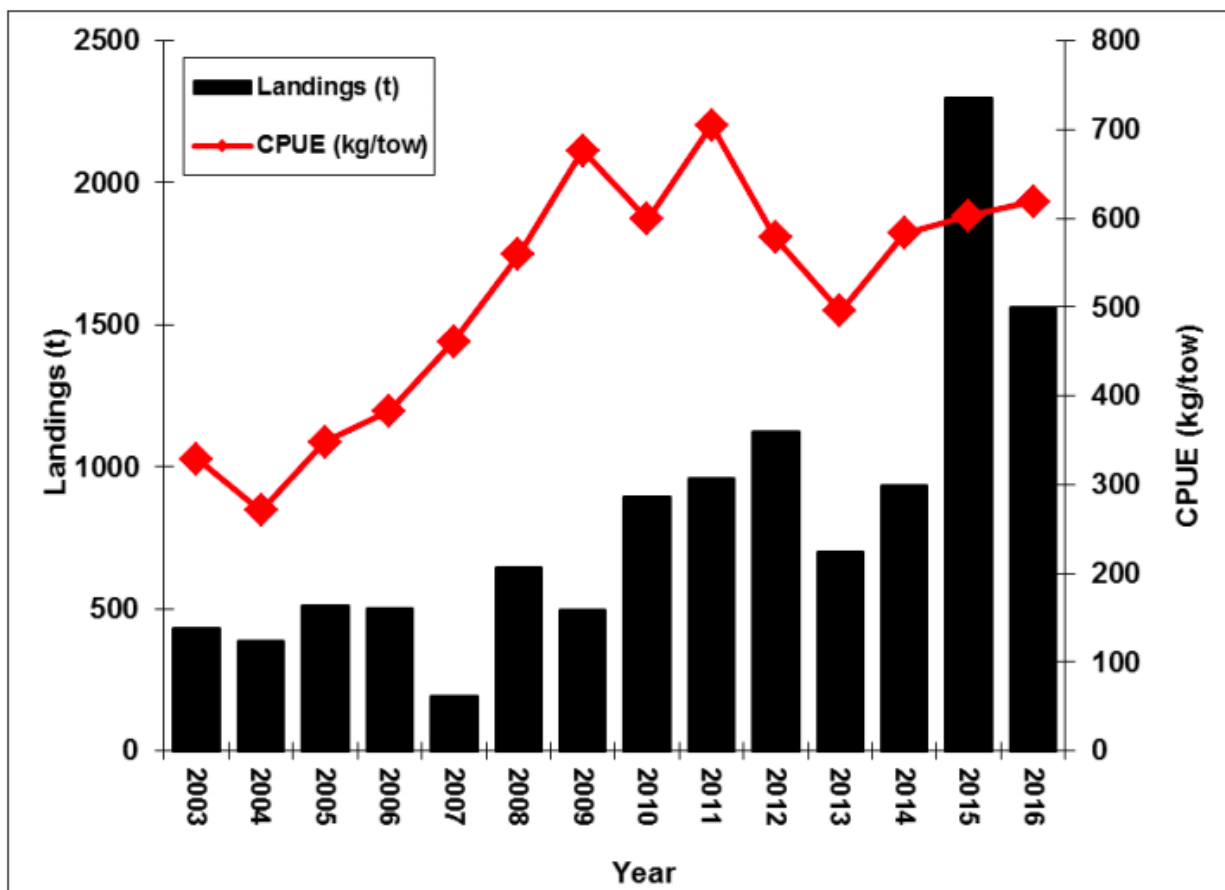


Figure 4 Trends in St. Pierre Bank landings and commercial CPUE (kg/tow) from 2003-2016. Figure from DFO (2017).

Prior to 2009, the exploitation rate was less than 1% (DFO 2009a). The current rate cannot be estimated because there is no reliable estimate of the biomass index (DFO 2018). Fishing is also prohibited in the eastern sea cucumber area, protecting a biomass three times larger than the area where harvesting takes place (DFO 2009a). Exploitation levels for other sea cucumber species between 2% and 4% are thought to be

sustainable; however, orange-footed sea cucumbers are slower growing and a more cautious approach may be needed (DFO 2018).

NOVA SCOTIA / NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

A sustainable exploitation rate is unknown. Quotas are based on apparently sustainable historic fishing practices; this is based on preliminary results that have not yet been peer-reviewed and published. Additional mortality occurs through the sea scallop fishery in NS, which has a significant portion of sea cucumber bycatch. Although all sea cucumbers are discarded, there have been no studies on post-release survival, and the scallop fishery's overall contribution to *C. frondosa* mortality has not been determined.

Therefore, it is unknown if fishing mortality is appropriate for the stock; therefore, this criterion scores a "moderate" concern.

Justification:

There are currently no biomass estimates, proxies or reference points for sea cucumbers in NS. According to the DFO, the measures that limit mortality – quotas, TACs (Total Allowable Catch) and limited days fishing – are instead largely based on historical fishing practices and set at levels that, according to preliminary data, appear to be sustainable (pers. comm., C. Smith 2016). However, these data have not yet been peer-reviewed and, given the lack of any stock assessment, it is unclear how sustainable the exploitation rates are.

Sea cucumbers also form a significant portion of catch in the sea scallop fishery in NS (pers. comm., S. Fuller 2017). Although no data is available for scallop fishing in the specific areas that the NS *C. frondosa* fishery operates in, reports from other scallop fishing areas (SFAs) in NS indicate that sea cucumbers can contribute between 1% and 14% of the total catch (Sameoto and Glass 2012). All cucumbers are discarded and mortality is unknown because there is no data on post-release survival.

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					
New Brunswick/Northwest Atlantic Towed Dredges Canada					
Subscore:	2.644	Discard Rate:	1.00	C2 Rate:	2.644
Species Stock	Abundance	Fishing Mortality	Subscore		
Green sea urchin	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)		

ORANGE-FOOTED SEA CUCUMBER					
Newfoundland And Labrador/Northwest Atlantic Towed Dredges Canada					
Subscore:	2.644	Discard Rate:	1.00	C2 Rate:	2.644
Species Stock	Abundance	Fishing Mortality	Subscore		
Green sea urchin	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)		

ORANGE-FOOTED SEA CUCUMBER					
Nova Scotia/Northwest Atlantic Towed Dredges Canada					
Subscore:	2.644	Discard Rate:	1.00	C2 Rate:	2.644

Species Stock	Abundance	Fishing Mortality	Subscore
Green sea urchin	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)

Surveys in 2016 and 2017 in NL report approximately 33% of the catch by weight as bycatch, with the prominent species being green sea urchin (*Strongylocentrotus droebachiensis*) and sand dollar (*Echinarachnius parma*) (DFO 2019). Only green sea urchin accounts for >5% of the catch (DFO 2017). Previous assessments for both NB and NL regions report low bycatch, and neither region reports catches of endangered, threatened or protected species. In NL, total bycatch was less than 2% (by weight) of the total catch each year (DFO 2009a) and in NB, bycatch was approximately 6% (by weight) of the total catch in 2008, with just over half made up of sea urchins (DFO 2009b). There is no assessment for the fishery in NS; however, similar gear is used (DFO 2016b) and it can be assumed to also have similar levels of bycatch.

All regions continue to record bycatch. In NL, data is collected through log books and is information that may be used in future assessments. In the Maritimes region, bycatch information is recorded by at-sea observers; however, since 2016, license holders themselves have been expected to report on the data collected (see C3.2 for more detail).

Although bycatch has historically been recorded as low, recent surveys suggest that green sea urchin may account for >5% of the catch. Therefore, this species is now included in the report.

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)

GREEN SEA URCHIN

Factor 2.1 - Abundance

NEWFOUNDLAND AND LABRADOR/ NORTHWEST ATLANTIC

Towed Dredges | Canada

NEW BRUNSWICK/ NORTHWEST ATLANTIC

Towed Dredges | Canada

NOVA SCOTIA/ NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

Too few data are collected in the Atlantic Canada fisheries to assess the status of green sea urchin. Therefore, inherent vulnerability is estimated using the PSA. Stocks with medium vulnerability and unknown stock status are scored as a "moderate" concern.

Justification:

The Newfoundland and Labrador fishery only collects landings data, which are insufficient to assess the stock (DFO 2007 NL) (Pisces 2014). There are no stock assessment data for the Nova Scotia fisheries (DFO 2011 SWNS) (DFO 2013 ENS). Managers have conducted two fisheries-independent surveys for the main areas of

the New Brunswick fishery (DFO 2010 LFA36) (DFO 2010 LFA38). Total biomass in the Bay of Fundy LFA 36 appeared to have changed little between those periods (1992 to 1994 and 2002 to 2003), and though there did appear to be a decline of 13 estimated fishable biomass, the significance of the result was confounded by high uncertainty. Similar patterns for total biomass and fishable biomass was shown in the Bay of Fundy LFA 38 (survey years 1992 and 2005). The fisheries also collect CPUE data. However, CPUE is known to correlate poorly with abundance in a similar green sea urchin fishery, particularly at low stock abundances (Chen and Hunter 2003).

PRODUCTIVITY ATTRIBUTE	RELEVANT INFO	REFERENCE	SCORE
AVERAGE AGE AT MATURITY	<5 years	(Meidel and Scheibling 1999)	1
AVERAGE MAXIMUM AGE	>50 years	(Russell et al. 1998)	3
FECUNDITY	>1 million eggs	(Thompson 1979)	1
REPRODUCTIVE STRATEGY	Broadcast spawner	(Thompson 1979)	1
TROPHIC LEVEL	<2.75	(Scheibling and Hatcher 2013)	1
DENSITY DEPENDENCE	Allee effects exist	(Wahle and Peckman 1999)	3
PRODUCTIVITY SCORE (P)			1.67

SUSCEPTIBILITY ATTRIBUTE	RELEVANT INFO	SCORE
AREAL OVERLAP	Unknown, so default score is used (>30% across their geographic range, considering all fisheries)	3
VERTICAL OVERLAP	Unknown, so default score is used	3
SELECTIVITY OF FISHERY	Gear type and size limits reduce susceptibility so default score is used (species is incidentally encountered and is not likely to escape gear, but conditions under 'high risk' do not apply)	2
POST-CAPTURE MORTALITY	Default score for retained or unknown species	3
SUSCEPTIBILITY		2.325

$$V = \sqrt{(1.67^2 + 2.325^2)} = 2.86 \text{ (medium vulnerability).}$$

Factor 2.2 - Fishing Mortality

NEWFOUNDLAND AND LABRADOR/ NORTHWEST ATLANTIC

Towed Dredges | Canada

NEW BRUNSWICK/ NORTHWEST ATLANTIC

Towed Dredges | Canada

NOVA SCOTIA/ NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

A paucity of data collection and reference points means fishing mortality relative to a sustainable level is unknown, a "moderate" 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

NEWFOUNDLAND AND LABRADOR/ NORTHWEST ATLANTIC

Towed Dredges | Canada

< 100%

There is no minimum landing size (MLS) and all sea cucumber catches must be returned. No bycatch is permitted; they must be returned to the water immediately as discards. Discard rate is low, around 2% (by weight) of the retained catch (DFO 2009a), thus amounting to less than 100% of the total retained catch.

Justification:

The 2009 assessment reported that bycatch was 2% or less (by weight) of the total catch in each year of the NL fishery (DFO 2009a).

NEW BRUNSWICK/ NORTHWEST ATLANTIC

Towed Dredges | Canada

< 100%

There is no minimum landing size (MLS) and all sea cucumber catches must be returned. No bycatch is permitted; they must be returned to the water immediately as discards. Discard rate is low, around 6% (by weight) of the retained catch (DFO 2009b) (DFO 2009a), thus amounting to less than 100% of the total retained catch.

Justification:

Discards made up 6 % (by weight) of total catch in 2008 (DFO 2009b).

NOVA SCOTIA / NORTHWEST ATLANTIC

Towed Dredges | Canada

< 100%

Discards in Nova Scotia are not reported; however, the gear type is very similar to that used in NB and NL. By proxy, it is expected that discards are also less than 100% of the retained catch. Therefore, the modifying factor 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: New Brunswick/Northwest Atlantic Towed dredges Canada	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)
Fishery 2: Newfoundland and Labrador/Northwest Atlantic Towed dredges Canada	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)
Fishery 3: Nova Scotia/Northwest Atlantic Towed dredges Canada	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Highly Effective	Yellow (3.000)

Criterion 3 Assessment

Factor 3.1 - Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals,

and is there evidence that management goals are being met? Do 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.

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

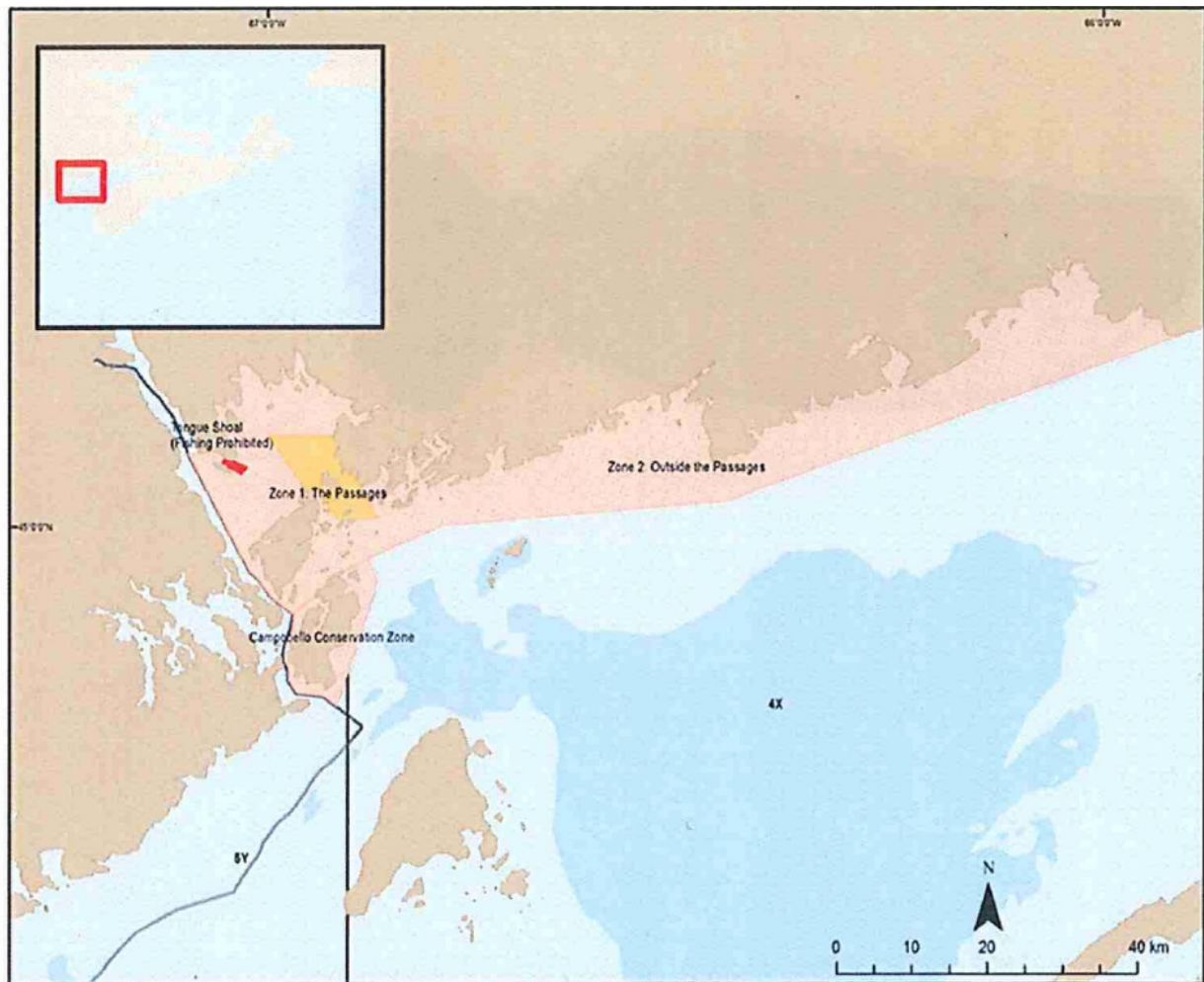
Moderately Effective

NB has a range of management strategies within a Conservation Harvest Plan (CHP). These include restricting fishing to specific areas, limiting catch by quota, and prohibiting fishing during the spawning season. There are no recent assessments to determine management effectiveness, but given the conservative nature of the strategies, a negative impact on the stock is unlikely. Therefore, and because there are no other species at risk being targeted, we deem this criterion to be "moderately effective."

Justification:

There are two licenses in southwest New Brunswick. The 2016 CHP permits license holders to fish within two zones (Fig. 4). Each zone has a TAC, Zone 1 has 1010 t and Zone 2 has 360 t, which is split equally between the two licenses (DFO 2016c). The current TAC is the same as it was in 2006, which was calculated on the basis of the average landings from the previous 5 years (DFO 2009b). A MLS was removed in 2013 due to difficulty in measuring sea cucumber length and enforcing the limit, and because post-release survival was unknown (DFO 2016c). The difficulty of measuring sea cucumber length is that the individuals must be split and drained of water to obtain a reliable measurement. This kills the animal and would defeat the purpose of attempting to return low-weight animals to the water; therefore, it is not considered a useful management tool. DFO may consider authorizing the return of small individuals in the future; however, post-discard survival is not yet known, so all sea cucumbers caught are required to be landed. Nonetheless, small sea cucumbers are not marketable and this provides an incentive for license holders to avoid areas with high numbers of small individuals.

Measures have not been in place long enough to measure effectiveness; but, due to their conservative nature, it is unlikely that there will be a serious negative impact on stock.



Note: Red indicates Tongue Shoal closure.

Figure 5 Fishing zones in southwest New Brunswick. Fishing is permitted in Zones 1 and 2 and prohibited in Tongue Shoal. Source DFO 2016c

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

The NL fishery came under an Integrated Fisheries Management Plan (IFMP) in 2019. Under this plan, the Eastern Bed was reopened with a quota of 4,773 t and an issuance of 32 temporary permits (DFO 2019). Each individual license holder is limited to 118 t, the fishing season is closed from January 1 to May 31, there is 100% dockside monitoring of all landings, and a Vessel Monitoring System is in place (DFO 2019). However, there is still no Precautionary Approach Framework for sea cucumbers in Newfoundland and Labrador. Recent assessments were unable to determine appropriate reference points so management effectiveness is uncertain; but, given the conservative nature of the strategies, it is unlikely that there will be a negative impact on the stock. Therefore, and because there are no other species at risk being targeted, we deem this criterion to be "moderately effective."

Justification:

The NL fishery had a TAC of 2,242 t equally divided between 19 license holders, which was calculated from a <3% exploitation rate based on the 2009 assessment (DFO 2009a) (DFO 2016a) (pers. comm., A. Rumbolt 2016). Although there are no reference points, this TAC had remained constant for at least 7 years. However, the TAC was recently increased and the Eastern Beds were opened to commercial fishing because harvesters were experiencing "substantial economic challenges" with the reduction in the snow crab quota and poor catches of cod (DFO 2019). The increase in TAC is no longer based on a specific exploitation rate because the stock assessment was unable to determine an exploitation rate without an understanding of a current biomass index (DFO 2017).

NOVA SCOTIA / NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

NS has a range of management strategies within a conservation harvest plan (CHP). These include restricting fishing to specific areas, limiting catch by quota and effort, and prohibiting fishing during the spawning season. There are no recent assessments to determine management effectiveness, but given the conservative nature of the strategies, it is unlikely that there will be a negative impact on the stock. Therefore, and because there are no other species at risk being targeted, we deem this criterion to be "moderately effective."

Justification:

The fishery is managed through a CHP for 2016 and is limited to four licenses, each restricted to fishing areas specific to the license (Figs. 5 and 6). Exploitation is controlled with individual quotas and fishing days; each license is allowed a maximum number of days fishing and a maximum landing tonnage, which varies with each license. However, there is no minimum landing size (MLS). Fishers are prevented from fishing in three zones that are protected for sensitive habitats and species (DFO 2016d). The fishery is closed in April to avoid the spawning season. Though measures have not been in place long enough to measure effectiveness, they are likely to be conservative enough to limit negative impacts on the stock.

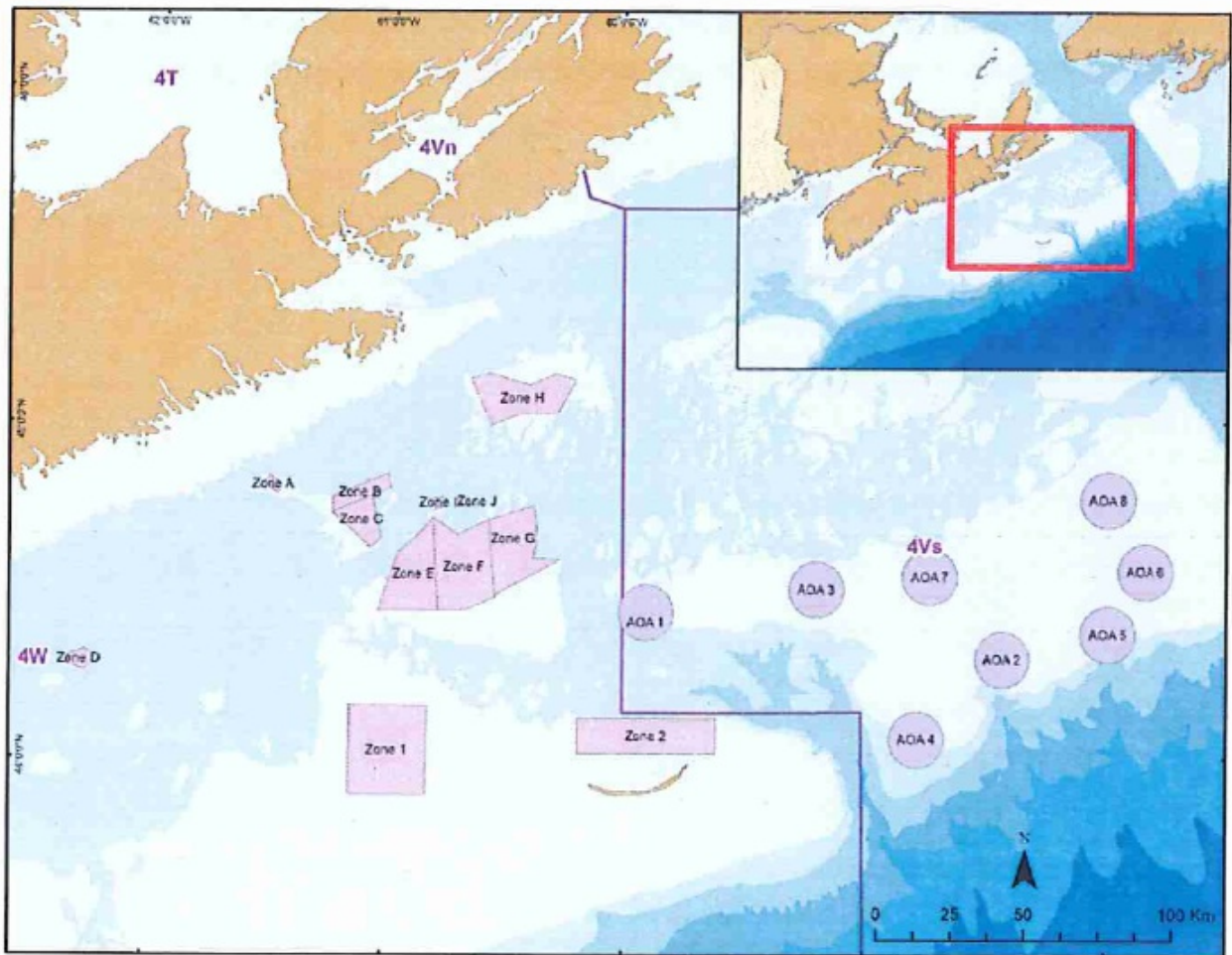


Figure 6 Fishing zones in Nova Scotia. a: Midshore and offshore Fishing zones in 4W (two licenses) and offshore zones in 4Vs (one license). Source DFO 2016d

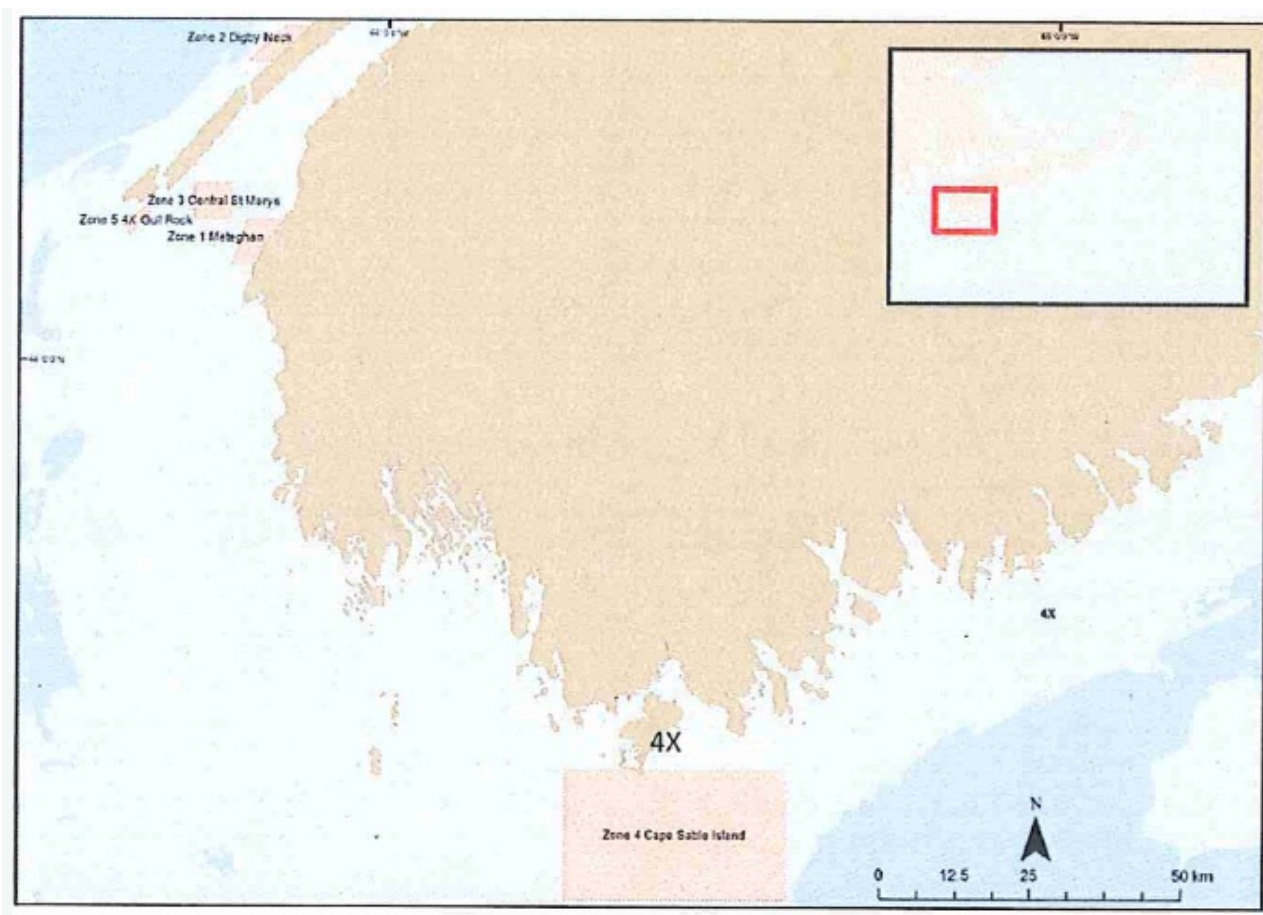


Figure 7 Inshore 4X fishing zones (one license). Source DFO 2016d

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.

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

The region uses a specific type of modified scallop/urchin dredge, which was initially developed to reduce bycatch in the Maine sea cucumber fishery (Barrett et al. 2007) (Rowe et al. 2009). License holders are required to avoid areas where they encounter high bycatch or large numbers of small sea cucumbers, and to log and return any bycatch in a manner that causes least harm (DFO 2016c). Bycatch was reported to be low in the 2009 assessment (DFO 2009), but higher in the 2017 assessment (DFO 2017). Bycatch reduction techniques are used but are of uncertain effectiveness, suggesting strategies are "moderately" effective.

Justification:

The authorized gear is "tinker gear," another type of modified scallop gear designed to reduce impact on other species. The specific dimensions of the gear are detailed in the CHP (DFO 2016c). The CHP also requires

fishers to distribute effort across the zones, avoiding areas of high bycatch and large numbers of small sea cucumbers. Bycatch has previously been recorded by at-sea observers but, from 2016, license holders are expected to report on bycatch themselves, going back in time and reporting on any at-sea observer data available under the license from previous years (DFO 2016c).

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

The Newfoundland and Labrador fishery uses a specific type of modified scallop/urchin dredge (DFO 2016a), which was initially developed to reduce bycatch in the Maine sea cucumber fishery (Barrett et al. 2007) (Rowe et al. 2009). Although there are no other specific requirements designed to reduce bycatch in the license conditions, bycatch was reported to be low in the 2009 assessment (DFO 2009), but higher in the 2017 assessment (DFO 2017). Bycatch reduction techniques are used but are of uncertain effectiveness, suggesting strategies are "moderately" effective.

Justification:

All fishing must be done using the "sea cucumber drag," based on the modified scallop dredge, or sea urchin drag, which was initially developed to reduce bycatch in the Maine sea cucumber fishery (Barrett et al. 2007), according to specific dimensions outlined in the license conditions (DFO 2016a). Any bycatch encountered must be discarded with minimal harm and recorded in logbooks (DFO 2016a).

NOVA SCOTIA/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

The NS region uses a specific type of modified scallop/urchin dredge, which was initially developed to reduce bycatch in the Maine sea cucumber fishery (Barrett et al. 2007) (Rowe et al. 2009). License holders are required to avoid areas where they encounter high bycatch or large numbers of small sea cucumbers, and to log and return any bycatch in a manner that causes least harm (DFO 2016d). Though there has been no assessment of NS, given the similar conditions to NB and NL, it can be assumed that similar levels of bycatch occurs. Therefore, this criterion scores "moderately" effective.

Justification:

Fishers are required to use a specific type of modified scallop gear known as "green gear," which has specific requirements outlined in the CHP (Rowe et al. 2009) (DFO 2016c). The CHP also expects fishers to avoid areas where they encounter high bycatch or large numbers of small sea cucumbers. Bycatch is recorded by at-sea observers and, since 2016, license holders have been expected to report on bycatch themselves, going back in time and reporting on any at-sea observer data available under the license from previous years (DFO 2016d).

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.

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

A comprehensive, independent stock assessment is lacking, and the most recent assessment of the fishery is more than 7 years old. However, all fishers are subject to 100% dockside monitoring of landings and must record bycatch. Also, fishers are required to take measurements from a sample of each catch and calculate the total area fished over the season. Because at least some data is collected and used to monitor and maintain the stock, including monitoring of bycatch, we deemed this criterion to be "moderately effective."

Justification:

All landings are subject to dockside monitoring. License holders are also expected to collect data on a sample of sea cucumbers from each trip (one "bushel basket"). Weight data, linked to the area caught and date of tow, are collected from each trip. Analysis on the split weight and area swept is conducted either by the harvesters or with assistance from the Maritimes Sea Cucumber Association (DFO 2016c). The DFO states that the data will be considered provisional indicators of stock status until a full assessment is produced. Such an assessment, including information on trends and recommendations for future quota changes and other management controls, will be submitted to resource management on 1 September 2016 (DFO 2016c). Reporting will be an annual requirement for the foreseeable future.

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

A comprehensive independent stock assessment is lacking, with the most recent assessment more than 7 years old. Fishers are required to complete logbooks and record bycatch; however, there are no sampling requirements or post-season surveys. Though data collection is minimal, a large area of spawning ground is protected from sea cucumber fishing as a reserve, a management strategy that requires minimal monitoring; therefore, scientific research and monitoring is deemed "moderately effective."

Justification:

The only data collection requirements for license holders are to complete logbooks and report any bycatch. No catch sampling is conducted by fishers, nor is any independent post-season survey conducted. It is hoped, however, that an updated assessment on the fishery will be produced in 2017/18 (pers. comm., A. Rumbolt DFO).

Though there is little data collection and analysis, management employs a strategy that requires only minimal monitoring, by only allowing fishing in the western sea cucumber area (DFO 2016a). This prevents sea cucumber harvesting in the eastern sea cucumber area, which the 2009 assessment found to have three times the biomass of the Western area (DFO 2009a).

NOVA SCOTIA/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderately Effective

There has never been a comprehensive assessment for the NS fishery. However, all fishers are subject to 100% dockside monitoring of landings and must record bycatch. Also, fishers are required to take measurements from a sample of each catch and calculate the total area fished over the season. Because at

least some data is collected and used to monitor and maintain the stock, including monitoring of bycatch, we deemed this criterion to be "moderately effective."

Justification:

All landings are subject to dockside monitoring. Also, license holders are expected to collect data on a sample of sea cucumbers from each trip (100 cucumbers). Weight data, linked to the area caught and date of tow, are collected from each trip. Analysis on the split weight and area swept is conducted either by the harvesters or with assistance from the Maritimes Sea Cucumber Association (DFO 2016d). The DFO states that the data will be considered provisional indicators of stock status until a full assessment is produced. Such an assessment, including information on trends and recommendations for future quota changes and other management controls will be submitted to resource management on 1 September 2017 (DFO 2016d). Reporting will be an annual requirement for the foreseeable future.

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.

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

Highly Effective

A degree of enforcement and monitoring is in place, with measures including dockside monitoring, vessel monitoring systems (VMS), at-sea observers and surveillance flights; also, some investigations of infractions are on-going. Therefore, enforcement of management regulations is deemed to be "highly effective."

Justification:

VMS is required on all trips and each vessel must have an at-sea observer on board for one trip per season. There is 100% dockside monitoring and fishers must hail in and out on every trip (DFO 2016c). According to DFO, an internal review is completed each year before the advisory committee meeting and there are currently no compliance issues.

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

Highly Effective

A degree of enforcement and monitoring is in place, with measures including dockside monitoring, vessel monitoring systems (VMS), at-sea observers, and surveillance flights; also, some investigations of infractions are on-going. Therefore, enforcement of management regulations is deemed to be "highly effective."

Justification:

License holders are subject to both in-port and at-sea inspections, VMS, and surveillance flights to enforce management regulations. Currently, some investigations ongoing, which may or may not lead to a violation being detected (pers. comm., A. Rumbolt 2016).

NOVA SCOTIA/NORTHWEST ATLANTIC

Towed Dredges | Canada

Highly Effective

A degree of enforcement and monitoring is in place, with measures including dockside monitoring, vessel monitoring systems (VMS), at-sea observers and surveillance flights; also, some investigations of infractions are on-going. Therefore, enforcement of management regulations is deemed to be "highly effective."

Justification:

VMS is required on all trips and each vessel must have an at-sea observer on board for one trip per season. There is 100% dockside monitoring and fishers must hail in and out on every trip (DFO 2016d). According to DFO, an internal review is completed each year before the advisory committee meeting and there are currently no compliance issues.

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.

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

Highly Effective

Stakeholder consultation is primarily through advisory groups. All stakeholders are included, such as aboriginal groups, fish processors, NGOs, and other governmental organizations (OGAs). Inclusivity is high and the information collected informs management decisions. Therefore, we deem this criterion to be "highly effective."

Justification:

An advisory group aims to meet every 3 years and includes aboriginal groups, processors and OGAs. Recommendations from the group highly inform the management process when there is a consensus, except when the recommendation is against scientific advice (pers. comm., A. Rumbolt 2016).

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

Highly Effective

Stakeholder consultation is primarily through advisory groups. All stakeholders are included, such as aboriginal groups, fish processors, NGOs, and other governmental organizations (OGAs). Inclusivity is high and the information collected informs management decisions. Therefore, we deem this criterion to be "highly effective."

Justification:

A formal review and consultation process takes place through the Maritimes Region Sea Cucumber Advisory Committee, which normally meets once a year and includes license holders, processors, aboriginal groups, and other governmental organizations (OGAs). Also, consultations with license holders are conducted throughout the season whenever necessary (pers. comm., C. Smith 2016).

NOVA SCOTIA / NORTHWEST ATLANTIC

Towed Dredges | Canada

Highly Effective

Stakeholder consultation is primarily through advisory groups. All stakeholders are included, such as aboriginal groups, fish processors, NGOs, and other governmental organizations (OGAs). Inclusivity is high and the information collected informs management decisions. Therefore, we deem this criterion to be "highly effective."

Justification:

A formal review and consultation process takes place through the Maritimes Region Sea Cucumber Advisory Committee, which normally meets once a year and includes license holders, processors, aboriginal groups, and OGAs. Also, consultations with license holders are conducted throughout the season whenever necessary (pers. comm., C. Smith 2016).

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
New Brunswick/Northwest Atlantic Towed dredges Canada	1	0	Moderate Concern	Red (1.732)
Newfoundland and Labrador/Northwest Atlantic Towed dredges Canada	1	0	Moderate Concern	Red (1.732)
Nova Scotia/Northwest Atlantic Towed dredges Canada	1	0	Moderate Concern	Red (1.732)

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

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

1

The NB fishery uses a modified scallop drag. Sea cucumbers are found on a variety of substrates, including bedrock, boulder, gravel, and sandy habitats (DFO 2016c). Therefore, we deemed this criterion to have a score of 1.

Justification:

Fishing for sea cucumbers encounters mixed substrates, and studies in NB have shown immediate localized impacts (DFO 2016c). The DFO assessment in NB recommended more studies on habitat, including mapping and investigating rates of recovery on known habitats in the fishery (DFO 2016c); to date, it appears that such studies have not been conducted.

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

1

The NL fishery uses modified drag gear (DFO 2016a). Sea cucumbers are found on a variety of substrates, including bedrock, boulder, gravel, and sandy habitats (DFO 2016c). Therefore, we deemed this criterion to have a score of 1.

Justification:

Fishing for sea cucumbers encounters mixed substrates, and studies in NB have shown immediate localized impacts (DFO 2016c). The DFO assessment in NB recommended more studies on habitat, including mapping and investigating rates of recovery on known habitats in the fishery (DFO 2016c); to date, it appears that such studies have not been conducted.

NOVA SCOTIA/NORTHWEST ATLANTIC

Towed Dredges | Canada

1

The NS fishery uses a modified scallop drag (DFO 2016d). Sea cucumbers are found on a variety of substrates, including bedrock, boulder, gravel, and sandy habitats (DFO 2016c). Therefore, we deemed this criterion to have a score of 1.

Justification:

Fishing for sea cucumbers encounters mixed substrates, and studies in NB have shown immediate localized impacts (DFO 2016c). The DFO assessment in NB recommended more studies on habitat, including mapping and investigating rates of recovery on known habitats in the fishery (DFO 2016c); to date, it appears that such studies have not been conducted.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

0

In the NB fishery, one small area is protected from fishing; however, it contributes less than 20% of the representative habitat. Therefore, the gear mitigation score is 0.

Justification:

Fishing is permitted in two zones (Fig. 4), with a small part of one restricted as a potential study site (DFO 2016c); however, this area contributes less than 20% representative habitat to the zone, and it is unclear whether areas outside of the fishing zones are viable sea cucumber habitat.

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

0

All gear modifications are designed to reduce bycatch, not to limit habitat impact. In NL, sea cucumber fishing is prohibited in the eastern cucumber area, which is approximately 1.5 times the size of the western cucumber area. However, fishing for other species is permitted, including trawling for groundfish, so habitat impacts may still occur; therefore, the gear mitigation score is 0.

Justification:

In the 2009 assessment, the eastern survey area was determined to have more than three times the biomass of the western survey area (Fig. 7). Fishing is prohibited from the eastern area, which is approximately 1.5 times of the size of the western area (DFO 2009a); however, because fishing for other species is allowed (pers. comm., A. Rumbolt 2016), a gear mitigation score was unable to be applied.

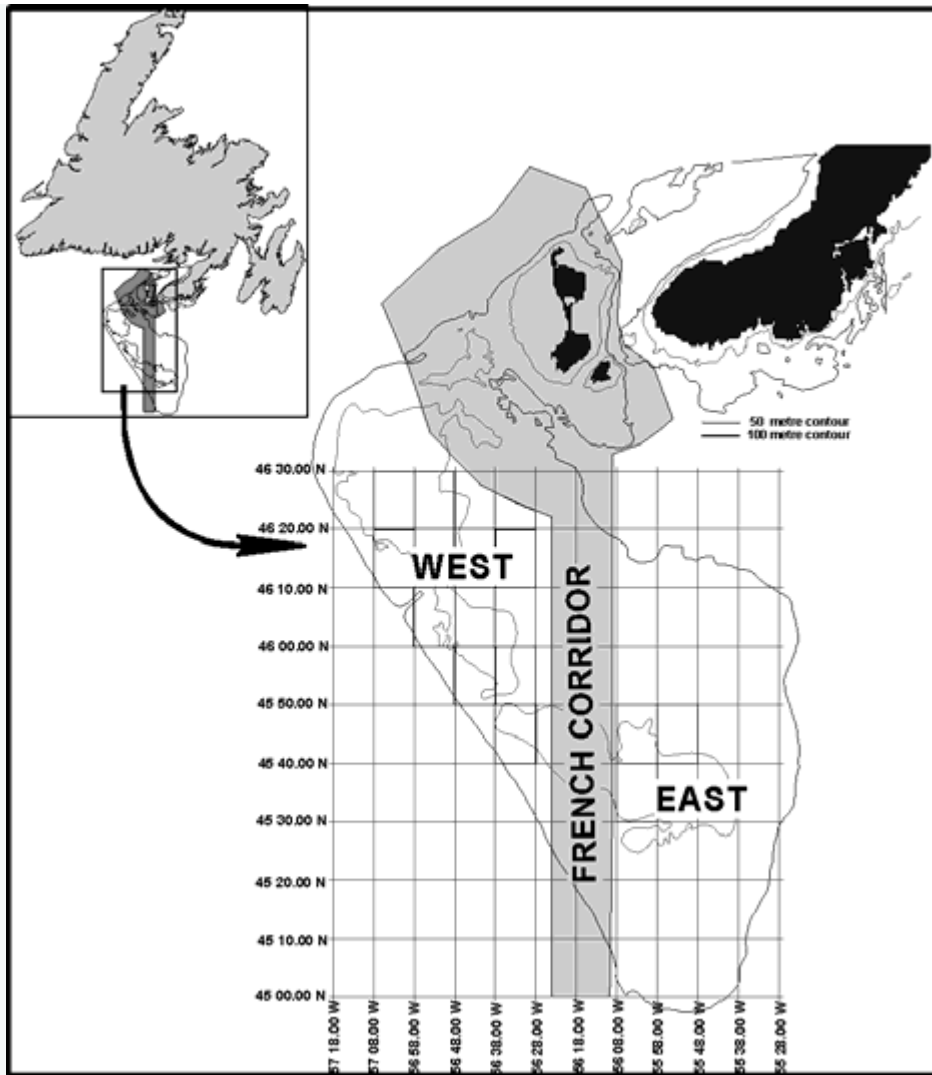


Figure 8 Survey areas on the St. Pierre Bank in Newfoundland and Labrador. Fishing is only permitted in the Western area. Source: DFO 2009a

NOVA SCOTIA / NORTHWEST ATLANTIC

Towed Dredges | Canada

0

All gear modifications are designed to reduce bycatch, not to limit habitat impact. In NS, the small areas that are protected from fishing contribute less than 20% of the representative habitat. Therefore, the gear mitigation score is 0.

Justification:

Fishing is restricted to specific zones (Figs. 5 and 6) and, under the CHP, is prohibited in three areas to protect sensitive habitats (DFO 2016d). However, this is less than 20% of the available habitat and it is unclear whether areas outside of the designated fishing zones function as sea cucumber habitat.

Factor 4.3 - Ecosystem-Based Fisheries Management

NEW BRUNSWICK/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

The ecological importance of *C. frondosa* is not well known, and there have been no attempts to fully assess the ecological impacts of the fishery. However, sea cucumbers are not an exceptional species and it is unlikely that detrimental food-web impacts occur. For these reasons, this criterion scores a "moderate" concern.

Justification:

Though sea cucumbers are thought to be nutrient recyclers, their contribution to the food web is poorly known. *C. frondosa* is a very selective suspension feeder and, other than the sea star *Solaster endeca* and the sea urchin *Strongylocentrotus droebachiensis*, it has limited predators (Hamel and Mercier 1996). Further ecological functions are unknown (DFO 2009b).

NEWFOUNDLAND AND LABRADOR/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

The ecological importance of *C. frondosa* is not well known, and there have been no attempts to fully assess the ecological impacts of the fishery. However, sea cucumbers are not an exceptional species and it is unlikely that detrimental food-web impacts occur. For these reasons, this criterion scores a "moderate" concern.

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NOVA SCOTIA/NORTHWEST ATLANTIC

Towed Dredges | Canada

Moderate Concern

The ecological importance of *C. frondosa* is not well known and there have been no attempts to fully assess the ecological impacts of the fishery. However, sea cucumbers are not an exceptional species, and it is unlikely that detrimental food-web impacts occur. For these reasons, this criterion scores a "moderate" concern.

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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 Orange-Footed Sea Cucumber Report

Updates to the September 5, 2017 Orange-Footed Sea Cucumber report were made on April 14, 2020:

Overall Recommendations for orange-footed sea cucumber caught by diving in Atlantic Canada remain unchanged, but individual criterion updates are outlined below.

- C1.2 (Newfoundland and Labrador) downgraded from "Low" Concern to "Moderate" Concern because the most recent stock assessment was unable to determine if current fishing levels are sustainable and Seafood Watch deems fishing mortality unknown.
- C2: (All areas) downgraded from Green to Yellow. Green sea urchin was added as a main species to the report. There is limited information for abundance and fishing mortality for green sea urchins in Canada; therefore, C2.1 and C2.2 are scored as "Moderate" Concern.
- C3.2 (All areas) downgraded from "Highly" Effective to "Moderately" Effective because bycatch recorded in the recent stock assessment (DFO 2017) was higher than previous estimates (DFO 2009), suggesting an uncertain effectiveness in bycatch reduction techniques.

Appendix B: Review Schedule

Newfoundland and Labrador

- New NL assessment – planned for 2017

Maritimes

- New NB assessment – data submitted to resource management 1 September 2016 - report in 2017
- New NS assessment – data submitted to resource management 1 September 2017 - report in 2018