Monterey Bay Aquarium
Seafood Watch

Draft Assessment for Review
November 2024

Kelp, Bull and Giant (British Columbia, Canada)

Nereocystis luetkeana, Macrocystis pyrifera

Pacific, Northeast

Hand implements

Report ID 28332

Seafood Watch Standard used in this assessment: Fisheries Standard v4

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About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the environmental 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. 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.

Seafood Watch's science-based ratings are available at www.SeafoodWatch.org. Each rating is supported by a Seafood Watch assessment, in which the fishery or aquaculture operation is evaluated using the Seafood Watch standard.

Seafood Watch standards are built on our guiding principles, which outline the necessary environmental sustainability elements for fisheries and aquaculture operations. The guiding principles differ across standards, reflecting the different impacts of fisheries and aquaculture.

- Seafood rated Best Choice comes from sources that operate in a manner that's consistent with our guiding principles. The seafood is caught or farmed in ways that cause little or no harm to other wildlife or the environment.

- Seafood rated Good Alternative comes from sources that align with most of our guiding principles. However, one issue needs substantial improvement, or there's significant uncertainty about the impacts on wildlife or the environment.

- Seafood rated Avoid comes from sources that don't align with our guiding principles. The seafood is caught or farmed in ways that have a high risk of causing harm to wildlife or the environment. There's a critical conservation concern or many issues need substantial improvement.

Each assessment follows an eight-step process, which prioritizes rigor, impartiality, transparency and accessibility. They are conducted by Seafood Watch scientists, in collaboration with scientific, government, industry and conservation experts and are open for public comment prior to publication. Conditions in wild capture fisheries and aquaculture operations can change over time; as such assessments and ratings are updated regularly to reflect current practice.

More information on Seafood Watch guiding principles, standards, assessments and ratings are available at www.SeafoodWatch.org.

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, Seafood Watch develops an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guides and online guide:

Best Choice/Green: Buy first; they're well managed and caught or farmed responsibly.

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

Avoid/Red: Take a pass on these for now; they're caught or farmed 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 kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis leutkeana*) fisheries in British Columbia, Canada. Harvesting occurs along the entire coast and is by hand, using a cutting tool to trim fronds and blades.

Both species of kelp form expansive beds with floating canopies along the coastline, known as kelp forests, which are among the most productive ecosystems in the world. *Macrocystis* is the largest marine plant capable of growing 30 cm/day in peak season and up to 45-60cm/day in peak growing conditions (pers. Comms. Ocean Wise Seaforestation Team, 2024). In British Columbia it is found in depths of up to 10 m. *Nereocystis* is found as deep as 20 m and extends a single stipe towards the surface ending in a float, from which 30-60 blades can grow, reaching up to 4 m. Both species are affected by the dynamic environment of the BC coast; *Macrocystis*, which lives 4-8 years in other parts of the world, rarely lives beyond 1-2 years, while *Nereocystis* has an effectively annual life cycle, with most of its population decimated each winter by storms.

Harvesting of kelp in BC has been ongoing since the mid-20th century and commercial operations occur along the BC coastline.. Management of the fishery is the responsibility of the provincial ministry of Water, Land and Resource Stewardship, who manage all aquatic plant harvesting in the province including issuing individual annual licenses to harvest kelp in one or more of Fisheries and Oceans Canada's (DFO) Pacific Fisheries Management Area (PFMA) sub-areas. Applicants request a harvest quota for one or both of the species, which is assessed by the Ministry on a case-by-case basis, based on historical inventories. There were 32 license applications in 2017, requesting a total of 900 t. *Macrocystis* is used in the herring spawn-on-kelp (SOK) fishery, while other products of both species include dried edibles, fertilizer and cosmetics.

The effects of harvesting on *Macrocystis* and *Nereocystis* communities in BC is not well understood. *Nereocystis* specifically has received limited study and there are concerns that it is more vulnerable due to an inability to re-grow after damage to its stipe and the possible reduction of reproductive potential when blades are removed. Bull Kelp is harvested by many First Nations communities as its serves various functions. Most commonly, bull kelp is eaten fresh, dried, or pickled, while the stipes and floats are useful for weaving materials and as floats, lines, or containers (MaPP 2023) .

Abundance in BC is a moderate concern; although inventories conducted by the provincial government identified large potential yields for both *Macrocystis* and *Nereocystis*, they were conducted many years ago, between 1967 and 2007, and with limited updated information available current stock status is unknown. Mortality is a low concern as license conditions do not allow cutting that would result in death of the plant. Fronds or blades must only be trimmed, and harvest is limited to targeting only 20% of the kelp plants in the bed. Although there may be some mortality from recreational harvesting, the impact is likely to be negligible due to the high natural mortality that already occurs in the dynamic environment. There is no concern for impact on other species as incidental capture is mitigated due hand-harvesting methods.

Management is precautionary, assessing license applications individually and employing license conditions that restrict harvesters to a conservative harvest rate and a harvest method that limits impacts to the plant. Inventories have not been updated for more than 20 years and, although there are proposals to conduct new stock assessments in collaboration with First Nations in coming years, there is no post-harvest analysis of fishery impacts. Stakeholder consultation with First Nations in whose territory the activity is occurring is a

legislated requirement from the province and is undertaken for every license. First Nations engagement is supported in the Northern Shelf Bioregion by the Marine Plan Partnership for the North Pacific Coast (MaPP) Regional Kelp Monitoring Program.. At more regional and local levels, efforts to encourage kelp forest growth has included re-introduction of sea-otters and/or sea-urchin removal, both strategies that intend to slow the loss of kelp via urchin predation (Hamilton et al. 2022). Some of these strategies have been developed alongside First Nations communities in order to target the needs of their local environments, such as the need for healthy kelp forests along the coast of Gwaii Haanas National Park, where the Haida Nation has implemented an urchin cull experimental program to preserve habitat for significant rockfish and abalone species (Hamilton et al. 2022) .

No ecosystem assessments have been conducted, nor is there any robust spatial management currently employed with specific regard for either species. Although both *Macrocystis* and *Nereocystis* are foundational species in kelp forest ecosystems, important as food and shelter, studies have shown that small-scale harvesting of kelp canopy has minimal impact on other kelp forest species compared to natural dynamics. Therefore, it is unlikely negative ecosystem effects will occur as a result of small-scale harvest activities compared to natural dynamics, and it is unlikely negative ecosystem effects will occur for either species as a result of current level of harvest activities.

As a result of these findings, harvest of both bull and giant kelp is rated green.

Final Seafood Recommendations

SPECIES | FISHERY	C 1 TARGET SPECIES	C 2 OTHER SPECIES	C 3 MANAGEMENT	C 4 HABITAT	OVERALL	VOLUME (MT) YEAR
Bull kelp | Northeast Pacific | Canada | British Columbia | Hand implements	3.413	5.000	3.000	3.873	**Best Choice (3.752)**	Unknown
Giant kelp | Northeast Pacific | Canada | British Columbia | Hand implements	3.413	5.000	3.000	3.873	**Best Choice (3.752)**	Unknown

Summary

Both bull kelp and giant kelp harvested in British Columbia using hand implements are rated green based on the species' low vulnerability and unknown density, minimal impact on other species, moderately effective management, and minimal concerns regarding impacts to the ecosystem.

Scoring Guide

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

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

Best Choice/Green = Final Score >3.2, and no Red Criteria, and no Critical scores

Good Alternative/Yellow = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern[2], and no more than one Red Criterion, and no Critical scores

Avoid/Red = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

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

Introduction

Scope of the analysis and ensuing recommendation

This report assesses the sustainability of harvesting two kelp species, giant kelp (*Macrocystis pyrifera spp.*) and bull kelp (*Nereocystis luetkeana*), along the entire coast of British Columbia, Canada. The recommendation covers harvesting by hand, using a cutting implement to trim fronds and blades.

Species Overview

The two largest marine plants, *Macrocystis* and *Nereocystis* are brown algae in the order Laminariales. These species are often known as "floating", or "canopy" kelps because, although they anchor to rock or gravel on the seafloor through their holdfast, much of their stipe and blades float at the surface, forming a dense canopy (Wheeler 1990)(Steneck et al. 2002). Both species tend to grow in expansive kelp beds or forests along the coastline, often together in mixed assemblages, forming one of the most productive ecosystems in the world (Wheeler 1990) (Lucas et al. 2007). In British Columbia kelp forests are extremely dynamic ecosystems heavily impacted by environmental conditions. *Nereocystis* is an annual plant that dies each fall, while *Macrocystis*, which can typically live 4-8 years (North 1987), generally only survives 1-2 years on the BC coast (Druehl and Wheeler 1986).

Both *Macrocystis* and *Nereocystis* are vulnerable to grazing by variety of herbivores, including sea urchins, fish, crustaceans and molluscs. Sea urchin grazing is a particularly powerful driver; when urchin predators such as sea otters are absent they have the ability to clear-cut whole kelp forests leaving "barrens" in their place (North 1987)(Tegner and Dayton 2000)(Steneck et al. 2002). A 23-year study along the west coast of Vancouver Island found a highly predictable relationship between sea otters and the rocky reef community phase state. When sea otters are present, algae dominate and urchins are rare, with the opposite true if otters are continuously absent (Watson and Estes 2011). Kelp ecosystems, are strengthened when there is top-down control on urchins, reinforcing the resilience of kelp forests and reducing persistence of urchin barrens (Burt et al. 2018).

Macrocystis

Macrocystis has a broad geographic range with a high degree of variability in physiology and life history, depending on its local environment (Graham et al. 2007). In the northern hemisphere, it is distributed along the Pacific coast of North America and, in the southern hemisphere, it is found around every continent except Antarctica (North 1987)(Guiry 2017). Though maximum depth can be as much as 55 m in southern Argentina, *Macrocystis* in British Columbia occurs only in depths up to 10 m and in areas with low seasonal variations in temperature or salinity (Druehl 1978) (Graham et al. 2007). Fronds grow out of the holdfast and are buoyed by gas-filled pneumatocysts that join blades to the frond, allowing a canopy to form when they reach the surface, with the largest plants having 40-60 fronds (North 1987)(Graham et al. 2007). Growth occurs through the apical meristem at the frond tip which is removed if cut, preventing re- growth (Figure 1); however, the plant can recover through the growth of new fronds from the holdfast to form a new surface canopy (North 1987). Production is high, with growth shown to reach 30cm/day during the peak growing season {Krumhansl *et al.* 2017). Although considered a perennial plant that usually lives 4-8 years (Druehl and Wheeler 1986) (Wheeler 1990) (Guiry 2017), the dynamic coastal environment of BC means that few plants live more than two years (Druehl and Wheeler 1986).

Adult *Macrocystis* plants (known as sporophytes) mature between 6 and 12 months old, growing reproductive

blades (sporophylls) near the base of the frond just above the holdfast (Figure 2) (Wheeler 1990). Sporophylls can number more than 100 on an individual plant and are extremely fecund, producing spores year-round (North 1987)(Wheeler 1990)(Graham et al. 2007). The zoospores contain a single set of chromosomes, which disperse and form microscopic male and female plants if they successfully settle. Provided they settle close enough together, the male plants will fertilize the female and a new sporophyte will grow from the female plant (Wheeler 1990). Fertilization requires the settled zoospores to be within a few millimetres of each other, so dispersal is typically spatially limited to within a few hundred meters from the kelp bed (North 1987). Nonetheless, detached sporophytes can remain reproductively viable for over 125 days as they drift, which aids long-distance colonization (Graham et al. 2007). Recruitment in BC kelp forests is continuous, with recruits making up 20- 80% of the population (Druehl and Wheeler 1986).

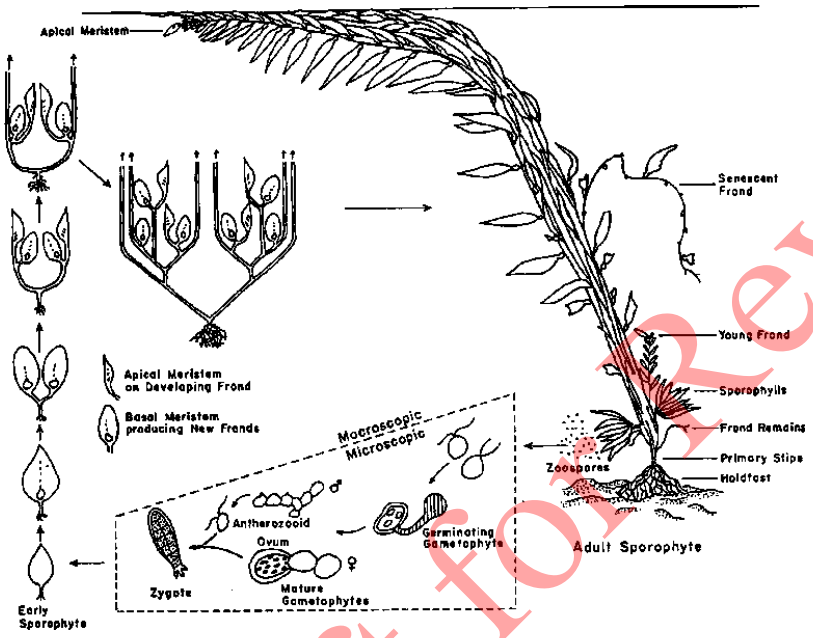

Figure 1. *Macrocystis* growth (North 1987).

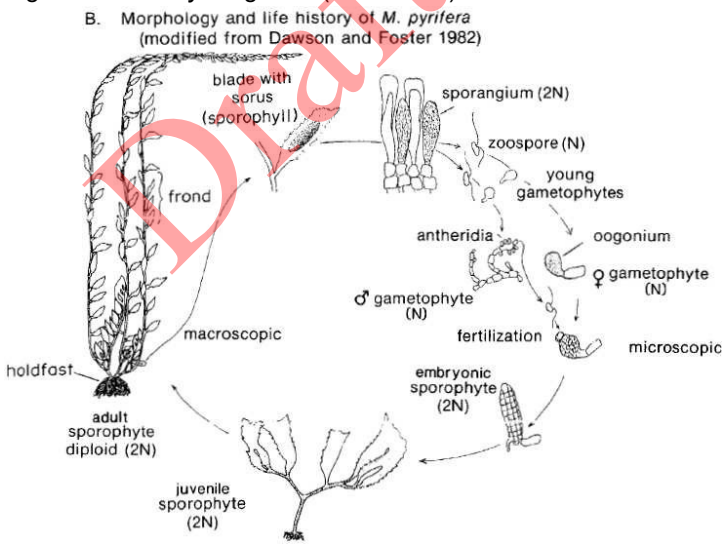

Figure 2. The morphology and life history of kelp, using *Macrocystis* as an example (Foster and Schiel 1985).

Nereocystis

Nereocystis is distributed from Unmak Island, Alaska, to Point Conception, California and is found in rocky habitat 3 to 20 m deep, in areas of high water movement {Vadas, R.L. 1972}(Wheeler 1990)(Carney et al. 2005) (Springer et al. 2010). Also known as bull kelp, this is the only species of kelp in the Salish sea that forms canopies (Dobkowski and Crofts 2021). The sporophyte grows a bladeless stipe from the holdfast, ending in a surface float from which tens of blades ultimately grow (Figure 3) (Wheeler 1990) . Bull kelp have an annual growing season starting in January and February, and grow more quickly throughout the year as they move away from a more proportional juvenile growth phase at a maxium rate of 14cm per day (Dobkowski and Crofts 2021) (British Columbia Marine Conservation Analysis 2013). However, by October and November, most of the adult plants are lost as the stipe breaks under the force of winter storms, resulting in the eventual destruction of the bed (Foreman, R.E 1984) (Wheeler 1990) (Springer et al. 2010) (Foreman, R.E 1984) (Wheeler 1990) (Springer et al. 2010). Unlike *Macrocystis,* the *Nereocystis* plant has a single pneumatocyst attached to the end of a long slim stipe, which holds several blades near the surface of the water (Springer et al. 2007). An adult sporophyte may hold 30-60 blades, which grow up to 4 m long (Springer et al. 2010).

Reproduction occurs through the broadcasting of spores (Figure 2), which are produced in visible dark patches on the blades, called sori, peaking in September and early October (Foreman, R.E 1984). *Nereocystis* is one of the most reproductively productive species in the world, producing approximately 3.7 x 10^{12} spores per plant in a single season (Scagel 1961) (Joska and Bolton 1987).

Figure 3. *Nereocystis*. Close up of pneumatocyst (left) and whole plant (right) (Smith 1944).

Kelp in BC

Between 1967 and 2007, the BC provincial government conducted a series of inventories of kelp beds (specifically for *Macrocystis* and *Nereocystis*) in British Columbia with potential for commercial harvest (Figure 4). These were created using a method known as KIM-I (Kelp Inventory Method-I) developed by

Foreman (Foreman, R.E 1984) that uses aerial infra-red photographs to determine surface cover combined with ground-truthed data from surveys (Wheeler 1990).

Resource limitations restricted the number of surveys, with only thirteen taking place over thirty years (Figure 4) and most places only surveyed once (Lucas et al. 2007). However, wherever repeat surveys have given the opportunity to observe changes over time, differences in both species composition and stock biomass have been noted (Field, E.J. and Clark, E.A.C. 1978) (Sutherland 1990) (Sutherland 1998) (Sutherland 1999) (Sutherland et al. 2008). The provincial government supports kelp monitoring in collaboration with First Nations Partners through the Marine Plan Partnership for the North Pacific Coast (MaPP) Regional Kelp Monitoring Program, which began in 2018. "This regionally-coordinated program utilizes existing institutions, such as First Nations Guardian Watchmen programs, to conduct a tiered program of information gathering using different survey types, including drone, kayak, and SCUBA surveys, to collect kelp forest data based on the needs and logistic capacity in each area" (Hamilton et al. 2022). In 2022 the government of BC began investing in the monitoring and sustainability of wild giant kelp harvest on Haida Gwaii using various data collection methods (sensors, digital imagery, remote operated vehicles, etc.) to gather environmental data and evaluate stressors on kelp forests (DFO 2022).

Several local-scale monitoring programs of kelp beds have also been conducted by other institutions around the coast, which have also tracked changes in abundance over time, including in the Georgia Strait, where a loss of *Nereocystis* in the central Strait region (Lamb et al. 2011) and the west coast of Vancouver Island (Watson and Estes 2011) was noted. Specific reasons for the changes over time are largely unknown, although environmental factors in dynamic systems can have a significant effect (Sutherland et al. 2008). A strong link between the presence of sea otters and an algae dominated community have been demonstrated on the west coast of Vancouver Island, as otters prey on urchin (Watson and Estes 2011). Sea temperature changes, as well as *El Nino,* have been suggested as possible reasons for changes in *Nereocystis* extent (Sutherland 1990) (Lucas et al. 2007) (Heath et al. 2015). Preliminary genetic studies have suggested that *Nereocystis* along the Pacific coast belong to 4 "clusters". Current speed, temperature, and substrate type have been shown to have impact on kelp canopy resilience and growth where studies have found that colder, more exposed areas were favorable for growth, whereas periods of intense warming like the 2014–2019 marine heatwave, caused considerable decline in some parts of BC (Starko et al. 2022)(Starko et al. 2024) (Mora-Soto et al. 2024). This means that while kelp have shown resilience to warming, and are among the most abundant coastal marine habitats, they are vulnerable to climate change, and may require targeted conservation efforts in the future (Starko et al. 2024).

Nereocystis in the Georgia Strait and Puget Sound, where kelp bed declines have also been observed (Mumford, T.F. 2007)(Schroeder et al. 2020), are part of the same "cluster" which have fewer alleles. Potentially, this cluster is less adaptive to environmental changes, such as temperature or pollution, than populations in other clusters like those in the Juan de Fuca Strait, where kelp canopy area has increased over time (Berry et al. 2005).

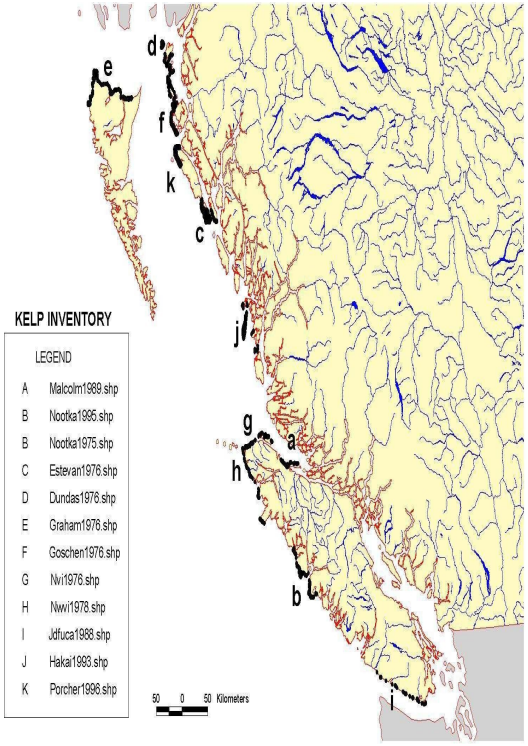

Figure 4. Map of kelp bed inventories in British Columbia, 1976-1996. The legend indicates survey year. A 2007 inventory is not shown, but took place in the same area as the 'j' survey (Sutherland et al. 2008).

History of the fishery and its management

Historically, kelps have been harvested primarily for their alginates, components that have a variety of industrial uses, including food processing, fertilizer, and construction (Scagel 1961) (Lewis 1985) (Wheeler 1990). While a significant industry developed in some parts of the world, for example California for *Macrocystis*, several attempts to harvest on an industrial scale in British Columbia have failed. The first project was initiated in 1946 and activities peaked in the late 1960s and early 1970s with 44 harvesting licenses held by 6 companies for the BC coast (Wheeler 1990) (Malloch 2000). However, these occasions, as well as initiatives in the 1980s, either failed to launch completely or only operated briefly due to a combination of financial and political complications (Malloch 2000). Since then, harvesting has been confined to small-scale operations that mostly yield less than 100 mt annually (Malloch 2000). A large portion of the kelp harvested in BC is *Macrocystis*, and much of it is gathered specifically by the herring spawn on kelp (SOK) fishery. This fishery involves either attaching kelp fronds to ropes and introducing them to herring that have been captured and contained in a pond, or depositing the fronds in wild spawning areas. The fish lay eggs on the fronds and those in ponds are then released unharmed, with the herring roe gathered together with the kelp and brined before being shipped to market (Malloch 2000). Other small-scale operations harvest both *Macrocystis* and *Nereocystis* and dry them for consumption or process them into cosmetics and fertilizers, or as feed in mariculture (Valdez et al. 2003) (Springer et al. 2007).

Until 2017, management of the kelp fishery in British Columbia has been the remit of the Ministry of Agriculture. However, after a provincial strategic review in light of the *Fish and Seafood Act* (Fish and

Seafood Act 2022), it was determined that management of aquatic plants better fit the mandate of the Ministry of Forests, Lands and Natural Resource Operations and recently responsibility was transferred to the Ministry of Water, Land and Resource Stewardship. There is currently no specific management plan for kelp harvesting in British Columbia.

Kelp harvesting licenses are awarded every year between February and June for particular areas of the coast based on applications received the previous year depending on a number of factors such as technical review and consultation. Harvest areas are defined by the management areas within Fisheries and Oceans Canada (DFO) Pacific Fishery Management Areas (PFMAs) and may be modified based on a number of factors including from First Nations consultation. There are 555 sub-areas that contain shoreline and possible kelp habitat (DFO 2007) although many of these areas may be without kelp, such as those in the Georgia Strait (DFO 2017).

Harvesters request quotas for one or more sub-areas and the applications are assessed on a case-by-case basis by the Ministry. In 2017, there were a total 32 applications for *Macrocystis* and *Nereocystis* harvesting (Table 1). Harvesters who use *Macrocystis* for the SOK fishery also need a separate fishing license, issued by Fisheries and Oceans Canada (DFO), known as a J-License. *Macrocystis* and *Nereocystis* license conditions require that all kelp harvesting be done by hand with a cutting tool. Additionally, the kelps must only be trimmed; removal of the holdfast is prohibited (Fish and Seafood Act 2022).

Recreational fishing of kelp is unlicensed and the extent is unknown. In BC, harvesting less than 100 kg (wet weight) of kelp for personal use does not require a wild aquatic plant licence and must be carried out in accordance with license conditions (Fish and Seafood Act 2022). However, as both species are subtidal (Lucas et al. 2007), they are hard to access without boats and opportunistic harvesters may be disincentivized. Therefore, recreational harvests are likely to be highly localized and a minor component of the fishery.

Table 1

Species	Number of Applications	Quota Requested (MT)
Nereocystis luetkeana	6	45
Macrocystis pyrifera	20	836
Both species	6	22.5
Total	32	903.5

Table 1. Applications in 2017 for *Macrocystis* and *Nereocystis* harvest. Note: 700mt of the *Macrocystis* quota requested was from a single application (MFLNRO unpublished data).

Production Statistics

Production increased 43% between 2014 and 2016, from 281 mt to 400 mt, respectively (Table 2). The 2016 harvest represents almost double the production from the early 2000s, which totaled approximately 200 mt per year (Figure 5). Actual harvest did not meet the quota requested in any year between 2014 and 2016.

Table 2

Year	Approved quota (mt)	Actual harvest (mt)
2016	676	402.75
2015	649	329
2014	887	281

Table 2. Combined Macrocystis and Nereocystis harvest in British Columbia. Source: MFLNRO (unpublished data).

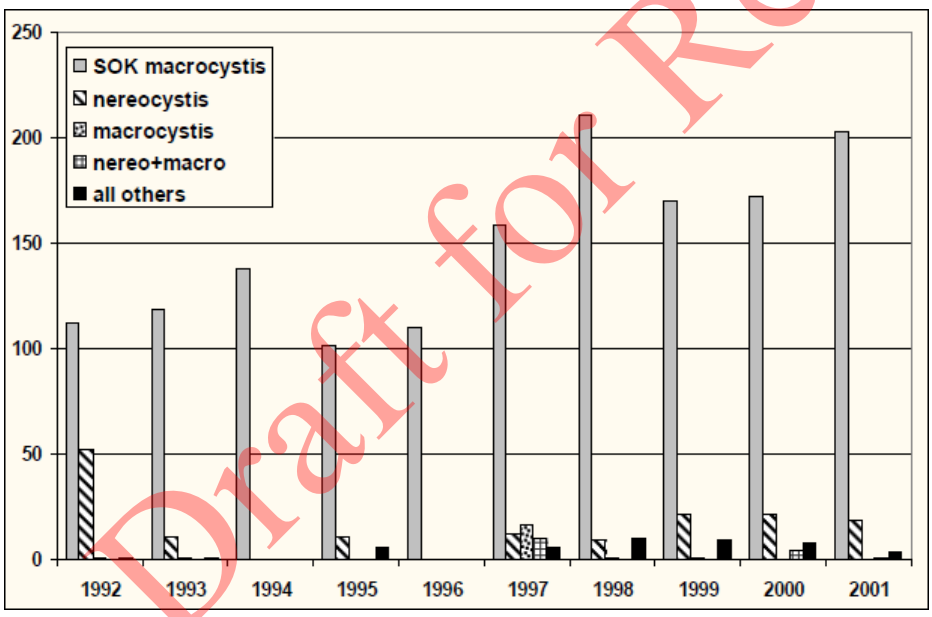

Figure 5. Kelp harvest (mt) in British Columbia 1992-2001 (Lucas et al. 2007).

Importance to the US/North American market.

No data is available for small-scale kelp harvesting operations in terms of trade; their product is largely sold directly online or in local markets (A. Swinimer personal communications 2024). *Macrocystis* used in the SOK fishery is almost entirely exported to Japan with virtually all processing done on arrival; only about 2% is consumed in North American Japanese restaurants (Edwin Blewett & Associates Inc 2001). The addition of herring spawn to kelp increases the value of both the roe and the kelp significantly (Malloch 2000) (Edwin

Blewett & Associates Inc 2001) however, weak demand in Japan has seen both landings and the landed value decline in recent years (Nelson, S. 2014), dropping from $29-44/kg in 2013 to $15-26/kg in 2016.

Common and market names.

Until recently, the *Macrocystis* genus was thought to contain four species due to their morphological differences; however, molecular analyses conducted in the 2000s suggested that the genus should only contain one: *M. pyrifera* (Demes et al. 2009)(Macaya and Zuccarello 2010). Although most historical literature refers to giant kelp in BC in its *M. integrifolia* form, this report follows the current scientific consensus and recognises *M. pyrifera* (formerly *integrifolia*) as the giant kelp species in BC, referring to the algae as *Macrocystis* throughout {Lindstrom 2023}. More recently, it has been recommended that all north-eastern Pacific specimens north of Point Conception, California, previously recognized as *M. integrifolia* and *M. pyrifera*, now be called *M. tenuifolia* (Sandra C. Lindstrom 2023). However, this is pending further molecular work and is not widely implemented at the time of this assessment. Likewise, as the only species in the genus, *N. luetkeana* is referred to as *Nereocystis*.

Other common names:

***Macrocystis pyrifera*:** Giant kelp (Scagel 1961), bladder kelp (NZMPI 2017).

Nereocystis luetkeana: Bull kelp, ribbon kelp, bull whip kelp, sea whip, bladder kelp (Guiry 2017).

Primary product forms

Both kelp species are primarily sold directly to chefs or individuals online or through local markets. Wild harvested kelp is most often sold fresh (whole), dried, pickled, or flaked.

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

BULL KELP			
REGION / METHOD	ABUNDANCE	FISHING MORTALITY	SCORE
Northeast Pacific | Canada | British Columbia | Hand implements	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

GIANT KELP			
REGION / METHOD	ABUNDANCE	FISHING MORTALITY	SCORE
Northeast Pacific | Canada | British Columbia | Hand implements	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

Key relevant information:

Stock assessments for kelp have been undertaken by the provincial government intermittently across British Columbia since 1967; however, most beds have only been surveyed once (Lucas et al. 2007). The most recent survey was in 2007. Other monitoring studies have indicated that kelp beds exhibit high variation in abundance over time (Berry et al. 2005) (Watson and Estes 2011). Due to the lack of stock assessment for both kelp species, a product-susceptibility analysis (PSA) was conducted and determined both *Macrocystis*

and *Nereocystis* to be of low vulnerability.

Recent studies on kelp throughout BC suggests that while canopy kelp forests have experienced variable patterns of change across coastal BC, with some areas experiencing persistence or even increases in canopy kelp, there have also been recent and substantial declines in some focal areas. The concurrent evidence of declines suggests that kelp forest ecosystems in several parts of BC may be threatened, which warrants conservation concern. This, combined with the fact that actual abundance for both species is unknown due to stock assessments being more than 10 years old, means abundance is a moderate concern.

Criterion 1 Assessments

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.*

Bull kelp (Nereocystis luetkeana)

Factor 1.1 - Abundance

Northeast Pacific | Canada | British Columbia | Hand implements

Moderate Concern

Nereocystis

Nereocystis has diminished from the Strait of Georgia and Puget Sound over the last two decades {Mumford 2007} (Lamb et al. 2011) and while there is evidence of bull kelp decline from 2005-2017 the impacts on total population growth is unknown and more evidence is required to distinguish trends from natural variability (Schroeder et al. 2020). Due to the unknown status of Bull kelp beds throughout BC and the use of a PSA, abundance received a moderate concern.

Justification:

Productivity Scores for Bull kelp (*Nereocystic luetkeana*)

Table 3

Productivity Attribute	**Relevant Information**	**Score (1 = low risk, 2 = medium risk, 3 = high risk)**
Average age at maturity	One year. Nereocystis is an annual plant (Wheeler 1990)	1
Average maximum age	As an annual, *Nereocystis* dies at the end of each season.	1
Fecundity	The most fecund kelp species. Produces 3.7 x 10^{12} spores per plant, three orders of magnitude larger than other kelps, except *Macrocystis* (Scagel 1961) (Joska and Bolton 1987)	1
Reproductive strategy	Broadcast spawner (Wheeler 1990) .	1
Trophic level	Kelps are a foundational species, photosynthesizing to produce energy at the base of food webs.	1
Productivity score		1

Susceptibility scores for Bull kelp (*Nereocystis luetkeana*)

Table 4

Susceptibility Attribute	**Relevant Information**	**Score (1 = low risk, 2 = medium risk, 3 = high risk)**

Areal overlap (Considers all fisheries)	Plant harvest is limited to 20% of the available biomass (Ministry of Agriculture 2017) . However, harvest intensity along the coast is so low on an entire-coast scale, that the vast majority (>90%) of the species. Other harvesting in the habitat, such as urchin fishing, is unlikely to have direct impact on the kelp bed or individual plant.	1
Vertical overlap (Considers all fisheries)	Although harvesting only targets the part of the plant at the surface, representing a small part of the depth range, this is where the primary productivity and reproductive areas are (Springer et al. 2010) , therefore putting *Nereocystis* at high risk.	3
Seasonal availability	Plants are harvested in a manner that allows regrowth throughout the season, where only 5-10% of the total seasonal production is harvested (Wheeler 1990) . However, seasonal trends in the fishery are unknown.	3
Selectivity of fishery (Specific to fishery under assessment)	Fishery is highly selective, targeting *Nereocystis* individually.	3
Post-capture mortality (Specific to fishery under assessment)	Properly harvested, blades are trimmed so that mortality does not occur (Ministry of Agriculture 2017) .	1
Susceptibility score		2.200

Inherent Vulnerability: 2.417 - Low Vulnerability

Factor 1.2 - Fishing Mortality

Northeast Pacific | Canada | British Columbia | Hand implements

Low Concern

Neither *Macrocystis* nor *Nereocystis* suffer mortality when harvested according to BC license regulations. Instead, harvesters cut the blades or stipe at limited lengths or depths, allowing for regrowth across the season (Wheeler 1990) (Ministry of Agriculture 2017) . Although the extent of recreational fishing is unknown and may involve mortality due to incorrect harvesting techniques, the impact is likely to be negligible relative to the high natural mortality in a dynamic environment. Therefore, it is highly likely that mortality from all sources is at a sustainable level and this criterion is low concern.

Justification:

Kelp harvesting performed in accordance with the license conditions does not result in mortality of the algae. Instead, in the case of Macrocystis only 25% of fronds are removed or, for Nereocystis, blades are trimmed (Ministry of Agriculture 2017). In both cases, regrowth occurs. As kelp plants are continually growing and losing material during the summer, the allowed harvest of 20% of the standing stock represents only approximately 5-10% of the total seasonal production(Wheeler 1990). In a study of small-scale Macrocystis harvesting, canopies fully recovered in most cases within four weeks of harvest (Krumhansl et al. 2017).

There are some concerns over the impacts of harvesting on kelp populations, particularly *Nereocystis*, however these generally focus on methods involving mortality (e.g., harvesting the whole plant)

(Springer et al. 2010). Even if *Nereocystis* mortality were to occur, studies suggest that the kelp community is relatively robust, with Foreman (Foreman, R.E 1984) reporting that 100 m strips could be clear cut in *Nereocystis* assemblages without risk to the resource. Similarly, regular harvesting by hand of *Macrocystis* in California at 1.2m below the waterline had no impact on local stocks (Dayton et al. 1998), nor did similar harvesting in Alaska (van Tamelen and Woodby 2001)).

Province-wide, harvesting pressure is very small, with historically few individuals harvesting wild kelp (A. Swinimer personal communications 2024) making harvest impacts highly localized; however, the harvest limitation to 20% of plants in any bed should spread effort enough to minimize such impacts. Some kelp mortality may occur through recreational harvesting due to a lack of regulation and education, though it is likely to be concentrated around coastal communities where kelp beds are accessible. However, both *Macrocystis* and *Nereocystis* have short life cycles and high recruitment, with highly dynamic populations as a result of susceptibility to natural disturbances (Tegner and Dayton 2000). As there is no evidence to suggest that harvesting greatly contributes to mortality, it is likely that mortality from unlicensed commercial methods or small recreational harvests will have a negligible effect.

It is also important to consider the scale of harvest. A particular *Macrocystis* bed in California is estimated to produce 33,000 mt/year of drift kelp (i.e. broken fronds and plants that drift on the current). Hand harvesting from the same bed produces 600 mt/yr., which represents an equivalent of only around 2% of the biomass lost as drift kelp (Donnellan and Foster 1999) . Given that the total kelp gathered in BC is less than 500 mt as of 2017 (MFLNRO, unpublished data), harvest impacts on mortality are likely to be small in comparison to natural environmental drivers.

Giant kelp (Macrocystis pyrifera)

Factor 1.1 - Abundance

Northeast Pacific | Canada | British Columbia | Hand implements

Moderate Concern

Macrocystis

Although evidence suggests giant kelp forests have been declining it is largely due to environmental changes and not likely a results of overexploitation from harvest (Sutherland et al. 2008). Impact on giant kelp abundance from harvesting activities is largely unknown. Considering the unknown abundance and distribution of Giant kelp beds throughout BC and the use of a PSA, abundance receives a moderate concern.

Justification:

Productivity scores for Giant kelp (*Macrocystis pyrifera*)

Table 5

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	Zoospore production beings at 6-12 months old (North 1987)	1
Average maximum age	Approximately 2 years. *Macrocystis* is a perennial plant, but the high dynamics of the B.C. coast mean that it rarely lives beyond 2 years (Druehl and Wheeler 1986) (Wheeler 1990). However, giant kelp has been known to live as long as 7 years (National Parks Service 2022).	1
Fecundity	Extremely high fecundity, estimated at 10,000 sporangia/cm^2 (North 1987) , or 3.15 x 10^{12} spores per plant (Joska and Bolton 1987)	1
Reproductive strategy	Broadcast spawner (Wheeler 1990)	1
Trophic level	Kelps are a foundational species, photosynthesizing to produce energy at the base of food webs.	1
Productivity Score		1

Susceptibility Scores for Giant kelp (*Macrocystis pyrifera*)

Table 6

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Plant harvest is limited to 20% of the available biomass (Ministry of Agriculture 2017) . However, harvest intensity along the coast is so low on an entire-coast scale, that the vast majority (>90%) of the species concentration is unharvested. Other harvesting in the habitat, such as urchin fishing, is unlikely to have direct impact on the kelp bed or individual plant.	1
Vertical overlap (Considers all fisheries)	Only 25% of the plant is taken (Ministry of Agriculture 2017) , so harvest overlap represents >66% of the plant unfished. Other fisheries in the same space, such as diver-caught urchin, are unlikely to have direct impact on the plant.	1
Seasonal Availability (Considers all fisheries)	Plants are harvested in a manner that allows regrowth throughout the season, where only 5-10% of the total seasonal production is harvested (Wheeler 1990) . However, seasonal trends in the fishery are unknown.	3
Selectivity of fishery (Specific to fishery under assessment)	Fishery is highly selective, targeting *Macrocystis* individually.	3
Post-capture mortality (Specific to fishery under assessment)	Properly harvested, blades are trimmed so that mortality does not occur (Ministry of Agriculture 2017) . In a study of small-scale Macrocystis harvesting, canopies fully recovered in most cases within four weeks of harvest (Krumhansl et al. 2017).	1
Susceptibility score		1.80

Inherent Vulnerability: 2.059- Low Vulnerability

Factor 1.2 - Fishing Mortality

Northeast Pacific | Canada | British Columbia | Hand implements

Low Concern

Neither *Macrocystis* nor *Nereocystis* suffer mortality when harvested according to BC license regulations. Instead, harvesters cut the blades or stipe at limited lengths or depths, allowing for regrowth across the season (Wheeler 1990) (Ministry of Agriculture 2017) . Although the extent of recreational fishing is unknown and may involve mortality due to incorrect harvesting techniques, the impact is likely to be negligible relative to the high natural mortality in a dynamic environment. Therefore, it is highly likely that mortality from all sources is at a sustainable level and this criterion is low concern.

Justification:

Kelp harvesting performed in accordance with the license conditions does not result in mortality of the algae. Instead, in the case of Macrocystis only 25% of fronds are removed or, for Nereocystis, blades are trimmed (Ministry of Agriculture 2017). In both cases, regrowth occurs. As kelp plants are continually growing and losing material during the summer, the allowed harvest of 20% of the standing stock represents only approximately 5-10% of the total seasonal production(Wheeler 1990). In a study of small-scale Macrocystis harvesting, canopies fully recovered in most cases within four weeks of harvest (Krumhansl et al. 2017).

There are some concerns over the impacts of harvesting on kelp populations, particularly *Nereocystis*, however these generally focus on methods involving mortality (e.g., harvesting the whole plant) (Springer et al. 2010). Even if *Nereocystis* mortality were to occur, studies suggest that the kelp community is relatively robust, with Foreman (Foreman, R.E 1984) reporting that 100 m strips could be clear cut in *Nereocystis* assemblages without risk to the resource. Similarly, regular harvesting by hand of *Macrocystis* in California at 1.2m below the waterline had no impact on local stocks (Dayton et al. 1998), nor did similar harvesting in Alaska (van Tamelen and Woodby 2001)).

Province-wide, harvesting pressure is very small, with historically few individuals harvesting wild kelp (A. Swinimer personal communications 2024) making harvest impacts highly localized; however, the harvest limitation to 20% of plants in any bed should spread effort enough to minimize such impacts. Some kelp mortality may occur through recreational harvesting due to a lack of regulation and education, though it is likely to be concentrated around coastal communities where kelp beds are accessible. However, both *Macrocystis* and *Nereocystis* have short life cycles and high recruitment, with highly dynamic populations as a result of susceptibility to natural disturbances (Tegner and Dayton 2000). As there is no evidence to suggest that harvesting greatly contributes to mortality, it is likely that mortality from unlicensed commercial methods or small recreational harvests will have a negligible effect.

It is also important to consider the scale of harvest. A particular *Macrocystis* bed in California is estimated to produce 33,000 mt/year of drift kelp (i.e. broken fronds and plants that drift on the current). Hand harvesting from the same bed produces 600 mt/yr., which represents an equivalent of only around 2% of the biomass lost as drift kelp (Donnellan and Foster 1999) . Given that the total kelp

gathered in BC is less than 500 mt as of 2017 (MFLNRO, unpublished data), harvest impacts on mortality are likely to be small in comparison to natural environmental drivers.

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

Criterion 2 score(s) overview

This table(s) provides an overview of the Criterion 2 subscore, discards+bait modifier, and final Criterion 2 score for each fishery. A separate table is provided for each species/stock that we want an overall rating for.

BULL KELP			
REGION / METHOD	SUB SCORE	DISCARD RATE/LANDINGS	SCORE
Northeast Pacific | Canada | British Columbia | Hand implements	5.000	1.000: < 100%	Green (5.000)

GIANT KELP			
REGION / METHOD	SUB SCORE	DISCARD RATE/LANDINGS	SCORE
Northeast Pacific | Canada | British Columbia | Hand implements	5.000	1.000: < 100%	Green (5.000)

Criterion 2 main assessed species/stocks table(s)

This table(s) provides a list of all species/stocks included in this assessment for each 'fishery' (as defined by a region/method combination). The text following this table(s) provides an explanation of the reasons the listed species were selected for inclusion in the assessment.

NORTHEAST PACIFIC | CANADA | BRITISH COLUMBIA | HAND IMPLEMENTS			
SUB SCORE: 5.000	DISCARD RATE: 1.000	SCORE: 5.000	
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Bull kelp	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

NORTHEAST PACIFIC | CANADA | BRITISH COLUMBIA | HAND IMPLEMENTS			
SUB SCORE: 5.000	DISCARD RATE: 1.000	SCORE: 5.000	
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Giant kelp	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

Bycatch of the kelp fishery is limited to animals and epiphytic algae that are attached to the plant at the time of harvesting and are directly removed with the kelp. Several species of invertebrates, fish and algae colonise the kelp fronds, with the greatest diversity found near the holdfast (Graham et al. 2007).

There are no studies investigating the bycatch of small-scale kelp harvesting and, although some fishers will visually inspect and generally shake off any attached animals, it is not a license requirement and it is likely that virtually all epifauna is removed with the kelp (A. Swinimer personal communications 2024). However, harvest conditions for *Macrocystis* only allow removal of 25% of fronds on any plant and *Nereocystis* harvesters must only trim the blades at the surface, while holdfast removal is explicitly prohibited for both kelps (Ministry of Agriculture 2017) , so species utilising the base of the plants are not affected.

As there are no significant impacts on any other species, either as a main component of the catch, or as a known primary source of mortality for a particularly species, criterion 2 requires no further assessment for *Macrocystis* or *Nereocystis* and full score of 5 is assigned to this Criterion.

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)

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

Factor 2.3 - Discard Rate/Landings

Northeast Pacific | Canada | British Columbia | Hand implements

< 100%

There is negligible discards from this fishery and any species attached to kelp fronds are likely removed by harvesters without significant mortality. Due to the hard-harvested nature of kelp, no bait is used. For these reasons discards and bait use do not exceed 100% of landings.

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.

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:

Criterion 3 Summary

FISHERY	MANAGEMENT STRATEGY	BYCATCH STRATEGY	DATA COLLECTION AND ANALYSIS	ENFORCEMENT	INCLUSION	SCORE
Northeast Pacific | Canada | British Columbia | Hand implements	Moderately Effective	Highly effective	Moderately Effective	Moderately Effective	Moderately Effective	**Yellow (3.000)**
Northeast Pacific | Canada | British Columbia | Hand implements	Moderately Effective	Highly effective	Moderately Effective	Moderately Effective	Moderately Effective	**Yellow (3.000)**

Criterion 3 Assessment

SCORING GUIDELINES

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.

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.

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.

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.

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.

Factor 3.1 - Management Strategy And Implementation

Northeast Pacific | Canada | British Columbia | Hand implements

Moderately Effective

Management measures include a conservative harvest rate and restrictions on harvest method that protect the plant (Ministry of Agriculture 2017) . Each harvest area has a limit of one licence per species and harvesters are granted a maximum harvest quota with their licence and must record the weight of harvest each day (A. Swinimer personal communications 2024). In order to obtain a license, harvesters are required to submit a comprehensive harvest plan outlining the area of harvest (for example, map and GPS locations), density of kelp in that area, and any potential effects harvesting may have on the ecosystem (A. Swinimer personal communications 2024). Since these species exhibit such marked spatial and temporal variability in canopy kelp abundance over time, management should be conducted at biologically relevant scales (e.g. that reflect spatial patterns in canopy kelp resilience) appropriate for sustainably managing kelp harvest. However, the lack of any stock monitoring means that the effectiveness of management measures is unknown, but their precautionary nature and the small scale of the fishery indicates that harvesting is unlikely to have significant negative impacts on either the *Macrocystis* or *Nereocystis* populations

Measures do not meet all the standards of “Highly Effective” management but still exceed those for “Ineffective” or “Critical”. Therefore, this factor receives Moderately Effective.

Justification:

There is no comprehensive management plan for the harvesting of aquatic plants; however, the provincial government manage the kelp fishery with a strategy similar to DFO’s precautionary harvest approach for data-limited fisheries, allowing only small harvests relative to the estimated biomasses (Edwin Blewett & Associates Inc 2001) .

Harvest areas are defined by DFO’s 48 Pacific Fishery Management Areas (PFMAs), which cover the entire BC coast and are divided into a variable number of sub-areas (DFO 2017) . Applications are submitted prior to October to harvest either kelp in one or several sub-areas the following year and are coupled with a quota request. Each application is assessed on a case- by-case basis and licenses are administered each year (A. Swinimer personal communications 2024). If approved, licenses grant the holder exclusive use of a harvest area and a non-transferable quota for a specific species over a calendar year (A. Swinimer personal communications 2024). Harvesting takes place year-round, although *Macrocystis* harvesting for the SOK fishery will occur between mid-February and the end of May, during the fishery openings (DFO 2023). As of writing in 2024, “... 10 licences are allocated for Haida Gwaii including 4 held by Haida individuals, 3 by Haida organizations, and 3 by non-Haida individuals or companies. Commercial SOK fishery operators are also required to obtain kelp harvesting permits from the Province of BC. With the signing of the Kunst'aa guu - Kunts'aayah Reconciliation Protocol between the Haida Nation and Province of BC in 2009, the Haida Gwaii Solutions Table began to advise on and jointly approve annual kelp harvesting permits (Haida Marine Planning 2022).

License conditions place specific restrictions on the harvest method, designed to protect the individual plants from mortality as well as limit harvest impacts on the kelp bed. Additionally, harvesting is not permitted within a BC provincial park, an ecological reserve, or protected area (Province of British Columbia 2024) . The harvest rate for both *Macrocystis* and *Nereocystis* is limited to 20% of the plants in the bed, though repeat harvesting of individual plants is permitted, and must not include harvest from protected areas or leased land. *Macrocystis* harvesting must be done using a sharp cutting tool and only fronds may be cut, with no more than 25% of the fronds on a single plant taken. *Nereocystis* license conditions require that only blades are cut and are cut no closer than 20 cm from the bulb (Ministry of Agriculture 2017) .

Factor 3.2 - Bycatch Strategy

Northeast Pacific | Canada | British Columbia | Hand implements

Highly effective

This fishery has no or very low (>5% total catch) bycatch, with no bycatch of species of concern during kelp harvest and therefore this factor receives Highly Effective.

Factor 3.3 - Scientific Data Collection and Analysis

Northeast Pacific | Canada | British Columbia | Hand implements

Moderately Effective

Since 2017, the Marine Plan Partnership (MaPP) has developed a Regional Kelp Monitoring Program that involves First Nation Guardian Watchmen, universities, non-profit institutions to help monitor kelp beds at biologically relevant temporal and spatial scales (Hamilton et al. 2022) . The quantity of kelp harvested by each license holder is monitored annually through a royalty program, where harvesters pay a fee depending on the quantity of kelp they gather; however, no analysis of the data is performed. The MFLNRO has had intentions to update the kelp bed inventories since 2017, however, progress has been limited and no updated inventories are currently available.

Therefore, although few recent studies have been published related to the abundance and distribution of kelp throughout BC, several efforts are underway to fill knowledge gaps and restore locations where kelp forests have been depleted (MaPP 2023) . Improvements to data-limited assessment and management methods have been made since 2017, and as such this factor receives “Moderately Effective”.

Justification:

Monitoring of the kelp fishery is limited to the requirement for harvesters to pay royalties on their yield.

As harvesters are responsible for recording how much they remove, this functions similarly to a fisher's log book and is used by managers to determine how much kelp has been harvested in each area. Management does not have the resources for more detailed monitoring where only two officers oversee kelp harvest throughout BC (A. Swinimer personal communications 2024). Given the scale of the fishery along the entire provincial coast and the relatively small harvest of only a few hundred tons, this may be an appropriate strategy, but the lack of direct oversight may lead to under-reporting.

The MFLNROF has expressed intent to conduct further monitoring and begin updating the kelp bed inventories through the MaPP. This partnership works in close collaboration with First Nation stakeholders along the central and north coasts, as well as the north of Vancouver Island. As of 2023, several projects are underway, including the monitoring of kelp on the North Pacific Coast (MaPP 2023) .

Factor 3.4 - Enforcement of and Compliance with Management Regulations

Northeast Pacific | Canada | British Columbia | Hand implements

Moderately Effective

The Ministry of Agriculture has previously had full time enforcement officers for aquatic plants, including the kelp fisheries, however the current level of monitoring and enforcement is unclear. With relatively few license holders, it is unclear how regularly monitoring of harvesters occurs, although historically compliance has been considered good, therefore this factor is a Moderate Concern.

Justification:

Two full-time enforcement officers from the Ministry of Agriculture monitor compliance of aquatic plant harvesting in BC (A. Swinimer personal communications 2024). There is no official reporting of enforcement/monitoring activity, so it is unclear how regularly harvesters are inspected. Overall, there are no significant compliance issues (A. Swinimer personal communications 2024).

Factor 3.5 - Stakeholder Inclusion

Northeast Pacific | Canada | British Columbia | Hand implements

Moderately Effective

Stakeholder engagement is limited to consultation with First Nations when harvesting applications are made within their territory. Though user conflicts are effectively addressed through this mechanism, there is a historical absence of engagement with other stakeholders including kelp harvesters. However, through initiatives like the MaPP, First Nations have been more broadly involved in management of kelp resources (MaPP 2023). Despite the lack of clarity regarding decision-making, improvements in stakeholder and rightsholder consultations have improved since 2017 and therefore management is moderately effective.

Justification:

With the signing of the Kunst'aa guu - Kunts'aayah Reconciliation Protocol between the Haida Nation and Province of BC in 2009, the Haida Gwaii Solutions Table began to advise on and jointly approve annual kelp harvesting permits in their territory (Haida Marine Planning 2022). Managers in other areas in BC have also recently begun to engage with First Nations through the MaPP (MaPP 2023). Engagement between managers and harvesters, however, is limited to license applications and royalty payment. There is no clear mechanism for communicating management decisions.

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

FISHERY	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	FORAGE SPECIES?	SCORE
Northeast Pacific | Canada | British Columbia | Hand implements	Score: 5	Score: 0	Moderate Concern		Green (3.873)
Northeast Pacific | Canada | British Columbia | Hand implements	Score: 5	Score: 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

Northeast Pacific | Canada | British Columbia | Hand implements

Score: 5

Harvesting is by hand and limited to cutting blades far from the holdfast, so there is no physical impact of the gear on the kelp habitat or substrate. Thus, gear does not contact the bottom and receives a “5”.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Northeast Pacific | Canada | British Columbia | Hand implements

Score: 0

Not applicable because gear used is benign and fishery received a score of “5”.

Factor 4.3 - Ecosystem-based Fisheries Management

Northeast Pacific | Canada | British Columbia | Hand implements

Moderate Concern

Kelp beds are important to the ecosystem both as a structural foundation species, providing the structure for a whole ecosystem, and at the base of food webs, putting energy into the system. There are no ecosystem assessments for either species and no spatial management is employed. However, studies on *Macrocystis* fisheries show that small-scale harvesting has minimal impact on the kelp forest ecosystem. Investigations into *Nereocystis* harvesting indicate that the impact on canopy coverage is dependent on the time of harvest, but the limited harvest rate is likely to minimize impacts.

Given the small scale of harvesting relative to the geographic scale of the fishery, and that harvesting does not cause mortality, it is unlikely that significant negative ecosystem effects will occur. Therefore, this criterion is a moderate concern.

Justification:

Kelp provide important ecosystem functions as a foundation species in the kelp forest habitat, and, by providing structure, shelter and a food source can enhance species diversity and productivity locally and across broad spatial scales {Krumhansl *et al.* 2017). As a food source, kelps provide the initial source of the carbon through which almost all the kelp forest species depend, while also providing a physical structure and shelter to protect juvenile fishes and invertebrates (Graham et al. 2007) (Springer et al. 2010). Kelp forests are also important nutrient recyclers and stores of atmospheric carbon (Springer et al. 2010) Krumhansl *et al.* 2017).

Kelp harvesting has been shown to affect *Macrocystis* ecology and, by extension, could potentially have some effect on population dynamics in the wider ecosystem. Some studies have suggested that partial canopy harvesting increases kelp recruitment, due to an increased availability of limiting resources, such as light and space (Kimura, R.S. 1980) (Kimura and Foster, 1984) (Reed 1987). Conversely, a study of harvesting at higher rates observed a decline in the density of juvenile *Macrocystis,* which are likely to have been out-competed by understory kelp species benefiting from the canopy reduction (Krumhansl *et al.* 2017). Harvesting may also impact reproductive potential. At high rates of canopy removal, where more than 75% of the canopy is removed, drastic decreases in both reproductive blade growth and sporophyll production have been recorded (Reed 1987) (Geange 2014), although declines in reproductive potential have not been observed when harvesting is conducted at smaller scales, such as those required in BC (Krumhansl *et al.* 2017).

Studies suggest that the direct impacts on the ecosystem from small-scale kelp harvesting are minimal. Canopy removal has little effect on understory algae species other than increasing growth, as the kelp is still taking up most of the substrate space unless mortality occurs (Wheeler 1990). Kelp canopy invertebrate populations appear to be unaffected (Wheeler 1990) and the only recorded impact on benthic grazers is poorer nutrition of urchin populations where harvesting has been severe (Druehl and Breen 1986).

Studies in California and Chile have shown that fish move out of areas where *Macrocystis* canopy is removed, but return when the bed re-grows (Miller and Geibel 1973); (Moreno, C.A. and Jara, H.F. 1984) , with the overall impact on fish from *Macrocystis* harvesting much less than that of commercial targeting of invertebrates such as lobster, abalone and sea urchin (Wheeler 1990). Similarly, investigation into small-scale harvesting in BC indicates that there is minimal effect on associated fish assemblages and that climate may be a stronger driver (Krumhansl *et al.* 2017). Overall, Tegner and Dayton (Tegner and Dayton 2000) suggest that given the high susceptibility of kelp forests to natural disturbances, well-managed kelp harvesting is a relatively benign disturbance.

Macrocystis harvest for the SOK has, by extension, a potential impact on herring populations as the fish are captured in a seine net and placed in ponds in order to lay eggs on the kelp fronds. However, the SOK fishery is managed to minimize impacts on the fish and the fish are released alive after spawning (DFO 2023). There is no evidence that any fluctuations in herring biomass are caused or accentuated by the SOK fishery.

There are no investigations specifically targeting the impact of *Nereocystis* harvest on kelp communities. Still, Roland (Roland 1985) found that partially removed blades do not grow back to their full extent, as well as the proportion bearing reproductive sori. Harvesting therefore could impact the amount of canopy biomass available for habitat, as well as food availability as detritus (Springer et al. 2010). It could also influence the number of reproductive propagules contributing to recruitment, and it was recommended that, instead of harvesting a whole bed at once, to stagger harvest across different plants throughout the year (Roland 1985) . The restriction in the BC fishery that limits harvesting to only 20% of the plants ensures that the whole bed is never taken.

There is no specific spatial management in this fishery, however, fishing is prohibited from protected areas and leased land, which will act as a refuge. In recent years, efforts to increase ecosystem-based management have been drive by many First Nations groups throughout BC, and most notably for kelp,

in Haida Gwaii. “In November 2018, the Gwaii Haanas Gina 'Waadluxan KilGuhlGa Land-Sea-People Management Plan was signed by representatives from the Government of Canada and the Haida Nation, outlining the shared vision for the future of Gwaii Haanas and the direction for the Archipelago Management Board to manage both the terrestrial and marine areas of Gwaii Haanas. In this plan, a commitment was made by the parties to collaboratively develop a rebuilding strategy and implementation plan by 2020 that preserves ecological integrity and promotes sustainable use of resources such as herring, eelgrass and kelp (Haida Marine Planning 2022) . Demonstrated efforts like this, alongside the precautionary harvest conditions (Ministry of Agriculture 2017), means that any overall ecosystem and food web impacts directly from harvesting are likely to be minimal.

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Scientific reviewdoes 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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