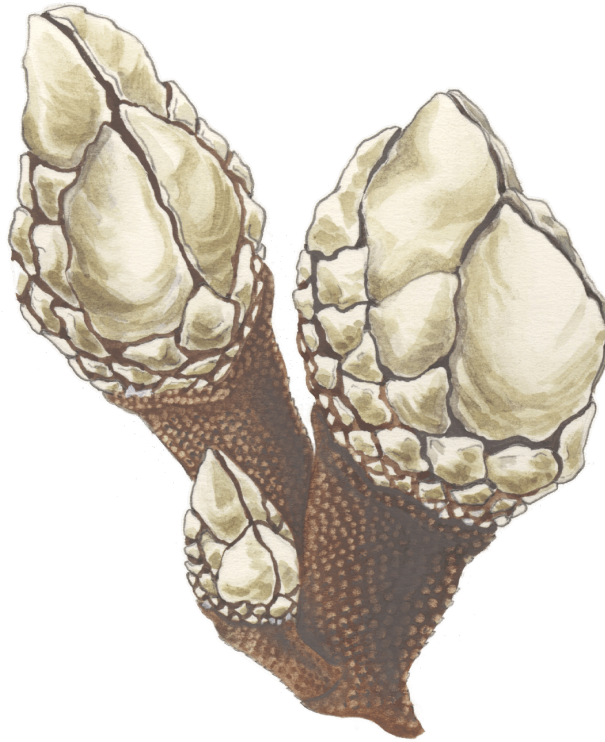




Monterey Bay Aquarium Seafood Watch

Environmental sustainability assessment of wild gooseneck/leaf barnacle
(*Pollicipes polymerus*) from British Columbia caught using hand implements



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Species: Gooseneck/leaf barnacle (*Pollicipes polymerus*)
Location: British Columbia: Pacific, Northeast
Gear: Hand implements
Type: Wild Caught
Author: Seafood Watch
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Table of contents

About the Monterey Bay Aquarium Seafood Watch program	3
Seafood Watch ratings.....	4
Guiding principles	5
Final ratings	8
Abbreviations.....	9
Summary.....	9
Introduction.....	11
Assessments.....	17
Criterion 1: Impacts on the species under assessment.....	17
Criterion 1 summary.....	18
Criterion 1 assessment.....	18
Criterion 2: Impacts on other species	25
Criterion 2 summary.....	26
Criterion 2 assessment.....	28
Criterion 3: Management effectiveness.....	47
Criterion 3 summary.....	48
Criterion 3 assessment.....	48
Criterion 4: Impacts on the habitat and ecosystem.....	55
Criterion 4 summary.....	56
Criterion 4 assessment.....	56
Acknowledgements.....	60
References.....	61

About the Monterey Bay Aquarium Seafood Watch program

The mission of the Monterey Bay Aquarium is to inspire conservation of the ocean and enable a future where the ocean flourishes and people thrive in a just and equitable world. To do this, the Aquarium is focused on creating extraordinary experiences that inspire awe and wonder, championing science-based solutions, and connecting people across the planet to protect and restore the ocean. We know that healthy ocean ecosystems are critical to enabling life on Earth to exist, and that our very survival depends on them. As such, our conservation objectives are to mobilize climate action, improve the sustainability of global fisheries and aquaculture, reduce sources of plastic pollution, and restore and protect ocean wildlife and ecosystems.

The aquarium is focused on improving the sustainability of fisheries and aquaculture given the role seafood plays in providing essential nutrition for 3 billion people globally, and in supporting hundreds of millions of livelihoods. Approximately 180 million metric tons of wild and farmed seafood is harvested each year (excluding seaweeds). Unfortunately, not all current harvest practices are sustainable and poorly managed fisheries and aquaculture pose the greatest immediate threat to the health of the ocean and the economic survival and food security of billions of people.

The Seafood Watch program was started 25 years ago as a small exhibit in the Monterey Bay Aquarium highlighting better fishing practices and grew into one of the leading sources of information on seafood sustainability, harnessing the power of consumer choice to mobilize change. The program's comprehensive open-source information and public outreach raises awareness about global sustainability issues, identifies areas for improvement, recognizes and rewards best practices and empowers individuals and businesses to make informed decisions when purchasing seafood.

We define sustainable seafood as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems, minimize harmful environmental impacts, assure good and fair working conditions, and support livelihoods and economic benefits throughout the entire supply chain. As one aspect of this vision, Seafood Watch has developed trusted, rigorous standards for assessing the environmental impacts of fishing and aquaculture practices worldwide. Built on a solid foundation of science and collaboration, our standards reflect our guiding principles for defining environmental sustainability in seafood.

Seafood Watch ratings

The Seafood Watch Standard for Fisheries is used to produce assessments for wild-capture fisheries resulting in a Seafood Watch rating of green, yellow, or red. Seafood Watch uses the assessment criteria to determine a final numerical score as well as numerical subscores and colors for each criterion. These scores are translated to a final Seafood Watch color rating according to the methodology described in the table below. The table also describes how Seafood Watch defines each of these categories. The narrative descriptions of each Seafood Watch rating, and the guiding principles listed below, compose the framework on which the criteria are based.

Green	Final Score >3.2, and either Criterion 1 or Criterion 3 (or both) is green, and no red criteria, and no critical scores	Wild-caught and farm-raised seafood rated green are environmentally sustainable, well managed and caught or farmed in ways that cause little or no harm to habitats or other wildlife. These operations align with all of our guiding principles.
Yellow	Final score >2.2, and no more than one red criterion, and no critical scores, and does not meet the criteria for green (above)	Wild-caught and farm-raised seafood rated yellow cannot be considered fully environmentally sustainable at this time. They align with most of our guiding principles, but there is either one conservation concern needing substantial improvement, or there is significant uncertainty associated with the impacts of the fishery or aquaculture operations.
Red	Final Score \leq 2.2, or two or more red criteria, or one or more critical scores.	Wild-caught and farm-raised seafood rated red are caught or farmed in ways that have a high risk of causing significant harm to the environment. They do not align with our guiding principles and are considered environmentally unsustainable due to either a critical conservation concern, or multiple areas where improvement is needed.

Disclaimer: All Seafood Watch fishery assessments are reviewed for accuracy by external experts in ecology, fisheries science, and aquaculture. Scientific review does not constitute an endorsement of the Seafood Watch program or its ratings on the part of the reviewing scientists. Seafood Watch is solely responsible for the conclusions reached in this assessment.

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Guiding principles

Monterey Bay Aquarium defines sustainable seafood as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems, minimize harmful environmental impacts, assure good and fair working conditions, and support livelihoods and economic benefits throughout the entire supply chain.

As one aspect of this vision, Seafood Watch has developed trusted, rigorous standards for assessing the environmental impacts of fishing and aquaculture practices worldwide. Environmentally sustainable wild capture fisheries:

1. Follow the principles of ecosystem-based fisheries management

The fishery is managed to ensure the integrity of the entire ecosystem, rather than solely focusing on maintenance of single species stock productivity. To the extent allowed by the current state of the science, ecological interactions affected by the fishery are understood and protected, and the structure and function of the ecosystem is maintained.

2. Ensure all affected stocks¹ are healthy and abundant

Abundance, size, sex, age and genetic structure of the main species affected by the fishery (not limited to target species) is maintained at levels that do not impair recruitment or long-term productivity of the stocks or fulfillment of their role in the ecosystem and food web.

Abundance of the main species affected by the fishery should be at, above, or fluctuating around levels that allow for the long-term production of maximum sustainable yield. Higher abundances are necessary in the case of forage species, in order to allow the species to fulfill its ecological role.

3. Fish all affected stocks at sustainable levels

Fishing mortality for the main species affected by the fishery should be appropriate given current abundance and inherent resilience to fishing while accounting for scientific uncertainty, management uncertainty, and non-fishery impacts such as habitat degradation.

¹“Affected” stocks include all stocks affected by the fishery, no matter whether target or bycatch, or whether they are ultimately retained or discarded.

The cumulative fishing mortality experienced by affected species must be at or below the level that produces maximum sustainable yield for single-species fisheries on typical species that are at target levels.

Fishing mortality may need to be lower than the level that produces maximum sustainable yield in certain cases such as forage species, multispecies fisheries, highly vulnerable species, or fisheries with high uncertainty.

For species that are depleted below target levels, fishing mortality must be at or below a level that allows the species to recover to its target abundance.

4. Minimize bycatch

Seafood Watch defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival and there is no documented evidence of negative impacts at the population level.

The fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss and by efficiently using marine and freshwater resources as bait.

5. Have no more than a negligible impact on any threatened, endangered or protected species

The fishery avoids catch of any threatened, endangered or protected (ETP) species. If any ETP species are inadvertently caught, the fishery ensures and can demonstrate that it has no more than a negligible impact on these populations.

6. Are managed to sustain the long-term productivity of all affected species

Management should be appropriate for the inherent resilience of affected marine and freshwater life and should incorporate data sufficient to assess the affected species and manage fishing mortality to ensure little risk of depletion. Measures should be implemented and enforced to ensure that fishery mortality does not threaten the long term productivity or ecological role of any species in the future.

The management strategy has a high chance of preventing declines in stock productivity by taking into account the level of uncertainty, other impacts on the stock, and the potential for increased pressure in the future.

The management strategy effectively prevents negative population impacts on bycatch species, particularly species of concern.

7. Avoid negative impacts on the structure, function or associated biota of aquatic habitats where fishing occurs

The fishery does not adversely affect the physical structure of the seafloor or associated biological communities.

If high-impact gears (e.g. trawls, dredges) are used, vulnerable seafloor habitats (e.g. corals, seamounts) are not fished, and potential damage to the seafloor is mitigated through substantial spatial protection, gear modifications and/or other highly effective methods.

8. Maintain the trophic role of all aquatic life

All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web, as informed by the best available science.

9. Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts

Fishing activities must not result in harmful changes such as depletion of dependent predators, trophic cascades, or phase shifts.

This may require fishing certain species (e.g., forage species) well below maximum sustainable yield and maintaining populations of these species well above the biomass that produces maximum sustainable yield.

10. 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

Any enhancement activities are conducted at levels that do not negatively affect wild stocks by reducing diversity, abundance or genetic integrity.

Management of fisheries targeting enhanced stocks ensures that there are no negative impacts on the wild stocks, in line with the guiding principles described above, as a result of the fisheries.

Enhancement activities do not negatively affect the ecosystem through density dependent competition or any other means, as informed by the best available science.

Final ratings

Ratings Details	C 1 Target Species	C 2 Other Species	C 3 Management	C 4 Habitat	Rating
Leaf barnacle Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area: Pacific, Northeast - Management Unit: West Coast of Vancouver Island	3.413	2.644	4.000	4.472	Green (3.564)

Abbreviations

Table 1:

Abbreviation	Description
ACFLR	Aboriginal Communal Fishing Licences Regulations
BC	British Columbia
DFO	Fisheries and Oceans Canada
FMP	Fisheries Management Plan
LEK	local ecological knowledge
LRP	limit reference points
MSFMP	Multispecies Fisheries Management Plan
PSA	productivity-susceptibility analysis
PSP	paralytic shellfish poisoning
TAC	total allowable catch
USR	upper stock reference
WCVI	west coast Vancouver Island

Summary

This report assesses the sustainability of the Nuu-chah-nulth leaf barnacle (*Pollicipes polymerus*) fishery on the west coast of Vancouver Island, Canada. Leaf barnacle is more commonly, and herein, known as gooseneck barnacle. All gooseneck barnacles are harvested by hand at specifically designated harvest sites in Clayoquot Sound within the T'aaq-wiihak Fishing Area.

Barnacles have unique life history strategies, being both sessile and live brooding organisms. Thus, they have a moderate inherent vulnerability to fishing. Today, there is uncertainty regarding the abundance of gooseneck barnacle stock; however, it is unlikely that the total population is experiencing overfishing, because there is a conservative harvest limit and there are integrated area-management considerations. Quotas are set on a site-specific basis, based on information derived from stock assessment techniques, which include both quantitative and local ecological knowledge methodology. Currently, the fishery remains relatively small, with limited fishing effort. Only adult gooseneck barnacles (3–20% of the biomass of most rocks) are marketable, and collection at a certain rock depends largely on tides and weather conditions. Incidentally caught (and discarded) species include California mussel (*Mytilus californianus*) and blue mussel (*Mytilus edulis*), as well as thatched barnacle (*Semibalanus cariosus*),

acorn barnacle (*Balanus glandula*), and juvenile gooseneck barnacle. Nonetheless, total bycatch is minimal, largely due to proper fisher training and highly selective hand-harvesting techniques.

The gooseneck barnacle fishery is managed by Fisheries and Oceans Canada (DFO) and the Nuu-chah-nulth First Nations. The current management plan is highly precautionary and aims to ensure the proper monitoring and long-term sustainability of the stock. Hand-harvesting techniques and fisher experience limit the amount of other species incidentally caught in the fishery. Overall, bycatch mitigation considerations during harvest, the lack of sensitive species interactions, and the absence of other fishing pressures in the ecosystem reduce the concerns over impacts to other species.

The tool used to remove desirable barnacles from the sites has negligible impacts on the rock substrate. Although the fishery for gooseneck barnacle occurs at specific sites, an additional 72% of the surrounding T'aaq-wiihak Fishing Area is located within Pacific Rim National Park Reserve. Commercial fishing is prohibited within the Park Reserve, while recreational fishing is permitted only in designated areas, which helps preserve the multitude of natural terrestrial and marine processes occurring along this coast. Overall, gooseneck barnacle is rated green.

Introduction

Scope of the analysis and ensuing rating

This report assesses the sustainability of the leaf barnacle (*Pollicipes polymerus*), also known as gooseneck barnacle, fishery on the west coast of Vancouver Island (WCVI), Canada. Gooseneck barnacle is an edible crustacean found in the intertidal zone along the west coast of North America from the Aleutian Islands, Alaska, to Baja California, Mexico. Gooseneck barnacle is hand-harvested from specific rocks in Clayoquot Sound, British Columbia, Canada. Currently, five First Nations participate in the fishery—Ahousaht, Ehattesaht/Chinehkint, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht—all of whom are members of the Nuuchahnulth First Nations (also referred to as “five Nations”). While a different fishery for gooseneck barnacle occurred in this region previously, and commercial collection still occurs in other parts of the world, this assessment and its recommendation pertain exclusively to the current Nuuchahnulth T’aaqwiihak fishery, which is the only commercial gooseneck barnacle fishery in North America.

Species overview

Gooseneck barnacle is a sessile, stalked cirriped found in the intertidal zone along the west coast of North America from the Aleutian Islands, Alaska, to Baja California, Mexico (Bernard 1988). While *P. polymerus* is the largest species of gooseneck barnacle and native to North America, three similar species exist worldwide: European stalked barnacle (*P. pollicipes*/*P. cornucopia*, coastal northwestern France south to Senegal), Pacific goose barnacle (*P. elegans*, eastern tropical Pacific), and goose barnacle (*P. spinosus*, New Zealand) (Lauzier, R.B. 1999). Based on calculations by Bernard (Bernard 1988), they likely live to around 12 years, with maturity reached at a rostral-carinal length of 14–17 mm, which occurs between 1 to 3 years (DFO 1999). Gooseneck barnacle is typically harvested at around 5 years of age.

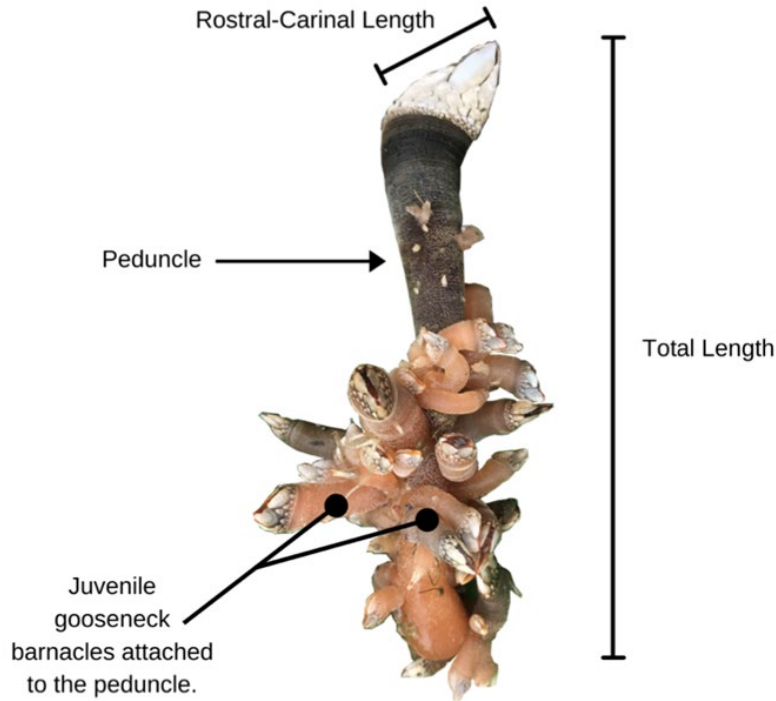


Figure 1: Image of a gooseneck barnacle showing both adult and juvenile forms (Edwards, 2020).

Gooseneck barnacle is hermaphroditic and reproduces via pseudo-copulation rather than self-fertilization (Galen Howard Hilgard 1960; Lewis and Chia 1981; Gagne et al. 2016). In fact, breeding was found to be limited to individuals within a proximity of no greater than 11 cm (Lewis and Chia 1981). But recent research by Barazandeh et al. (2013) suggests that *P. polymerus* may also mate by sperm-casting. Because only sperm are released into the water column, this mechanism of fertilization is dissimilar to broadcast spawning (in which both eggs and sperm are released). Although the regularity of sperm-casting is still unknown, this behavior does enable individuals out of physical range to fertilize one another; ongoing research seeks to determine the prevalence and potential population impacts of this (and other) mating strategies in barnacles (Barazandeh et al. 2013; Yusa et al. 2013). Once fertilized, after roughly 25 days, barnacles release free-swimming cyprid larvae that then undergo six naupliar stages and spend approximately 42–45 days in the plankton phase before settling (Lewis 1975). Spawning occurs from April to October, peaking in July (DFO 1999). Each adult gooseneck barnacle produces between 475,000 and 950,000 embryos each season (DFO 1999). Larvae settle once they reach 0.5 mm in length after roughly 30–40 days and continue to grow rapidly for the first year, after which growth slows to a maximum size of 153 mm (DFO 1999). Dispersal of gooseneck barnacle in British Columbia is not well known, but studies in other regions have estimated possible dispersals as limited as 13–56 km in Northern Spain to over 185 km elsewhere, depending on upwelling activities and local current velocities (Lewis 1975; Rivera et al. 2014). Despite the information available from these studies, dispersal of *P. polymerus* along Vancouver Island is not well known.

Gooseneck barnacle settlement occurs most often on biological substrate, including conspecifics and co-occurring invertebrates, including mussels and other barnacles (Bernard 1988; Hoffman 1989; Gagne et al. 2016; Edwards,

2020). *P. polymerus* is found most commonly in rosette-shaped clusters, and this community formation protects juveniles against vigorous wave action, while simultaneously preventing “out competition” by mussels (Bernard 1988; Lauzier, R.B. 1999; Jamieson et al. 2001}. Gooseneck barnacle rarely lives in isolation from other species, and is most commonly found coexisting with California mussel (*Mytilus californianus*), thatched barnacle (*Semibalanus cariosus*), and acorn barnacle (*Balanus* spp.) on a variety of rock substrates in regions of heavy surf and wave action (Lauzier, R.B. 1999). Barnacles may also be removed from biological substrate, such as blue mussel (*Mytilus edulis*) or acorn barnacle when harvested (Gagne et al. 2016).

Production statistics

Gooseneck barnacle has always been an important traditional food source for the Nuuchahnulth First Nations, with evidence of harvest in the area dating thousands of years (Gagne et al. 2016; Efford, 2019; Edwards, 2020). The Ćaʔinwa (the Nuuchahnulth word for goose barnacle) fishery is open year-round in Clayoquot Sound and exists within a group of First Nations rights-based fisheries known as Tʼaaq-wiihak, which refers to fishing with the permission of the Haʼwiih (hereditary chiefs) (Edwards, 2020). Five Nations fishers observe a code of environmental stewardship based on the Nuuchahnulth principles of hishukish tʼsawalk (everything is one) and iisaak (respect with caring), which work to preserve rather than deplete fisheries resources for future generations.

A commercial fishery was first established in 1978 and peaked in the mid-1980s on the west coast of Vancouver Island (WCVI) until its closure in 1999 for concerns from DFO about a lack of management and sustainability (Gagne et al. 2016; DFO 2023). Gooseneck barnacle harvest peaked in 1988 with 467 licenses issued. This significant increase in fishers resulted in an equally substantial increase in the amount of gooseneck barnacles harvested—from only 3 t in 1986 to a peak of 49 t in 1988 (Lauzier, R.B. 1999); the majority of landings came from the southwest coast Vancouver Island fishing areas (i.e., DFO Pacific Management Areas 23, 24, and 26) (Government of British Columbia, 2008). As a result, it was closed by DFO in May 1999 as a precaution for concerns over inadequate management, a lack of sufficient biological and ecological data, and concerns over overexploitation (Lauzier, R.B. 1999; -). Of specific concern was a lack of data on both the gooseneck barnacle population (i.e., biomass, distribution, and abundance information), as well as uncertainty about the impacts the fishery was having on the surrounding intertidal habitat (Lauzier, R.B. 1999; Gagne et al. 2016).

Experimental harvests continued with small landings (< 1.8 t) until the reopening of a commercial fishery from 2003 to 2005 under DFO’s New and Emerging Fisheries Policy (Gagne et al. 2016; DFO 2023). In 2003, DFO opened an experimental commercial fishery with barnacle collection permitted in Barkley Sound, Clayoquot Sound, and Kyuquot/Checleseth (DFO 2023). The new experimental fishery management plan was created with input from multiple parties, including DFO, the provincial government, WCVI communities, First Nations, nongovernmental organizations, harvesters, processors, and buyers (Day et al. 2012; Edwards, 2020; DFO 2023). During this time, local ecological knowledge (LEK) was collected to inform harvest limits and the regrowth of gooseneck barnacles on harvestable rocks (Edwards, 2020). Despite these efforts, the fishery closed in 2005 for a lack of funding for continued management and data collection required by DFO and a decrease in market demand (DFO 2023).

The information gathered from these fisheries was reviewed by the Tʼaaq-wiihak Nations in 2010 with the intention of developing a more sustainable fishery (Gagne et al., 2016). DFO supported these efforts by issuing communal

commercial licenses so the Nations could develop fishery protocol, conduct market tests, and provide training opportunities (Gagne et al. 2016).

In 2013, a limited commercial fishery reopened and currently allows harvest from 52 gooseneck barnacle rocks in Clayoquot Sound (PFMA 24 and 124) (Gagne et al. 2016). While recreational harvest of gooseneck barnacles is permitted, participation is assumed negligible (Gagne et al. 2016). Harvest rates are between 9 and 15 kg of commercial product per hour (Gagne et al. 2016).

Presently, the primary management focuses are ensuring fisher safety and maintaining stock sustainability with ongoing market demand. Only adult gooseneck barnacles (3–20% of the biomass of most rocks) of a certain size are marketable, and collection at a certain rock depends largely on tides and weather conditions (Gagne et al. 2016). Harvestable-sized goose barnacles typically have a rostral-carinal (RC) length of 15 to 30 mm, peduncle length between 20 and 80 mm, and a volume of 5 to 25 ml (DFO 2024). Only members of Ahousaht, Ehattesaht, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht First Nations are eligible to participate in the fishery and are designated by other members of the nation (DFO 2023). These designations are personal and nontransferable.

Given these ecological and biological parameters, only a quite small portion of the total stock within the T'aaq-wiihak Fishing Area on the west coast of Vancouver Island is harvestable at any given time. Although Pacific Rim National Park of Canada lies within the traditional territory of the Nuuchahnulth People, no harvest is permitted within this park and several other ecological reserves; 72% of the T'aaq-wiihak Fishing Area is protected by no-take zones (Gagne et al. 2016).

In 2009, the BC Supreme Court recognized the aboriginal rights of the five Nuuchahnulth Nations to catch and sell all species traditionally harvested within their territories (Ha'oom Fisheries Society 2024). On January 30, 2014, the Supreme Court of British Columbia upheld this decision (Ahousaht Nation v. Canada), dismissing a second appeal from Canada, and affirming the aboriginal right of the five aforementioned Nuuchahnulth Nations to fish commercially within their traditional territories. This decision—which is now final and constitutionally protected—is “only the second case in Canada in which aboriginal rights to sell fish have been established outside of a treaty and the first such case that expressly applies that right to any species of fish available in the First Nations’ territories” (Kirchner 2010).

In 2016, the Five Nations and DFO updated the gooseneck barnacle bed assessment framework to identify research priorities that would improve the sustainable development of the fishery as the fishery continues to face challenges attracting buyers (Gagne et al. 2016; Edwards, 2020). This data, along with local ecological knowledge, informs the current management and operation of the fishery.



Figure 2: Removal of gooseneck barnacles from barnacle-mussel matrix. Harvesters select small clumps of marketable barnacles and use a modified spring leaf tool to pry them out of the surrounding population of intertidal organisms. Use of this tool requires great precision and dexterity; harvesters aim to avoid taking (or damaging) nontarget organisms while carefully removing barnacles without damaging their peduncles (since this makes them unmarketable) (Ha'oom Fisheries Society 2024).

Importance to the US/North American market

Gooseneck barnacle has been gathered and consumed by the Nuu-chah-nulth First Nations for centuries. Previously shipped abroad to Europe, gooseneck barnacle remains popular overseas. Currently, the Nuu-chah-nulth catch is only sold domestically within Canada (Gagne et al. 2016). On average, gooseneck barnacle fetches about CAD15/lb (Jefferies 2018).

Common and market names

In North America, gooseneck barnacle may also be referred to as goose barnacle, stalked barnacle, leaf barnacle, or by its aboriginal name: *ca?inwa/ts'a7inwa* (pronounced "tsa-in-wa"). It may also go by *percebes*, as it is almost always called in both Spain and Portugal. The most common appellation in France is *pouce-pied* or *anatifes*.

Primary product forms

Collection of gooseneck barnacle occurs exclusively by hand harvesting using a long steel bar with the help of a modified vehicle leaf spring tool called a goose gun (Gagne et al. 2016). Traditionally, gooseneck barnacle has been harvested with a prying stick and eaten steamed, boiled, or roasted (Efford, 2019).

Once collected, gooseneck barnacle will degrade rapidly if not properly transported and packaged. In addition, it is quite fragile and can be easily damaged in the shipping process. Product is sold live to bulk buyers at the dock and delivered to restaurants (Edwards, 2020). The configuration of the stalk, rather than the weight of the barnacle, is the underlying indicator of product quality (Lessard et al. 2003). In restaurants, it is typically boiled or sautéed and served on its own as well as in soups, chowders, salads, or other seafood dishes. Depending on the meal, it can also be served barbequed or smoked.

Summary

This report covers the gooseneck barnacle (*Pollicipes polymerus*) fishery in British Columbia using hand harvesting techniques. This is an indigenous fishery with limited participants that uses quantitative stock assessment methods and local ecological knowledge to drive management decisions. Gooseneck barnacle is rated green overall.

Assessments

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

Leaf barnacle			
Region / Method	Abundance	Fishing Mortality	Score
Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area: Pacific, Northeast - Management Unit: West Coast of Vancouver Island	2.330 Moderate Concern	5.000 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.*

Leaf barnacle (*Pollicipes polymerus*)

1.1 Abundance

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderate concern

Gooseneck barnacle stock assessments are largely unavailable; however, stock monitoring is performed in lieu of full assessments. In addition, three different methodologies—GPS bed mapping, quadrat mapping, and local ecological knowledge (LEK)—have been used to develop gooseneck barnacle biomass and abundance estimates (Gagne et al. 2016). Quadrat surveys were conducted from 2001 to 2003 in Clayoquot Sound, Barkley Sound, and Kyuquot and resulted in 395 gooseneck barnacle density estimates ranging from 0 to 39 kg/m² and averaging 7 kg/m² (ibid). A total of 1,058,870 m² of potential gooseneck barnacle habitat (potential bed areas) exists within Clayoquot Sound (ibid). This area is used as a proxy for B₀, where the limit reference point (LRP) (20%B₀) would be 211,774 m² and the upper stock reference (USR) (40%B₀) would be 423,548 m² (ibid). Therefore, gooseneck barnacle in Clayoquot Sound would be considered in the healthy zone if a minimum of 423,548 m² of gooseneck barnacle area remained untouched, and outside the healthy zone if an area less than 211,774 m² was left (ibid). The LRP would be breached if refugia area was less than 211,774 m². Currently, 72% (761,125 m²) of Clayoquot Sound lies within the Pacific Rim National Park Reserve and is off-limits to commercial harvest (ibid), which would place the total gooseneck barnacle population within the healthy zone with the park acting as an important recruitment resource. Several areas of uncertainty remain regarding gooseneck barnacle abundance in BC waters. There are limitations of spatial and temporal data that may be biased toward surveyor behavior, and there is inherent subjectivity in the LEK estimates by experienced harvesters (ibid). Ground truthing has not been done to determine the proportion of occupied versus unoccupied potential habitat areas (Gagne et al. 2016). Tides and sampling conditions influence the proportion of beds possible to survey (ibid).

Because of the uncertainty in stock abundance for gooseneck barnacle, a productivity-susceptibility analysis (PSA) was conducted for this assessment (see Justification). The results of the PSA determined that gooseneck barnacle has a medium vulnerability, so gooseneck barnacle abundance is considered a “moderate concern” overall (per lines 2.a. and 2.e. in table 1.1.1 of the Seafood Watch Standard).

Supplementary information

Local ecological knowledge (LEK) surveys were conducted on 41 out of 52 harvest rocks to estimate harvestable gooseneck barnacle biomass over various periods between 2003 and 2005, and again in 2014 (Gagne et al. 2016). “LEK estimates of harvestable biomass over all years ranged from 0 to 2,727 kg (0 to 6,000 lbs)” (ibid). Though LEK and abundance surveys have continued beyond 2014, there is limited information available to update previous publications on growth, age, and natural mortality from 1999 (Lauzier, R.B. 1999; Gagne et al. 2016). This also means that appropriate harvest rates have not been updated since the initial fishery of the 1990s. To estimate the total biomass from LEK harvestable biomass, an equation was used by (Gagne et al. 2016). From this, a quantitative relationship between gooseneck barnacle bed area and LEK of harvestable biomass was established and provided a total rock biomass estimate for gooseneck barnacle (Edwards, 2020).

Despite these studies, there is still limited knowledge of gooseneck barnacle life history, and current abundance rates relative to a sustainable level are unknown, so a PSA is required.

Productivity-Susceptibility Analysis score for gooseneck barnacle in British Columbia.

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Average age at maturity	< 5 years	5–15 years	> 15 years	1	Mature at a rostral-carinal length of 14–17 mm, at between 1 and 3 years (DFO 1999).
Average maximum age	< 10 years	10–25 years	> 25 years		Unknown
Von Bertalanffy (Brody) Growth Coefficient (K) (to be used for species that exhibit first-order growth)	> 0.25	0.15–0.25	< 0.15		Unknown

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Fecundity	> 20,000 eggs per year	100–20,000 eggs per year	< 100 eggs per year	1	Producing 475,000–950,000 embryos per adult each season (spawning occurs from April to October, peaking in July). Larvae are planktonic and settle at 30–40 days or 0.5 mm (DFO 1999).
Reproductive strategy	Broadcast spawner	Demersal egg layer or brooder	Live bearer	2	Gooseneck barnacle is hermaphroditic and reproduces via pseudo-copulation rather than self-fertilization (Gagne et al. 2016; Lewis and Chia 1981; Galen Howard Hilgard 1960). Sperm-casting is also known to occur but the prevalence of this strategy is unknown.

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Density dependence	Compensatory dynamics at low population size demonstrated or likely	No depensatory or compensatory dynamics demonstrated or likely	Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely	1	Density dependence of gooseneck barnacle is unknown, but other barnacle species have exhibited positive population dynamics at higher densities (Leslie, 2005).
Productivity score (mean of attribute scores)				1.4	

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value/Notes; (Reference)
Areal overlap (all fisheries)	> 90% of species concentration is unfished	70-90% of species concentration is unfished	< 30% of species concentration is unfished	3	Considering the vast distribution of gooseneck barnacle throughout North America and that there is only one active fishery with minimal license, it is unlikely that areal overlap is below 30%, but it is still largely unknown.

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value/Notes; (Reference)
Vertical overlap	> 67% of species' depth range is unfished	33–66% of species' depth range is unfished	< 33% of species' depth range is unfished	3	Gooseneck barnacle is the target species and the fishery interacts directly with the barnacle and its habitat.
Seasonal availability (all fisheries)	Fisheries overlap with species < 3 months/year	Fisheries overlap with species 3–6 months/year	Fisheries overlap with species > 6 months/year	3	Fishery is open for harvest throughout the year (DFO 1999).
Selectivity of fishery (specific to fishery under assessment)	Species is not targeted AND is not likely to be captured by gear	Species is targeted, or is incidentally encountered AND is not likely to escape the gear	Species is targeted or is incidentally encountered AND combination of fishery attributes and species' biology increases its susceptibility to the gear	2	Highly selective, hand harvesting only
Post-capture mortality (specific to fishery under assessment)	> 66% individuals survive post-capture	33–66% individuals survive post-capture	Retained species or > 66% do not survive post-capture	3	100% mortality, damage may occur to unharvested barnacles, but post-harvest mortality is unknown.
Susceptibility score (mean of attribute scores)				2.8	

Productivity-Susceptibility Score ($V = \sqrt{(P2 + S2)}$)	3.13
Vulnerability Rating: < 2.64 = Low vulnerability, ≥ 2.64 and ≤ 3.18 = Medium vulnerability, > 3.18 = High vulnerability	Medium

1.2 Fishing mortality

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Low concern

Natural environmental conditions (i.e., seasonal tides and weather, intertidal topography) and marketable morphological requirements (i.e., correct size, shape, and color) limit the amount of gooseneck barnacle available for harvest at any given time. It was estimated that less than 10% of the entire west coast of Vancouver Island stock was available to the fishery during the experimental harvest in 2003–05 (DFO 2023). Today, gooseneck barnacle collection is localized to specific sites in Clayoquot Sound. At present, only 52 rocks have been designated as harvest sites.

Given the market requirements, many barnacles at harvest sites are not marketable and harvesters make an effort to avoid them. Harvesting is highly selective, and harvesters take care to avoid damaging nontargeted barnacles. Gooseneck barnacle harvest rates typically range from 9 to 15 kg of marketable product/hour and are limited to 7.5% of the estimated total rock biomass as a reference point that represents a sustainable level of harvest (Gagne et al. 2016; Edwards 2020). When this target harvest amount is reached, individual rocks are closed for 6 months, based on LEK (Edwards, 2020). Using the relationship between the LEK estimate of harvestable biomass and the quantitatively estimated median total biomass, the total rock biomass was estimated to range from 1,975 to 11,501 kg across the six study rocks (Gagne et al. 2016). Because of these precautionary limits and that there are no other fisheries for gooseneck barnacle in North America, the fishery is not a substantial contributor to fishing mortality, so total fishing mortality is considered a “low concern” (per line 1 in table 1.2.1 of the Seafood Watch Standard).

Criterion 2: Impacts on other species

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

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

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

Guiding principles

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

Criterion 2 summary

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.

Leaf barnacle			
Region / Method	Sub Score	Discard Rate/Landings	Score
Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area: Pacific, Northeast - Management Unit: West Coast of Vancouver Island	2.644	1.000: < 100%	Yellow (2.644)

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 - West Coast of Vancouver Island			
Sub Score: 2.644	Discard Rate: 1.000		Score: 2.644
Species	Abundance	Fishing Mortality	Score
Acorn barnacle	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
California mussel	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Thatched barnacle	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Leaf barnacle	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Blue mussel	5.000: Very Low Concern	5.000: Low Concern	Green (5.000)

Given that harvesters have specific marketable size and shape requirements, an individual barnacle can be assessed before its removal, thus making this a highly selective fishery. Harvesters use hand implements to remove barnacles of marketable size from their rocks and remove any attached conspecifics (nonmarket-sized gooseneck barnacle) and heterospecifics (i.e., mussels). This process means that the incidental take of nontarget species can occur. Most of the bycatch is juvenile barnacles, which attach to the peduncles of larger mature individuals.

Two mussel species, California mussel (*Mytilus californianus*) and blue mussel (*M. edulis*), are also collected when they are tightly attached to a clump of harvestable barnacles. There is currently no directed commercial fishery for

California mussel in BC; however, harvest does occur to support the Canadian Shellfish Sanitation Program to monitor Paralytic Shellfish Poison (PSP) along the coast (Schmidt 1999). Blue mussel is not native to BC and has been introduced from mussel farming operations (Schmidt 1999). Recreational harvest of blue mussel occurs but is limited and not considered widespread. Because of the nonnative nature of blue mussel and the harvest of both species for PSP, bycatch within the gooseneck barnacle fishery is considered a “low concern.”

Edwards (2020) “found that for every 1% increase of gooseneck barnacles harvested, there was a 2% increase in bycatch of mussels.” Edwards (2020) also observed low mortality rates of mussel bycatch, where mussels that were removed from rocks and replaced onto the substratum were able to secure themselves back in place by secreting new byssus threads. Given these findings, the small area in which the barnacle fishery operates relative to the range of these species, and that no fisheries for these mussel species currently exist, these mussel stocks are likely near virgin biomass, and the fishery is deemed to have negligible impacts on the populations of these species. Similarly, acorn barnacle (*Balanus glandula*) and thatched barnacle (*Semibalanus cariosus*) have the potential to occur as bycatch, but rates of bycatch have not been quantified to date (ibid). Any species that occur alongside gooseneck barnacle are removed during harvest and returned to the rocks.

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

Acorn barnacle (*Balanus glandula*)

2.1 Abundance

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderate concern

Acorn barnacle forms dense aggregations on rocky substrate, with gooseneck barnacle beds forming within and on top of these other conspecifics. Therefore, acorn barnacle may be taken during harvest in cases where it is tightly attached to a clump of harvestable gooseneck barnacle. There are currently no other harvest activities for acorn barnacle, and little information is available about its total abundance in BC waters.

Because of the limited knowledge of acorn barnacle abundance in BC, a PSA was conducted. The results of the PSA determined that acorn barnacle has a medium vulnerability. Therefore, acorn barnacle abundance receives a “moderate concern” score (per line 3 in table 1.1.1 in the Seafood Watch Standard).

Supplementary information

Because of the overlap of acorn barnacle beds with harvestable gooseneck barnacle habitat, it is possible that some disturbance of beds occurs. The overlap of the fishery with acorn barnacle density is unknown, and there is a lack of formal stock assessments or detailed biological information, so a PSA was conducted.

Productivity-Susceptibility Analysis for acorn barnacle.

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Average age at maturity	< 5 years	5–15 years	> 15 years	1	Maturity occurs within the first year (Barnes and Barnes 1959).
Average maximum age	< 10 years	10–25 years	> 25 years	1	Maximum lifespan is usually less than 3 years (Newman, W. A., & McConnaughey, R. A. 1987)

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Von Bertalanffy (Brody) Growth Coefficient (K) (to be used for species that exhibit first-order growth)	> 0.25	0.15–0.25	< 0.15		Unknown
Fecundity	> 20,000 eggs per year	100–20,000 eggs per year	< 100 eggs per year	1	Tens of thousands of eggs per reproductive cycle (Barnes and Barnes 1959).
Reproductive strategy	Broadcast spawner	Demersal egg layer or brooder	Live bearer	1	Simultaneous hermaphrodite; both cross- and self-fertilization possible, with evidence of sperm-casting also being used (Barnes and Barnes 1959).
Density dependence	Compensatory dynamics at low population size demonstrated or likely	No compensatory dynamics demonstrated or likely	Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely	2	High density of barnacles can reduce individual growth and reproductive output (Connell, 1985). Barnacle clearing negative affects recruitment from rock beds.
Productivity score (mean of attribute scores)				1.2	

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value/Notes; (Reference)
Areal overlap (all fisheries)	> 90% of species concentration is unfished	70-90% of species concentration is unfished	< 30% of species concentration is unfished	3	Acorn barnacle is widespread throughout the intertidal zone, with distribution overlapping with coastal harvest zones; however, the total extent of overlap throughout its range is unknown.
Vertical overlap	> 67% of species' depth range is unfished	33-66% of species' depth range is unfished	< 33% of species' depth range is unfished	3	As an intertidal species, acorn barnacle is accessible throughout the tide cycle and overlaps with vertical distribution of gooseneck barnacle harvest; however, the full extent is unknown.

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value/Notes; (Reference)
Seasonal availability (all fisheries)	Fisheries overlap with species < 3 months/year	Fisheries overlap with species 3–6 months/year	Fisheries overlap with species > 6 months/year	2	Available year-round with reproductive peaks corresponding to changing water temperatures throughout its range; however, this is unlikely to affect overlap with gooseneck barnacle harvest and there are currently no other fisheries or harvest for acorn barnacle.
Selectivity of fishery (specific to fishery under assessment)	Species is not targeted AND is not likely to be captured by gear	Species is targeted, or is incidentally encountered AND is not likely to escape the gear	Species is targeted or is incidentally encountered AND combination of fishery attributes and species' biology increases its susceptibility to the gear	1	Fishery is highly selective.
Post-capture mortality (specific to fishery under assessment)	> 66% individuals survive post-capture	33–66% individuals survive post-capture	Retained species or > 66% do not survive post-capture	3	Post-capture mortality is unknown.
Susceptibility score (mean of attribute scores)				2.4	

Productivity-Susceptibility Score ($V = \sqrt{(P2 + S2)}$)	2.68
Vulnerability Rating: < 2.64 = Low vulnerability, ≥ 2.64 and ≤ 3.18 = Medium vulnerability, > 3.18 = High vulnerability	Medium

2.2 Fishing mortality

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderate concern

Total fishing mortality of other barnacles removed during gooseneck barnacle harvest is unknown. No other commercial or recreational fishery exists for this species. Bycatch of conspecific barnacles during gooseneck barnacle harvest has been reported, but the hand harvesting techniques of the fishery aim to reduce the potential for mortality, and efforts are taken to avoid densely aggregated beds of other barnacles (Picco 2025, pers comm). For these reasons, fishing mortality is considered a “moderate concern” (per line 3 in table 1.2.1 in the Seafood Watch Standard).

Blue mussel (*Mytilus edulis*)

2.1 Abundance

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Very low concern

Blue mussel is associated with gooseneck barnacle when the mussel is attached to a clump of harvestable barnacles. Blue mussel is not native to BC and has been introduced from mussel farming operations (Schmidt 1999). Recreational harvest of blue mussel occurs but is limited and not considered widespread. Because of the nonnative nature of blue mussel, there is little concern about its abundance despite an absence of stock assessments. Therefore, abundance is considered a “very low concern” (per line 3 in table 1.1.1 of the Seafood Watch Standard).

2.2 Fishing mortality

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Low concern

Fishing mortality of blue mussel from gooseneck barnacle harvest is not well known; however, hand harvesting techniques reduce the total impact on nontarget species. Studies have suggested that bycatch of mussels during gooseneck harvest is limited and that mortality is unlikely (Edwards, 2020). Blue mussel is nonnative to BC waters and was introduced as a result of mussel cultivation. Therefore, fishing mortality is considered a “low concern” (per line 2 in table 1.2.1 in the Seafood Watch Standard).

California mussel (*Mytilus californianus*)

2.1 Abundance

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderate concern

California mussel may be taken during harvest in cases where it is tightly attached to a clump of harvestable barnacles. There is currently no directed commercial fishery for California mussel in BC; however, harvest does occur to support the Canadian Shellfish Sanitation Program to monitor Paralytic Shellfish Poison (PSP) along the coast (Schmidt 1999). Any species that occurs alongside gooseneck barnacle is removed during harvest and returned to the rocks, including mussels. Recreation fishing for California mussel is permitted in BC, with a limit of 25 mussels per day (total possession of 50 mussels) on the south coast of Vancouver Island and a reduced limit of 12 mussels per day within the Pacific Rim National Park on WCVI (Gillespe 1999). Other areas along Vancouver Island are closed to shellfish harvest because of contamination concerns. Recreational harvest occurs by hand and is considered limited across BC. Previous reports have outlined the potential of a commercial fishery for California mussel in BC, but no fishery has since been established (Gillespe 1999) (Schmidt 1999).

Because of the limited knowledge on California mussel abundance in BC, a PSA was conducted. The results of the PSA determined that California mussel has a low vulnerability. Therefore, abundance receives a “moderate concern” score (per lines 2a and 2e in table 1.1.1 in the Seafood Watch Standard).

Supplementary information

Because of the overlap of California mussel beds with harvestable gooseneck barnacle habitat, it is possible that some disturbance of mussel beds occurs. The overlap of the fishery with mussel density is unknown, and there is a lack of formal stock assessments for California mussel, so a PSA was conducted.

Productivity-Susceptibility Analysis for California mussel.

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Average age at maturity	< 5 years	5–15 years	> 15 years	1	Average size at maturity is between 70 and 150 mm and is reached in an average of 3 years (Gillespe 1999; Neal, E 2014); however, some records show that maturity in highly productive, warm environments can be reached in as little as 1 year (Vriesman et al. 2022).
Average maximum age	< 10 years	10–25 years	> 25 years	2	20 years, with upper estimates reaching 50–100 years (Gillespe 1999).
Von Bertalanffy (Brody) Growth Coefficient (K) (to be used for species that exhibit first-order growth)	> 0.25	0.15–0.25	< 0.15		Unknown

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Fecundity	> 20,000 eggs per year	100–20,000 eggs per year	< 100 eggs per year	1	Highly fecund with reproduction happening year-round and producing an estimated ten million eggs, and fecundity is known to increase with mussel size (Gillespe 1999).
Reproductive strategy	Broadcast spawner	Demersal egg layer or brooder	Live bearer	1	California mussel is a broadcast spawner that releases gametes into the water year-round, with peak seasons in the spring and fall (Gillespe 1999).

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Density dependence	Compensatory dynamics at low population size demonstrated or likely	No depensatory or compensatory dynamics demonstrated or likely	Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely	2	California mussel exhibits density-linked stochasticity, where population fluctuations are driven by environmental variations rather than traditional density dependence (Wootton and Forester 2013). Large mussel beds may support recruitment of new mussels by protecting against wave action during settlement (Gillespe 1999).
Productivity score (mean of attribute scores)				1.4	

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value and notes
Areal overlap (all fisheries)	> 90% of species concentration is unfished	70–90% of species concentration is unfished	< 30% of species concentration is unfished	1	California mussel is native to the West Coast of North America, ranging from Alaska to Baja California (Gillespe 1999). The gooseneck barnacle fishery only occurs on 52 rocks in Clayoquot Sound off the coast of WCVI. Similarly, recreational and scientific sampling occur in limited geographic ranges and quantities. Though the extent of California mussel beds within the harvestable area is unknown, the total overlap of the fishery with the range of California mussel occurrence is quite low.

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value and notes
Vertical overlap	> 67% of species' depth range is unfished	33–66% of species' depth range is unfished	< 33% of species' depth range is unfished	1	California mussels beds are densely aggregated and range from the upper intertidal to subtidal depths (Gillespe 1999). Though overlap with fishing activity from all sources is possible, it covers a small extent of total mussel habitat.
Seasonal availability (all fisheries)	Fisheries overlap with species < 3 months/year	Fisheries overlap with species 3–6 months/year	Fisheries overlap with species > 6 months/year	3	California mussel is effectively a sessile individual that spawns year-round, with peak reproduction occurring in the spring and fall (Gillespe 1999).
Selectivity of fishery (specific to fishery under assessment)	Species is not targeted AND is not likely to be captured by gear	Species is targeted, or is incidentally encountered AND is not likely to escape the gear	Species is targeted or is incidentally encountered AND combination of fishery attributes and species' biology increases its susceptibility to the gear	1	Hand harvesting is a highly selective method. Mussels are avoided by harvesters wherever possible and returned to the beds once barnacles are removed.

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value and notes
Post-capture mortality (specific to fishery under assessment)	> 66% individuals survive post- capture	33-66% individuals survive post-capture	Retained species or > 66% do not survive post- capture	3	Post-harvest mortality is unknown; however, mussels have demonstrated the ability to reattach to substrate by regrowing byssal threads after removal. California mussel beds are known to recover from disturbance, and the rate of recovery is dependent on the size of the gap (Gillespe 1999). Recovery of small gaps is rapid, whereas large gaps may take longer to recover (Gillespe 1999).
Susceptibility score (mean of attribute scores)				1.8	

Productivity-Susceptibility Score ($V = \sqrt{(P2 + S2)}$)	2.28
Vulnerability Rating: < 2.64 = Low vulnerability, ≥ 2.64 and ≤ 3.18 = Medium vulnerability, > 3.18 = High vulnerability	Low

2.2 Fishing mortality

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderate concern

Total fishing mortality of California mussel removed during gooseneck barnacle harvest is unknown. No other commercial fishery exists for this species, but some recreational harvest is permitted. Bycatch of California mussel during gooseneck barnacle harvest has been reported, but the hand harvesting techniques of the fishery aim to reduce the potential for mortality, and all incidentally taken mussels are returned to the rocks (Edwards, 2020). It is not well known how readily mussels may reattach to substrate, but it is possible for mussels to regrow byssal threads and reestablish within the bed area (Edwards, 2020). For these reasons, fishing mortality is considered a “moderate concern” (per line 3 in table 1.2.1 in the Seafood Watch Standard).

Thatched barnacle (*Semibalanus cariosus*)

2.1 Abundance

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderate concern

Thatched barnacle forms dense aggregations on rocky substrate, with gooseneck barnacle forming within and on top of these other conspecific beds. Thatched barnacle grows up to roughly 60 mm in diameter. Therefore, thatched barnacle may be taken during harvest in cases where it is tightly attached to a clump of harvestable gooseneck barnacles. There are currently no other harvest activities for thatched barnacle, and little information is available about its total abundance in BC waters. Because of the limited knowledge on thatched barnacle abundance in BC, a PSA was conducted. The results of the PSA determined that thatched barnacle has a medium vulnerability. Therefore, abundance receives a “moderate concern” score (per lines 2a and 2e in table 1.1.1 in the Seafood Watch Standard).

Supplementary information

Because of the overlap of thatched barnacle beds with harvestable gooseneck barnacle habitat, it is possible that some disturbance of beds occurs. The overlap of the fishery with thatched barnacle density is unknown, and there is a lack of formal stock assessments or detailed biological information, so a PSA was conducted.

Productivity-Susceptibility Analysis of thatched barnacle.

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Average age at maturity	< 5 years	5-15 years	> 15 years	1	Average age at maturity is unknown, but likely occurs within the first year, similar to other barnacle species.
Average maximum age	< 10 years	10-25 years	> 25 years	2	Known to live up to 15 years, yet average lifespan is unknown (Cowles 2006).
Von Bertalanffy (Brody) Growth Coefficient (K) (to be used for species that exhibit first-order growth)	> 0.25	0.15-0.25	< 0.15		Unknown
Fecundity	> 20,000 eggs per year	100-20,000 eggs per year	< 100 eggs per year	2	Fecundity of thatched barnacle is not well known, but in keeping with similar barnacles species, is likely tens of thousands per year.

Productivity Attribute	High productivity (low risk, score = 1)	Medium productivity (medium risk, score = 2)	Low productivity (high risk, score = 3)	Score	Value and notes
Reproductive strategy	Broadcast spawner	Demersal egg layer or brooder	Live bearer	2	Eggs are brooded in the fall and/or winter depending on water temperature and location, with larvae being released in the spring before settling (University of California, Santa Cruz. n.d.).
Density dependence	Compensatory dynamics at low population size demonstrated or likely	No depensatory or compensatory dynamics demonstrated or likely	Depensatory dynamics at low population sizes (Allee effects) demonstrated or likely	2	Like other barnacles, high densities can reduce individual growth and reproductive output (Connell, 1985). Barnacle clearing negatively affects recruitment from rock beds (Menge, 2000).
Productivity score (mean of attribute scores)				1.8	

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value and notes
Areal overlap (all fisheries)	> 90% of species concentration is unfished	70–90% of species concentration is unfished	< 30% of species concentration is unfished	3	Thatched barnacle is widespread throughout the intertidal zone, with distribution overlapping with coastal harvest zones; however, the total extent of overlap throughout its range is unknown.
Vertical overlap	> 67% of species' depth range is unfished	33–66% of species' depth range is unfished	< 33% of species' depth range is unfished	3	As an intertidal species, thatched barnacle is accessible throughout the tide cycle and overlaps with vertical distribution of gooseneck barnacle harvest; however, the full extent is unknown. There is no other known take of thatched barnacle from fishing. Intertidal and shallow subtidal zone inhabitant (Menge, 2000).

Susceptibility Attribute (default scores in bold)	Low S (score = 1)	Medium S (score = 2)	High S (score = 3)	Score	Value and notes
Seasonal availability (all fisheries)	Fisheries overlap with species < 3 months/year	Fisheries overlap with species 3–6 months/year	Fisheries overlap with species > 6 months/year	2	Available year-round with reproductive peaks corresponding to changing water temperatures throughout its range; however, this is unlikely to affect overlap with gooseneck barnacle harvest.
Selectivity of fishery (specific to fishery under assessment)	Species is not targeted AND is not likely to be captured by gear	Species is targeted, or is incidentally encountered AND is not likely to escape the gear	Species is targeted or is incidentally encountered AND combination of fishery attributes and species' biology increases its susceptibility to the gear	1	Fishery is highly selective.
Post-capture mortality (specific to fishery under assessment)	> 66% individuals survive post-capture	33–66% individuals survive post-capture	Retained species or > 66% do not survive post-capture	3	Post-capture mortality is unknown.
Susceptibility score (mean of attribute scores)				2.4	

Productivity-Susceptibility Score ($V = \sqrt{(P2 + S2)}$)	3.00
Vulnerability Rating: < 2.64 = Low vulnerability, ≥ 2.64 and ≤ 3.18 = Medium vulnerability, > 3.18 = High vulnerability	Medium

2.2 Fishing mortality

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderate concern

Total fishing mortality of other barnacles removed during gooseneck barnacle harvest is unknown. No other commercial or recreational fishery exists for this species. Bycatch of conspecific barnacles during gooseneck barnacle harvest has been reported, but the hand harvesting techniques of the fishery aim to reduce the potential for mortality, and efforts are taken to avoid densely aggregated beds of other barnacles (Picco 2025, pers comm). For these reasons, fishing mortality is considered a “moderate concern” (per line 3 in table 1.2.1 in the Seafood Watch Standard).

2.3 Discard rate/landings

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

< 100%

Although no formal discard information is available for this fishery, discards do occur when undersized barnacles or nontarget species are incidentally taken because they are attached to harvestable gooseneck barnacles. Any species associated with gooseneck barnacle clusters is removed and discarded during harvest, but not all gooseneck barnacle rosette clusters will occur with other species. Bycatch and discards of some gooseneck barnacles is unavoidable because those with damaged peduncles are unmarketable. But the majority of removed biomass is of the target size and of the primary target species. Mussels that are removed without damage when attached to gooseneck barnacle clusters are able to be placed back onto rocks to reattach (Edwards, 2020) (Picco 2025, pers comm). Because there is no bait use in this fishery and the total amount of discards is minimal, the discard to landing ratio is < 100% (per line 1 in table 2.3.1 in the Seafood Watch Standard v4).

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 strategy' 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 And Implementation	Bycatch Strategy	Scientific Data Collection and Analysis	Enforcement of and Compliance with Management Regulations	Stakeholder Inclusion	Score
Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area: Pacific, Northeast - Management Unit: West Coast of Vancouver Island	Highly effective	Highly effective	Moderately Effective	Highly effective	Highly effective	Green (4.000)

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 managers follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

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.

3.1 Management strategy and implementation

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Highly effective

Gooseneck barnacle harvest is managed on a rock-by-rock basis for the 52 harvest rocks in Clayoquot Sound with a quite small quota (12,000 lb) authorized by DFO on an annual basis (DFO 2023). Harvest rock, quota, and harvest rate may change in season depending on biological assessment information (DFO 2023). The fishery is managed on rotating closures where fishing areas are closed for 6 months once the LEK limit is reached, to allow for recovery (Edwards, 2020). But recent research suggested that this timeline may not be long enough to allow the recovery of harvested areas and that 14 months may be a more precautionary timeline (Edwards, 2020). Edwards notes that this may only be required during periods of slower growth rates and stresses the need for more continued research on gooseneck barnacle recovery rates (Edwards, 2020). Rock-specific quotas are based on precautionary estimates of site abundance, and strict assessment and monitoring measures are in place for a site once it reaches its harvest threshold. In addition to the sustainable harvest of gooseneck barnacles, one of the primary management goals is filling in data gaps pertaining to this species, both ecologically and biologically. Managing this fishery as a smaller group of stocks (i.e., rocks) was suggested as a more conservative way to prevent overfishing and an alternative to managing the fishery as one large meta-population (Lauzier, R.B. 1999).

The 2023/24 Fisheries Management Plan (FMP) is the fifth Multi-Species FMP developed by DFO since the 2018 Court Order for gooseneck barnacle, and includes other species harvested by the five Nations (salmon, sea cucumber, crab, halibut, and spot prawn) (DFO 2023). Only members of the Nuu-chah-nulth Five Nations (Ahousaht, Ehattesaht, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht First Nations) are eligible to participate in the fishery, and participants are designated by their Nation (DFO 2023). The fishery is currently comanaged by DFO and the Nuu-chah-nulth First Nations. The Ha'oom Fisheries Society works cooperatively to support and facilitate the participation of the Five Nations in the implementation of their commercial rights-based fisheries, including data collection and monitoring of the fisheries (Edwards, 2020). Ha'oom staff work closely with DFO on stock assessment and fishery management.

The fishery has highly appropriate strategy and goals (Gagne et al. 2016) and there is evidence that the strategy is being implemented successfully. Management strategy and implementation is considered “highly effective” (per lines 1–6 in table 3.1.1 of the Seafood Watch Standard).

Supplementary information

Since 2010, five Nations representatives, Uu-a-thluk (the aquatic resource management organization administered through the Nuuchahnulth Tribal Council), and DFO staff have been reviewing the information from the 2003–05 experimental fishery and planning the reopening of the WCVI gooseneck barnacle fishery (DFO 2023). A limited fishery reopened in September 2013 as a market-test fishery and will grow and expand as markets and harvester capacity are developed. In 2016, a publication updating the existing Gooseneck Framework from 1999 (Lauzier, R.B. 1999) was produced by T'aaq-wiihaak and DFO staff (Gagne et al. 2016) that outlines a method for assessing gooseneck population density in Clayoquot Sound using both quadrat and LEK methods, as well as gooseneck bed area mapping. This publication supports the recommended 7.5% harvest rate from (Lauzier, R.B. 1999) calculated using the Gulland model (Gulland 1971; DFO 2023).

Harvest rates are currently set at this precautionary 7.5% of the estimated biomass for each rock, ensuring that appropriate conservation and allocation goals are met. By preventing overexploitation at every rock, this precautionary approach precludes the need for a critical reference point (B_{crit}) for the fishery as a whole. A novel approach was used in the development of reference points compliant with the Precautionary Approach (DFO 2009), where the use of estimated total potential habitat as a proxy for virgin biomass (B_0) is recommended as an interim measure. This approach proposes provisional limit reference points (LRP) and upper reference points (URP) of 20% and 40% of the estimated total potential habitat. Because LRP and UR values are provisional, closures have been used to conserve abundance with the current estimate of 72% of gooseneck barnacle area being in refugia, placing the Clayoquot Sound population in the healthy zone (Gagne et al. 2016). No rocks have been closed so far, thus $B_{current} = .93B_0$ at each site. Management objectives have been defined in the 2014–2015 T'aaq-wiihak Goose Barnacle Harvest Plan (T'aaq-wiihak 2015). DFO has set a landing quota of 1,000 lb (453 kg) per month; as a result of inaccessibility (i.e., ocean conditions) and low market demand, this quota has not been reached in any month since the fishery opened. Communal Sale Fishery licenses are used within the fishery, and the Nations' traditional leadership (the Ha'wiih) designates fishers to participate (Edwards, 2020) (T'aaq-wiihak 2015).

Other goals of the fishery pertain to ensuring fishery safety (i.e., fishers must travel in pairs, log all weather conditions, and report in as required), as well as maintaining the economic viability of gooseneck barnacle, for long-term fisher job security. Although few fishers participate in the fishery at the present, overcapacity (and thus overexploitation) should ultimately be limited by the location of the fishery (i.e., it is only permitted in certain regions of the T'aaq-wiihak Fishing Area) and by the number of individuals designed to participate in the fishery.

3.2 Bycatch strategy

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Highly effective

There are currently no overfished, depleted, endangered, or threatened species targeted or retained by the fishery. Mussels and other barnacles may be incidentally harvested, but hand harvesting techniques and specialized gear help to reduce incidents of bycatch. If mussels are incidentally taken, every effort is made to ensure that they are returned to the rocks and have the potential to reattach. Specialized training and harvester experience also help to ensure that nonharvestable barnacles and potential bycatch are handled in appropriate ways to reduce incidental mortality. Because of these considerations of bycatch during harvest, the minimal bycatch, and the lack of sensitive species interactions, bycatch strategy is considered “highly effective” (per lines 1, 2b, and 3 in table 3.2.1 of the Seafood Watch Standard).

3.3 Scientific data collection and analysis

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Moderately effective

The management process uses an independent and up-to-date, species-specific stock analysis that integrates both fishery-independent and appropriate fishery-dependent data. Research and monitoring, while not complete, have been ongoing for the fishery since its original commercial operations in the 1980s and 1990s. After the closure of the fishery in 1999, two experimental harvests took place in conjunction with stock and habitat assessment projects (DFO 2023). Over the years, other efforts to increase the understanding of gooseneck barnacle in Clayoquot Sound have been undertaken, primarily the inclusion of LEK and GPS mapping to identify site-specific population structures (Gagne et al. 2016). The 2014 stock assessment included these methodologies, and landings data for each harvest rock have been collected since the fishery reopened in 2013 (DFO 2023). LEK is increasingly used to supplement quantitative scientific information and fill in data gaps. Incorporating LEK into management decision-making and scientific assessment allows fishers to become more involved and empowered, bringing benefits such as better fish stock management and conservation strategies that are more localized (Rivera et al. 2014; Gagne et al. 2016).

Ha'oom Fisheries Society works collaboratively to support the scientific research, monitoring, and facilitation of the five Nations' participation in their commercial rights-based fisheries, including gooseneck barnacle (Ha'oom Fisheries Society 2024). Ha'oom employs biologists, research technicians, and community liaisons to perform research activities, produce rigorous scientific assessments, and implement fisheries management decision-making. Through their efforts, the fishery has regular data collection and monitoring to ensure that harvest levels are appropriate and that harvested rocks are recovering (Edwards, 2020). Since 2014, two peer-reviewed publications from Gagne et al. (2016) and Edwards (2020) have added to the general knowledge and understanding of the gooseneck barnacle fishery. Because of the regular data collection, scientific data collection and analysis is considered “moderately effective” (per line 1 in table 3.3.1 of the Seafood Watch Standard).

3.4 Enforcement of and compliance with management regulations

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Highly effective

Regulations and agreed voluntary arrangements between DFO and the fishery are regularly enforced and independently verified. Enforcement measures include the validation of logbook reports, 100% dockside monitoring, proper fisher training, post-harvest rock site checks (i.e., fisheries managers examine the state of recent harvest sites), and ensuring that the fishery operates outside of designated BC Provincial Park reserves. Fishers complete Ha'oom Logbook templates that must remain with the harvester at all times during the duration of harvest and are completed each night and submitted (DFO 2024). Dockside observers validate and weigh the harvesters' catch, collect their logbooks, and issue sales slips once landed (Edwards, 2020).

Because of safety considerations, permission to fish from the Ha'wiih is granted only to fishers who have experience and training to harvest. The five Nations' right-based commercial fishery is authorized under the Aboriginal Communal Fishing Licenses Regulations (ACFLR), where community members and vessels are chosen and authorized to participate in the fishery under the conditions set out in the license(s) issued by DFO authorizing the fishery (DFO 2023). If a harvester breaks the rules (e.g., knowingly takes barnacles from a closed area, sells any barnacles illegally), the Ha'wiih can revoke the permission to fish ("permission to fish" is the Nuu-chah-nulth word T'aaq-wiihak).

One of the main concerns for the sustainability of the fishery and gooseneck barnacle beds is clear-cutting, where barnacles are less likely to have recovery potential. To prevent clear-cutting (which was a concern pertaining to novice harvesters in the 1980s/1990s barnacle fishery), all new fishers must be trained and supervised by an experienced harvester before their participation in the fishery (Gagne et al. 2016). Given the current size of the fishery, noncompliance has not yet been a serious concern, so this relationship is largely in place as a precautionary measure if the fishery expands in the future. Therefore, enforcement of and compliance with management regulations is considered "highly effective" (per line 1 in table 3.4.1 of the Seafood Watch Standard).

3.5 Stakeholder inclusion

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Highly effective

The five Nations gooseneck barnacle fishery is comanaged by the five Nations and DFO. While DFO licenses the fishery, TACs are derived through ongoing, cooperative discussions between Nuu-chah-nulth and government representatives; members from both organizations meet frequently. Experienced Nuu-chah-nulth fishers are invaluable to the management process because they conduct ongoing LEK surveys for the stock assessments and provide training and mentorship for new gooseneck barnacle fishers (Gagne et al. 2016). T'aaq-wiihak gooseneck barnacle harvesters have developed a robust LEK knowledge base from the amount of time spent at harvesting sites and the frequency of harvest schedules (ibid). Further, Nuu-chah-nulth First Nations have been harvesting gooseneck barnacle for centuries using traditional harvesting techniques, which has supported LEK development over many generations of harvesters. Experience in barnacle harvest is passed down by harvesters, often between family members to younger members entering the fishery (ibid).

Despite engagement in fishery decision-making, the five Nations do not agree that the FMP fully accommodates their Aboriginal right or complies with the judgments of the BC courts. Therefore, the five Nations developed a Multi-Species Fisheries Management Plan (MSFMP) for 2023–24 that outlines their expectations for fishery management, species allocations, and fishery implementation. DFO has considered this plan in developing the 2023–24 FMP (DFO 2023). The Government of Canada and the five Nations have completed the ratification process for the 2024 Incremental Reconciliation Agreement for Fishery Resources (IRA FR), which would see the creation of a five-Nations-led Annual Fishing Plan to replace the 2023–24 FMP (DFO 2024). The IRA FR was signed in July 2024, and collaborative development of the Community-Based Economic Fishery Annual Fishing Plan is underway. DFO has committed to continue working with the Nation to support fishery comanagement and allocation and the Community-Based Economic Fishery under the terms of a 2024 reconciliation agreement.

The Ha'oom Fisheries Society also supports five Nations rights-based fishing allocation and engages directly with the fishery and DFO. The comanagement structure and involvement of local fishers and five Nations members in decision-making show that, although imperfect, stakeholder and rightsholder inclusion is happening, and the influence of processes such as LEK integration are having positive impacts on the fishery and its management.

Management decision-making is transparent and includes input from fishers and/or organizations acting on their behalf, with high levels of local input on research and data collection. Therefore, stakeholder inclusion is considered “highly effective” (per line 1 in table 3.5.1 of the Seafood Watch Standard).

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	Physical Impact of Fishing Gear on the Habitat/Substrate	Modifying Factor: Mitigation of Gear Impacts	Ecosystem-based Fisheries Management	Score
Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area: Pacific, Northeast - Management Unit: West Coast of Vancouver Island	Score: 5	Score: 0	Low Concern	Green (4.472)

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.*

4.1 Physical impact of fishing gear on the habitat/substrate

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Score: 5

Barnacles and mussels are habitat-forming species, so the potential impacts to habitat include the direct harvest of barnacle clusters and attached conspecifics, as well as direct contact with the substrate by the harvesters while accessing each rock. But the fishery is limited to a few people over a small area of the intertidal habitat that is available to these habitat-forming species, so the fishery has no significant impact on the substrate or habitat. Because of the remote and dangerous nature of the harvest sites, there is no public traffic, and the only people visiting these rocks would be barnacle harvesters. The physical impact on the substrate is minimal.

The gear used for this fishery does not contact the bottom, apart from fisher foot traffic on sandy or muddy intertidal areas and contact with harvestable rocks, which cause minimal disturbance. Therefore, physical impact of fishing gear on the habitat/substrate receives a score of “5” (per line 1 in the Seafood Watch Standard).

Supplementary information

A modified vehicle leaf spring tool (a.k.a. “goose gun”) is used to pry a fistful of gooseneck barnacles from the surrounding barnacle–mussel bed. As a result, harvesters are able to remove marketable barnacles without contacting the underlying rock substrate with this tool.

4.2 Modifying factor: mitigation of gear impacts

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Score: 0

There is no impact on other species or habitat that requires mitigation, so there are no modifying factors.

4.3 Ecosystem-based fisheries management

Canada - British Columbia - Northeast Pacific Ocean - Hand implements - FAO Major Area:
Pacific, Northeast - Management Unit: West Coast of Vancouver Island

Low concern

A substantial proportion of the fishery area is protected in no-take marine reserves, which are designed to be effective for protecting the underlying ecosystem function. The fishery for gooseneck barnacle falls within a clearly defined coastal region in Clayoquot Sound along WCVI (i.e., within the T'aaq-wiihak Fishing Area). As discussed (see Criterion 1), only specific sites within this area are available to fishers. As much as 72% (761,125 m²) of Clayoquot Sound lies within the Pacific Rim National Park Reserve and is off-limits to commercial harvest. These no-take reserves create areas of refuge to support the ecosystem function and recovery of harvested gooseneck barnacle rocks and other intertidal species. The presence of these reserves also helps maintain the ecological processes and interactions that occur naturally between both terrestrial and marine flora and fauna along the WCVI. The inclusion of LEK in decision-making and management also considers the role of the larger ecosystem, and the Nuu-chah-nulth have stewarded their natural resources for generations. Five Nations' fishers observe a code of environmental stewardship based on the Nuu-chah-nulth principles "hishukish t'sawalk" (everything is one) and "iisaak" (respect with caring) that works to preserve rather than deplete fisheries resources for future generations (Ha'oom Fisheries Society 2024). This fishery has a quite low impact and minimal effect on the ecosystem, where the natural removals of large swaths of the barnacle community on harvestable rocks by annual storms are much larger than the average harvest amount (Picco 2025, pers comm). Thus, ecosystem-based fisheries management is considered a "low concern" (per lines 1.a, 1.b, and 1.c in table 4.3.1 of the Seafood Watch Standard).

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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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