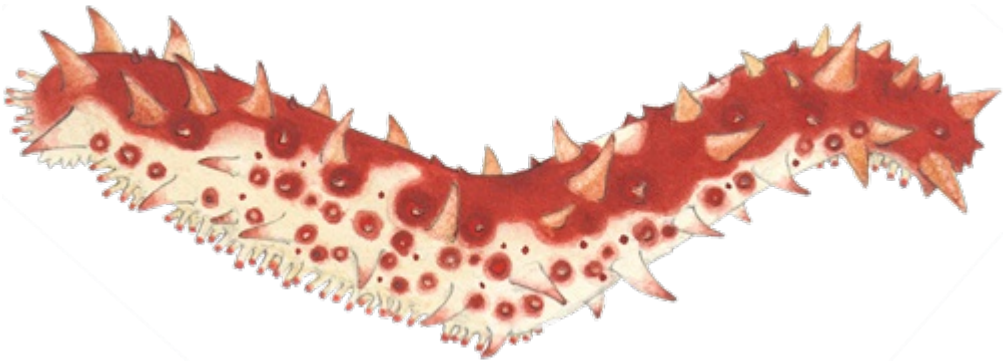
Monterey Bay Aquarium Seafood Watch®

Sea cucumber (British Columbia)

Parastichopus californicus



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British Columbia/Northeast Pacific

Diving

Published January 09, 2017, Reviewed April 14, 2020 – see appendix for more details

Seafood Watch Consulting Researcher

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

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About Seafood Watch

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

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

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

Guiding Principles

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

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

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

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

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

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

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

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

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

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

Summary

This report assesses the sustainability of the giant red sea cucumber *(Parastichopus californicus)* fishery in British Columbia, Canada. Harvesting occurs in designated areas along the entire coast and is carried out by divers.

P. californicus has a range from the Gulf of Alaska to southern California and is found from the intertidal to 250 m. It lives on a range of substrates and, despite low mobility, has relatively few predators that generally only target cucumbers opportunistically. The species has separate sexes and reproduction is by broadcast spawning, with juveniles maturing after 4 years and growing up to 50 cm in length. It feeds on organic detritus lying on the seabed and functions in the ecosystem as a nutrient recycler.

The primary market for sea cucumbers is Asia, where muscle strips and dried skin are valuable products. A commercial fishery in BC has existed since the early 1970s, which became more robustly managed in the early 1990s, when limited licenses and individual quotas were introduced. In 1997, an Adaptive Management Plan (AMP) was introduced to establish a biologically based Management Strategy that limited fishing to 25% of the coast, established a conservative 4.2% harvest rate of the estimated biomass, and undertook a rigorous 10-year program of data collection (Phase 1). This management included setting a precautionary total allowable catch (TAC) that increased over time as more information became available. Upon completion of Phase 1 in 2008, commercial harvesters were allowed to return to some of the areas previously closed, and a new harvest rate of 6.7% was set (Phase 2). In 2011, Phase 2 continued as an Adaptive Rotational Fishing Strategy (ARFS) was introduced, meaning that each area would be fished once every 3 years under an equivalent 3.3% annual harvest rate. The fishery is currently in its second rotational cycle, from 2014 to 2016.

The current management scheme is highly precautionary, using a harvest rate lower than the conservative 4.2% rate initially recommended. Instead of limit reference points, which are of relatively low value in a fishery of this type because a lack of resources limits the opportunities to repeatedly survey the same areas, Commercial No Take Reserves (CNTRs) are used as insurance against uncertainty by closing areas to commercial fishing and allowing spillover of larvae and adults into adjacent areas. The locations of CNTRs are established through stakeholder consultation, which is a strategy used extensively throughout the development of the management regime (including during annual reviews). Other management strengths include precautionary strategies such as a minimum density threshold, where areas closed in Phase 1 must have a density of at least 2.5 cucumbers per meter of shoreline before they can be reopened in Phase 2.

As a selective dive fishery, the fishery has no impact on habitat or non-target species. Recreational activity is minimal and First Nations fishing of sea cucumbers accounts for only a tiny percentage of their total shellfish catch. The most recent Department of Fisheries and Oceans Canada (DFO) management plan reports that current stocks are considered to be healthy.

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
Giant red sea cucumber British Columbia/Northeast Pacific | Diving | Canada	Green (3.413)	Green (5.000)	Green (4.000)	Green (3.873)	**Best Choice (4.032)**

Summary

The giant red sea cucumber dive fishery in British Columbia is considered a **Best Choice** recommendation due to low bycatch, precautionary management and minimal environmental impact.

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 giant red (California) sea cucumber *(Parastichopus californicus)* dive fishery in British Columbia (BC), Canada. *P. californicus* is found throughout the Pacific northwest coast, from the Gulf of Alaska to Cedros Island, west of the Lower California Peninsula (Baja California) (Lambert 1997); however, this assessment refers specifically to fishing activities in British Columbia.

Species Overview

Sea cucumbers are holothurians belonging to the phylum Echinodermata, which also includes species such as sea stars and sea urchins. Although approximately 30 species of sea cucumber are found along the coast of British Columbia, *P. californicus* is the only species that is commercially harvested. It is also the largest species, with individuals reaching 50 cm and living in a variety of habitats, though densities are greatest on hard substrates in waters with moderate current and generally not abundant in quiet waters at the heads of inlets. Sea cucumbers range in depth from the intertidal to 250 m, though mobility is limited to around 4 m per day (Lambert 1997).

Giant red sea cucumbers feed on organic detritus in the sediment, particularly bacteria and fungi, performing an important function as nutrient recyclers (Lambert 1997). Annually, they undergo atrophy and regeneration of their internal organs, which is preceded by a cessation of feeding (Fankboner & Cameron 1985). Adult sea cucumbers have relatively few predators, except for sea stars and sea otters (DFO 2015). Threat of predation from the sunflower sea star has been shown to elicit a vigorous flight response, with the sea cucumber leaving the seabed and swimming to escape (Margolin 1976). Sea otters prey upon sea cucumbers opportunistically rather than as a preferential target, unless other food sources are depleted. But the long-term presence of sea otters in Alaska has been shown to result in 100% sea cucumber density depletion (Larson et al. 2013).

The sexes are separate and spawning occurs from late spring through summer (Cameron & Fankboner 1985). Spawning is by broadcast, and larvae remain planktonic for between 5 and 8 weeks (Lambert 1997). In the juvenile stage, individuals attach to a variety of surfaces, growing to 1 cm by the end of the first year, and between 4 and 10 cm by the end of the second. Recruitment into the commercial fishery is thought to occur after 4 years, with adult populations typically containing individuals no smaller than 15 cm.

History and management of the fishery

The primary fishery for *P. californicus* in British Columbia is commercial and has existed since 1971. In the early 1980s, markets were established for sea cucumbers, resulting in a rapid increase in effort that led to the implementation of management measures to alleviate conservation concerns. In 1991, limited licenses were introduced and set at 85, with the commercial industry forming the Pacific Sea Cucumbers Harvesters Association (PSCHA) in 1992 to represent license holders' interests. A rotational style fishery began in 1993, allowing a 2- year recovery between openings, and in 1995, individual quotas (IQ) were introduced, permitting each license holder an equal share of the total allowable catch (TAC).

Between 1997 and 2007, DFO undertook an Adaptive Management Plan (AMP) to gather the information needed to develop a biologically based sustainable management (Phase 1— collecting for new information). To facilitate the collection of the fishery-dependent information needed, the AMP restricted the commercial fishery to 25% of the BC coastline. A harvest rate (HR) of 4.2% of the estimated biomass was applied, based on conservative harvest rates from the *P. californicus* fisheries in Alaska and Washington State. Previous arbitrary quotas were replaced with a precautionary baseline TAC, which increased steadily from 1998 to 2005 due to the completion of surveys and a doubling of the baseline density estimate in 2002. In 2006, the TAC was set at 1.2 million

pounds, which remained static until a 9.5% increase in 2011 (DFO 2015).

Upon completion of the 10-year AMP in 2008, harvesters were allowed to return to some previously closed areas (Phase 2—fishing for commerce). Work by Hand et al. (2009) concluded that the 4.2% harvest rate was precautionary and suitable for a variety of habitats and densities. A harvest rate of 6.7% was recommended if unproductive, low-density areas were avoided (Hand et al. 2009), and this was applied to all newly opened areas. The 4.2% HR rate continued to be applied to areas opened during Phase 1.

An Adaptive Rotational Fishing Strategy (ARFS) was adopted in 2011, where each sea cucumber Quota Management Area (QMA) is harvested once every 3 years. The fishery is currently in its second rotational cycle, from 2014 to 2016. Within this 3-year scheme, a new triennial harvest rate of approximately 10% was applied, which falls within the range of recommended annual harvest rates in Hand et al. (Hand et al. 2009) and is equivalent to a 3.3% annual harvest rate, which is less than either the 4.2% or 6.7% HRs previously applied. The West Vancouver Island license area remained as an annual-style fishery and continues with the 4.2% HR. In total, approximately 48% of the BC coast was open to commercial harvest in 2015 (DFO 2015).

The fishery contains a number of Commercial No Take Reserves (CNTRs) that are closed to commercial harvest, and it is hoped that spillover of adults and larvae will occur into adjacent areas. These reserves exist in tandem with other marine parks around the BC coast that likely have the same effect; however, CNTRs are surveyed prior to establishment and are only established in areas known to have sea cucumber populations.

License numbers remain at 85, with sea cucumbers harvested by divers operating from a vessel 8 to 12 m in length. Crew typically includes the vessel master and one or two additional crew members, and it is common for vessels to stack license eligibilities to make fishing more economical, with the 2015 fishery involving 32 vessels. Most vessels also hold licenses for other dive fisheries, such as red and green urchin and geoduck, though they do not harvest them at the same time (pers. comm., Erin Wylie 2016). The fishery opens in October and is scheduled for 8 weeks (DFO 2015).

A First Nations fishery for food, social, and ceremonial (FSC) purposes exists under an annual open license and is the first priority after conservation. There are no catch limits, except in Nations where the Council has established their own for Band members. The recreational fishery is coast-wide and year-round, and operates under daily limits, although activity is believed to be minimal (DFO 2015).

Production Statistics

In 2011, the total catch increased from 1.2 million pounds (split) to 1.36 million pounds (split), because of increased availability as sections of the coast reopened after the end of Phase 1 of the AMP in 2008. The value of the sea cucumbers has generally reflected the quota available (Figure 2). But prices have more than doubled since 2008, from an average of $2.30 per split pound to an average of $5.50 per split pound in 2015 (Fig. 2). This reflects increased demand in Asia because of increased affluence and desire for luxury items ((Purcell 2010), (DFO 2015)).

Processing in BC adds further value to the landed catch. In 2011, sea cucumbers represented a wholesale value of $10.8 million in 2011, equating to $4.3 million value-added to the landed value. But in 2013, wholesale value was $7.3 million, representing $0.8 million value-added (BSCI 2014). In 2008, sea cucumber processing was found to contribute 8% of the wild shellfish processing employment in BC, equating to 680 person-months of work (DFO 2015).

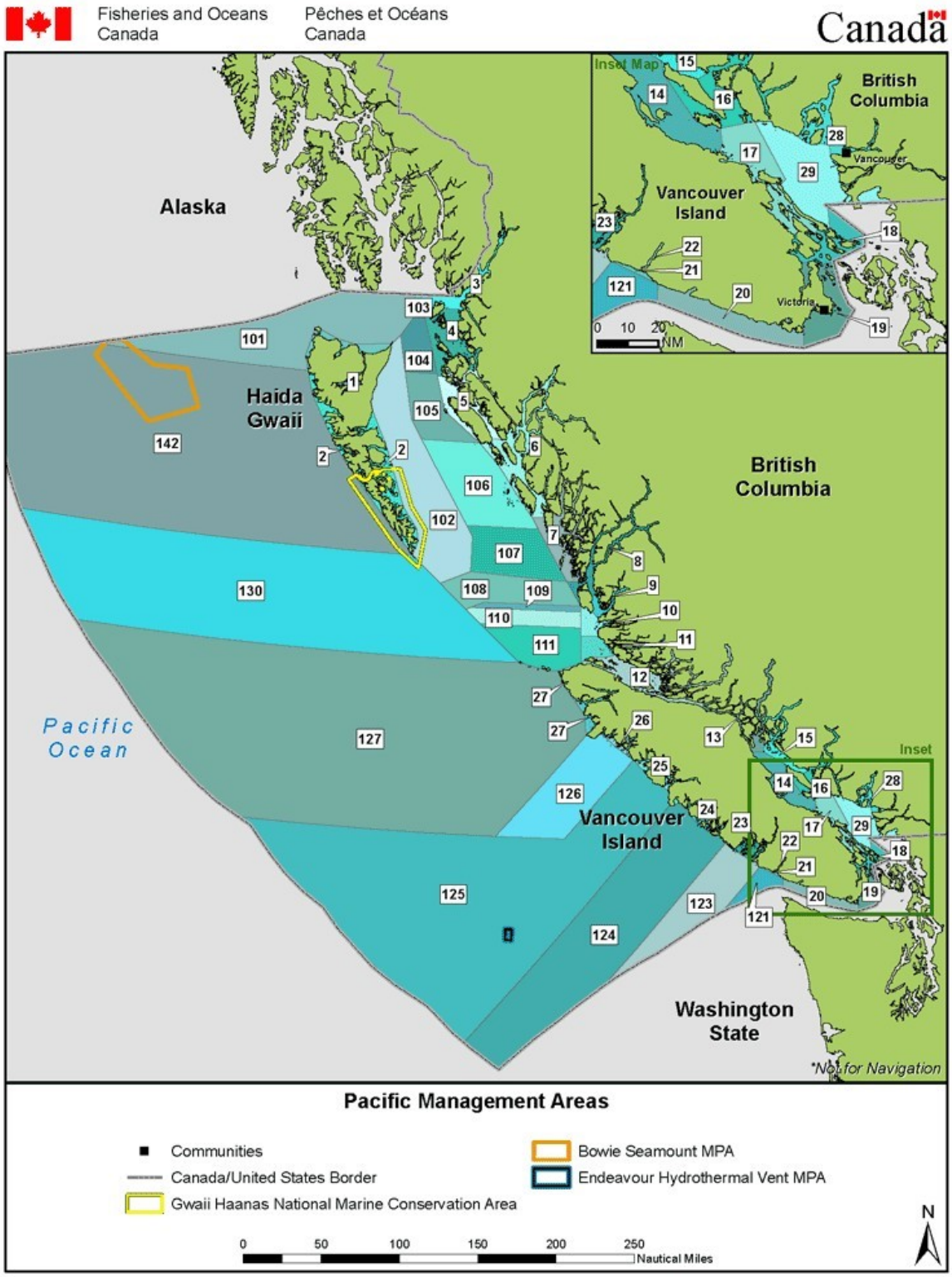

Figure 1 Map of DFO Pacific Management Areas. Quota Management Areas are formed as subsections of the Pacific Management Areas and are detailed in both the Integrated Fisheries Management Plan for Giant Sea Cucumbers (DFO 2015) and online at http://pac.dfo-mpo.gc.ca/fm-gp/maps-cartes/areas-secteurs/index-eng.html (Source: (DFO 2016))

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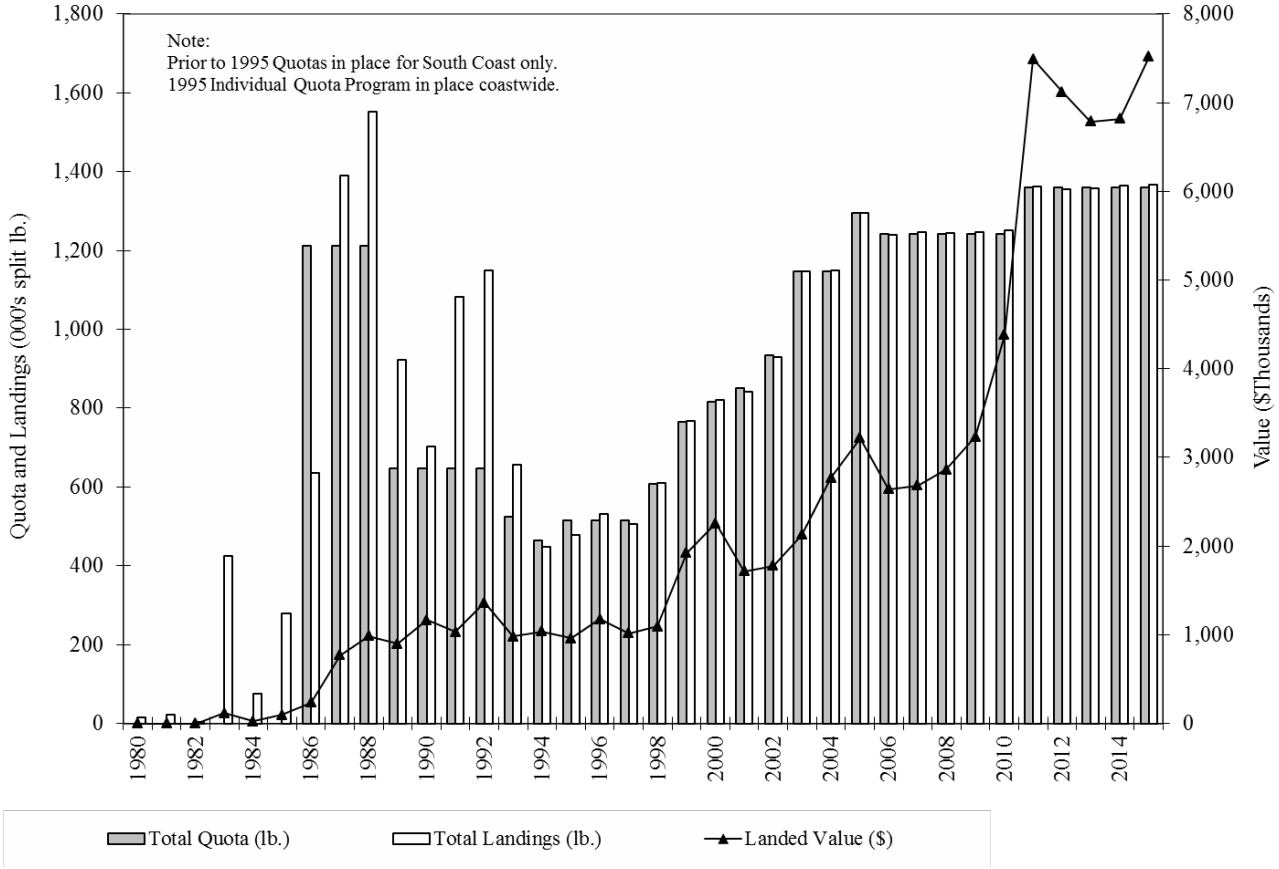

Figure 2 Annual sea cucumber quota (split lb.), landings (split lb.), and value ($) in BC for 1980– 2015 (Source: (DFO 2016)).

Importance to the US/North American market.

The North American market for sea cucumbers is small (DFO 2015), with effort instead focused on marketing the product to Asia (PSCHA 2016).

Common and market names.

Giant red; California (DFO 2015); or big sea cucumbers (Lambert 1997).

Primary product forms

Harvested sea cucumbers are processed into frozen muscle strips and dried skin. The primary market is Asia where sea cucumber products, particularly the skin, have been used for centuries as a medicinal food (Purcell 2010). The muscle strips are removed from the skin and immediately frozen, while the skin is semi-processed in BC plants, where it is boiled and salted before shipping ((Purcell 2010) , (DFO 2015)).

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

GIANT RED SEA CUCUMBER			
Region | Method	**Abundance**	**Fishing Mortality**	**Score**
British Columbia/Northeast Pacific | Diving Canada	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)

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.*

GIANT RED SEA CUCUMBER

Factor 1.1 - Abundance

BRITISH COLUMBIA / NORTHEAST PACIFIC
Diving | Canada

Moderate Concern

Although the results of Hand et al. (Hand et al. 2009) show that population abundance is not negatively affected by the harvest rate, this is the only data-limited study that measured the impact of fishing on abundance. According to SFW guidelines, to be considered of low conservation concern, the fishery would need a quantitative stock assessment no more than 10 years old, or two data-limited studies suggesting that the stock is healthy. Therefore, because the species is not highly vulnerable according to the Productivity Susceptibility Analysis and no target reference point has been set, but with the most recent data-limited surveys occurring almost 10 years ago in 2007, abundance is considered a "moderate" concern, scoring 2.33.

Justification:

A complete picture of sea cucumber stock abundance in BC is difficult to ascertain due to the geographic size of the fishery and the resource limitations that restrict DFO from being able to survey it entirely. Some areas of the coast are considered to be at a "virgin" state because they were closed during Phase 1 of the fishery and have not been fished for over 10 years (DFO 2015). During Phase 1, between 1997 and 2007, intensive surveying was conducted within experimental fishing areas (EFAs) that were closed to commercial harvest, to give a 10-year density time series. Repeated surveys were also conducted in six locations open to commercial harvest. In both the EFAs and the commercial areas, it was found that fishing had no negative effect on sea cucumber abundance (Hand et al. 2009). In Phase 2, DFO continues to conduct annual stock assessments of selected Pacific Fisheries Management Areas (PFMA) subareas to estimate sea cucumber density and biomass, but based on peer-reviewed assessment advice (Duprey et al. 2011), the areas surveyed are different each year. DFO has surveyed 142 new areas since 2007 that have provided a snapshot of site-specific densities, rather than a time series (Duprey & Stanton 2015).

A limit reference point (LRP) of 50% B0 (virgin biomass) based on work by Hand et al. (Hand et al. 2009) has been set; however, DFO (DFO 2015) admits that it is of limited use due to the lack of recent repeated surveys of the same stock that would give an idea of changes over time. Resource limitations mean that the use of the LRP has been restricted to just a few locations. Instead, a minimum density threshold of 2.5 cucumbers per meter of shoreline sets the abundance required to reopen areas for Phase 2 that were closed during Phase 1. Surveying has found that some areas that were open during Phase 1 have densities below the minimum threshold, but because the "virgin" density is not known, it is not clear whether this is due to harvesting or another factor (DFO 2015). No target reference point (TRP) has been established.

Despite these limitations, DFO (DFO 2015) reports that stocks are generally considered to be healthy, and the lack of reference points is appropriate given the precautionary management regime, the scale of the fishery, and the resource availability to the DFO. Relatively few licenses are available, fewer vessels prosecute the fishery, and it operates under an adaptive plan with precautionary strategies and flexibility to adjust management as new information becomes available.

Factor 1.2 - Fishing Mortality

BRITISH COLUMBIA / NORTHEAST PACIFIC
Diving | Canada

Low Concern

The annual commercial harvest rate of sea cucumbers is kept to an extremely conservative 3.3% of the estimated biomass. Harvesting for First Nations FSC and recreational purposes is minimal, so mortality is highly likely to be at a sustainable level and is considered "low" concern, scoring 5.

Justification:

The fishery operates as a rotational-style fishery, with each area fished once every 3 years. A triennial harvest rate (HR) of approximately 10% is applied to each area, equivalent to approximately 3.3% annual HR (DFO 2015). This is less than the 4.2% or 6.7% harvest rate used prior to 2011 and is extremely conservative. Surveying of four experimental fishing areas (EFAs) found that harvesting at a 4.2% rate would be sustainable for 75 years in all four areas ((Hand et al. 2009), (DFO 2015)); therefore, the rate of 3.3% can be reasonably expected to keep mortality at a sustainable level. First Nations fishing appears to be small, with sea cucumbers contributing approximately 0.2% of their total catch of any shellfish species from 1991–2008, while recreational fishing is minimal (DFO 2015), so mortality from these sources is of no concern.

As an alternative to reference points, DFO has employed several strategies to limit mortality. This includes Commercial No Take Reserves (CNTRs), where sea cucumber fishing is prohibited; and a minimum density threshold, requiring that Phase 2 subareas have a sea cucumber density of at least 2.5 cucumbers per meter of shoreline prior to opening. Additionally, the fishery employs precautionary harvest rates and strategies to spread effort, such as limiting licenses to certain areas and managing catch through quota management areas (QMAs), which are smaller than license areas and each has its own quota (DFO 2015).

Over the last five seasons, total landings were slightly above the TAC in all years except 2012 and 2013 (Figure 2). DFO (DFO 2015) consider any quota taken over the TAC to be a conservation concern and will continue to monitor overages, with enforcement action pursued if necessary. But the current overage is an extremely small percentage of the overall TAC and is not a current conservation concern.

Criterion 2: Impacts on Other Species

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

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

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

Guiding Principles

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

Criterion 2 Summary

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

GIANT RED SEA CUCUMBER British Columbia/Northeast Pacific | Diving | Canada					
Subscore:	**5.000**	**Discard Rate:**	**1.00**	**C2 Rate:**	**5.000**
Species | Stock	**Abundance**	**Fishing Mortality**	**Subscore**		
No other main species caught					

Bycatch concerns in the BC sea cucumber dive fishery are eliminated due to the high selectivity of the fishing technique. Each sea cucumber is hand-picked by the harvester and placed into a mesh bag, which is then lifted to the surface by inflated air bags to be picked up by the fishing vessel. Because the sea cucumbers are individually selected and the gear does not touch the sea floor, impact on non-target species is negligible. Although many vessels hold licenses for other dive fisheries, they do not target other species while harvesting sea cucumbers (pers. comm., E. Wylie 2016). Therefore, the fishery scores 5 for impacts on other species.

2.4 - Discards + Bait / Landings

BRITISH COLUMBIA / NORTHEAST PACIFIC Diving | Canada
< 100%

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: British Columbia/Northeast Pacific | Diving | Canada	Highly Effective	Highly Effective	Moderately Effective	Moderately Effective	Moderately 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 manages follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

Highly Effective

Adaptive and precautionary management measures are in place, with well-defined targets appropriate to the scale of the fishery. Strategies exist for over-depletion, and surveys indicate that the conservative exploitation rate is unlikely to cause a decline, suggesting that management measures are effective. Therefore, we deem management strategy and implementation to be "highly effective."

Justification:

Management measures for the BC sea cucumber fishery are based upon the precautionary principle and peer-reviewed scientific advice from Hand et al. (Hand et al. 2009) and Duprey et al. (Duprey et al. 2011). The precautionary policies for the fishery fit into the wider national strategy of the Sustainable Fisheries Framework, which aims to conserve stocks and promote economically prosperous fisheries, while management follows an Adaptive Rotational Fishing Strategy that allows for flexibility when new information becomes available.

Several strategies are employed to limit overharvesting, including limited licensing, quota management areas (QMA), and fishing quotas. Annual licenses are limited to 85 that are spread across four geographic areas and depend on the quota available in each area in any given year. This spatial quota management is augmented by QMAs, which are smaller than license areas and are used to further spread fishing effort around each license area (DFO 2015).

The fishery has several defined management targets. A fixed total allowable catch (TAC) of 1.36 million pounds has been in place since 2011, with 2% reserved for First Nations food, social, and ceremonial (FSC) purposes. The targets also include minimum density thresholds, which set the density requirement for a section of coast to be commercially reopened, and a limit reference point (LRP), which is set at 50% of B0 (virgin biomass). But for LRPs to be useful, stocks must be assessed multiple times to observe stock changes over time. In the BC sea cucumber fishery, the time, money, and effort to do so is generally prohibitive, so reference points are considered of limited use (DFO 2015). As an alternative, Commercial No-Take Reserves (CNTRs) are employed to ensure that areas of the coast remain closed to harvesting, and these act as additional insurance against uncertainties in stock assessment and management. It is expected that CNTRs provide spillover of sea cucumber adults and larvae—sometimes to distant areas, given the species' long larval period of 2 to 4 months (DFO 2015)—as well as providing opportunities for research. There are currently 20 }CNTRs, making up approximately 3.2% (930 km) of the BC coast (DFO 2015). Furthermore, only half of the BC coast is open for commercial harvest, which leaves half of BC's coastline as a natural sea cucumber reserve.

Although such a selective fishery runs the risk of localized depletion as a result of concentrated effort, stocks are considered generally healthy. And, repeated surveying of areas fished in Phase 1 shows no signs of detrimental effects on stocks from annual harvesting, indicating that management of the fishery is being implemented successfully (DFO 2015). The management strategy has attempted to minimize such risks by reducing the size of QMAs, as needed, to spread fishing effort, and the adaptive nature of the plan allows for a review of the size of, and the harvest rate applied to, each QMA prior to each season.

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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Highly Effective

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

Annual stock assessments using biomass surveys and harvest data inform the management process; however, the biomass assessments are resource-limited and only cover selected areas each year. Scientific research and monitoring therefore receives a "moderately effective" score.

Justification:

DFO conducts annual stock assessments to inform the management process. All scientific advice for the fishery is peer-reviewed primarily through a committee called the Centre for Science Advice—Pacific (CSAP) (DFO 2015). The assessment utilizes both annual biomass surveys conducted for selected PFMA subareas (which measure *P. californicus* density) and harvest data from logbooks. Rigorous data collection began in 1995. Repeated surveys were conducted in six locations open to commercial harvest from 1999 to 2007. Survey data collection using Experimental Fishing Areas (EFAs) began in 1997 (Phase 1) and is ongoing. The EFA data have directly informed the current management regime, helping to set baseline densities and sustainable harvest rates ((Duprey et al. 2011), (Duprey & Stanton 2015), (DFO 2015)).

Because of the geographic range of the fishery and resource pressures on the DFO, biomass surveys are only conducted for selected subareas each year, resulting in snapshots of abundance, rather than time-series trends. Even though all available data are included in scientific monitoring, surveys do not comprehensively cover all fishing grounds. Independent observer coverage is limited to dockside monitoring; however, this is largely appropriate for the scale of the fishery ((Purcell 2010), (DFO 2015)).

The PSCHA collaborates with the DFO and First Nations to conduct additional research into sea cucumber growth, recruitment, settlement, and mortality. Investigations also are ongoing into the effectiveness of CNTRs while the EFAs from Phase 1 are still in use.

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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Moderately Effective

The fishery relies on vessel hailing and dockside observers to monitor effort and landings. Although there are no apparent major compliance concerns, enforcement is opportunistic due to resource limitations. Known infractions include vessels not giving adequate hail notification in 2010, 2011, and 2017, which may result in quota overages (DFO 2018). Additionally, illegal fishing activity has increased in recent years as the value of this species has increased (DFO 2018). Although there are some monitoring efforts in place, the effectiveness of these efforts is uncertain.

Justification:

The fishery extends across the entire province, but there are only 85 licenses spread across 32 vessels (in 2015), meaning that the scale of effort in the fishery is relatively small. Rather than using vessel monitoring systems (VMS) to monitor effort, license holders are required to hail prior to leaving the dock and indicate which harvest area they intend to fish. Onboard monitoring (such as cameras and observers) is not used; instead, harvesters must have all catches weighed and logbooks checked by DFO-certified observers at the dockside when landing. The observers are independent third parties, funded by the industry ((Purcell 2010), (DFO 2015)).

Enforcement by DFO is tempered by commitments to higher priority issues, such as species at risk and fisheries with conservation issues, so inspections, patrols, and investigations of violations are opportunistic. Some monitoring of fishing practices by fisheries officers on dive patrols, as well as air surveillance, occurs when resources allow. Capacity to control the fishery is largely appropriate to its small scale and, though violation detection often relies on user reporting, DFO (DFO 2015) considers compliance to be good.

Quota overages vary from year to year (Fig. 2), but overall overages are low and generally only 1% to 2% of the TAC. An overage below 500 lbs. on one license may be transferred to another license, but any overage that is not transferred is considered a Non-Transferable Overage (NTO). Zero NTOs are permitted and the DFO will pursue enforcement action if the amount of NTOs becomes an issue (DFO 2015).

Factor 3.5 - Stakeholder Inclusion

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

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Moderately Effective

Most relevant stakeholder groups are included in the management process. A Sea Cucumber Research Subcommittee and a Sea Cucumber Sectoral Committee both meet once a year to discuss initiatives for upcoming research and stock assessments, and for post-season review and pre-season planning, respectively. Both groups include representatives from DFO, First Nations, and the Pacific Sea Cucumber Harvesters Association (PSCHA), and the sectoral committee meeting also includes the independent dockside monitoring contractor. However, fishermen are not typically represented on the sectoral committee, many mistrust the management process, and a majority of harvesters who were interviewed believe that the PSCHA "primarily represents the interest of licence holders, of which few are harvesters, and license holder priorities often conflict with those of harvesters" (O'Regan 2015). Although the management process is transparent and includes stakeholder input, not all user groups are effectively considered. Therefore, stakeholder inclusion records a score of “moderately effective.”

Justification:

These groups provide a mechanism for transparent decisions based on a constructive relationship between managers, scientists, and industry members, as well as a forum to address user conflicts, but many fishermen feel left out of the process. High participation is encouraged in both the assessment and management process. For example, in 2014 and 2015, DFO Fisheries Management included questionnaires with harvest logbooks to allow harvesters to include comments on any QMAs they harvested, and 6% of the shoreline in one First Nation's claimed traditional territory was set aside as Commercial No-Take Reserves (CNTRs) in 2014. The locations of CNTRs were based on advice from DFO Science, First Nations, and the PSCHA (DFO 2015).

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
British Columbia/Northeast Pacific | Diving Canada	5	0	Moderate Concern	Green (3.873)

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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5

There is no impact on the habitat substrate, so this criterion scores 5.

Justification:

The sea cucumber dive fishery in British Columbia involves divers fishing by hand from a boat. Sea cucumbers are selected individually by hand and placed in a mesh bag that is lifted to the surface. The gear does not touch the bottom and boats donot anchor while fishing ((DFO 2015), pers. comm., E. Wylie 2016).

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

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0

N/A

Factor 4.3 - Ecosystem-Based Fisheries Management

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Moderate Concern

A precautionary approach is followed and spatial management is used. Additionally, Commercial No-Take Reserves (CNTRs) are created through the management plan. Only approximately 50% of the BC coastline is open for commercial harvest, so this performs a similar role in preventing the fishing of sea cucumbers in certain areas. Although none of these make specific reference to the particular ecological role of sea cucumbers, detrimental food- web impacts are highly unlikely, so we deem this criterion to have a "moderate" conservation concern and a score of 3.

Justification:

Although poorly understood, the primary ecosystem function of sea cucumbers is nutrient recycling (DFO 2015). Some species bury themselves in sediment and are thought to help oxygenate upper sediment layers and play a role in bioturbation, while species such as *P. californicus* that live on harder reefs mop up organic matter and recycle detritus (Purcell 2010).

At a national level, DFO implements the *Sustainable Fisheries Framework*, which contains conservation policies designed to incorporate an ecosystem-based and precautionary approach. These are incorporated into all new Integrated Fisheries Management Plan (IFMP) templates (DFO 2015). Additionally, spatial planning for various types of marine protected areas (MPAs) to protect ecosystem functioning exists under national policies in the Oceans Act (1996, c. 13), the Canada National Marine Conservations Areas Act (2002, c. 18) and the Canada Wildlife Act (R.S.C., 1985, c. W-9). Within the current IFMP for sea cucumbers, CNTRs have been established over areas totaling approximately 3.2% of the BC coastal shoreline, and these function similarly to MPAs by preventing the fishing of sea cucumbers and by allowing spillover of adults and larvae along the coast. The approximately 50% of the BC coast that is not currently open for commercial harvest and the cucumber habitat beyond harvestable depth by divers (≈20–250 m) also provide informal refuges ((Duprey et al. 2010), (DFO 2015), (DFO 2016)).

Although there are no policies in place to protect the specific ecosystem function of *P. californicus* in BC, given the lack of predators and the precautionary management of the fishery, it is unlikely that detrimental food web impacts will occur.

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 BC Sea Cucumber Report

Updates to the January 9, 2017 British Columbia Sea Cucumber report were made on April 14, 2020:

Overall Recommendations for giant sea cucumber caught by diving in British Columbia remain unchanged, but individual criterion updates are outlined below.

Updates included:

- C3.4 (Enforcement) downgraded from "Highly" Effective to "Moderately" Effective because there has been violations of management measures in recent years, suggesting an uncertain effectiveness of current monitoring efforts.
- C3.5 (Stakeholder Inclusion) downgraded from "Highly" Effective to "Moderately" Effective because not all user groups are effectively considered.

Appendix B: Review Schedule

There are annual updates to the IFMP, detailing changes to openings or QMAs. Additionally, 2016 is the last year of the second 3-year management rotational cycle, therefore, there may be some changes in 2017.

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