



# Monterey Bay Aquarium Seafood Watch®

## Leaf Barnacle (Gooseneck barnacle)

*Pollicipes polymerus*



Image © Monterey Bay Aquarium

## British Columbia

Hand Collected

June 4, 2015

Laurenne Schiller, Consulting Researcher

### Disclaimer

Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

## **About Seafood Watch®**

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

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

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

## Guiding Principles

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

Based on this principle, Seafood Watch had developed four sustainability **criteria** for evaluating wild-catch fisheries for consumers and businesses. These criteria are:

- How does fishing affect the species under assessment?
- How does the fishing affect other, target and non-target species?
- How effective is the fishery’s management?
- How does the fishing affect habitats and the stability of the ecosystem?

Each criterion includes:

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

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

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

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

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

---

<sup>1</sup> “Fish” is used throughout this document to refer to finfish, shellfish and other invertebrates.

## **Summary**

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

The 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. Barnacles have unique life history strategies, being both sessile and live brooding organisms. As such, they have a high inherent vulnerability to fishing.

A previous gooseneck barnacle fishery existed in this region in the 1980/90s. However, due to concerns of overcapacity and uncertainty of fishing impacts it was closed in 1999 to allow for rebuilding and proper assessment. A limited commercial gooseneck barnacle fishery re-opened most recently in September 2013, and it is currently co-managed by the Canadian Department of Fisheries and Oceans (DFO) and the Nuu-chah-nulth First Nations.

Today, the gooseneck barnacle stock is not overfished and no overfishing is occurring. Quotas are set on a site-specific basis, based on information derived from three independent stock assessment techniques. At present, the fishery is very small, with only four groups of 2-3 individuals each collecting barnacles from the 48 designated harvest rocks. 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 and bay mussels, as well as juvenile gooseneck barnacles. Nonetheless, total bycatch is minimal, largely as a result of proper fisher training and highly selective hand harvesting techniques.

The current management plan is highly precautionary and aims to ensure proper monitoring and long-term sustainability of the stock. However, specific bycatch mitigation and management measures have yet to be implemented, and no data pertaining to this aspect of the fishery is currently available.

The tool used to remove desirable barnacles from the sites has negligible impacts on the rock substrate itself. Although the fishery for gooseneck barnacles occurs at specific sites (within a clearly defined coastal region in Clayoquot Sound), an additional 70% of the surrounding T'aaq-wiihak Fishing Area is located within BC Park Territory. Fishing is prohibited in reserves, which helps preserve the multitude of natural terrestrial and marine processes occurring along this coast.

### Table of Conservation Concerns and Overall Recommendations

Stock / Fishery	Impacts on the Stock	Impacts on other Spp.	Management	Habitat and Ecosystem	Overall Recommendation
Gooseneck barnacle British Columbia Northeast Pacific – Hand Collected	Green (5.00)	Green (5.00)	Green (4.00)	Green (5.00)	<b>Best Choice (4.729)</b>

#### Scoring Guide

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

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

- **Best Choice/Green** = Final Score >3.2, **and** no Red Criteria, **and** no Critical scores
- **Good Alternative/Yellow** = Final score >2.2-3.2, **and** neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern<sup>2</sup>, **and** no more than one Red Criterion, **and** no Critical scores
- **Avoid/Red** = Final Score <=2.2, **or** either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern **or** two or more Red Criteria, **or** one or more Critical scores.

---

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

## **Table of Contents**

About Seafood Watch® .....	2
Guiding Principles .....	3
Summary .....	4
Introduction .....	7
Assessment .....	17
Criterion 1: Stock for which you want a recommendation.....	17
Criterion 2: Impacts on Other Species .....	22
Criterion 3: Management effectiveness .....	24
Criterion 4: Impacts on the habitat and ecosystem.....	31
Acknowledgements.....	35
References .....	36

## **Introduction**

### **Scope of the analysis and ensuing recommendation**

This report assesses the sustainability of the leaf barnacle, *Pollicipes polymerus*, also known as gooseneck barnacle, on the west coast of Canada. This fishery is composed of five Nations—Ahousaht, ʔiihʔatis/cʔiinaxʔint, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht—all of whom are members of the Nuuchah-nulth First Nations. While a different fishery for gooseneck barnacles 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 Nuuchah-nulth Tʔaaq-wiihak fishery, which is the only commercial gooseneck barnacle fishery in North America.

### **Overview of the species and management bodies**

The 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 the maximum age of this species is unknown, maturity is reached at a rostral-carinal length of 14-17 mm (between 1-3 years old)(Lauzier 1999a)(Lewis and Chia 1981).

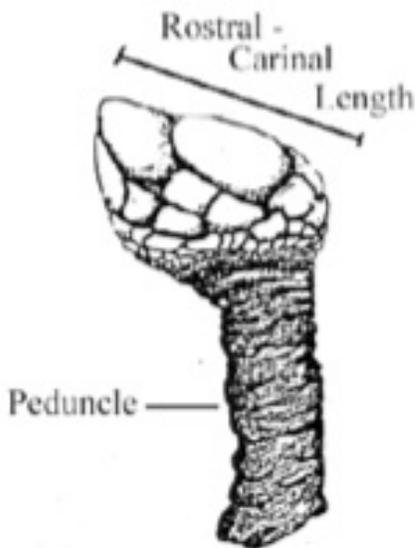


Figure 1. Gooseneck barnacle (*P. polymerus*). Maturity is reached at a rostral-carinal length of 14-17 mm. Marketable barnacles typically have a rostral-carinal length of 15-30 mm, a peduncle length of 40-80 mm, and a wet weight of 10-30 g. (Image originally published in DFO 1999; used with permission).

Unlike the majority of invertebrate species, gooseneck barnacles reproduce by pseudocopulation rather than broadcast spawning. Despite being hermaphroditic, self-fertilization does not occur and Lewis and Chia (1981) found that breeding appears to be limited to individuals within proximity of no greater than 11 cm. Until recently, this type of mating was thought to be the sole mode of reproduction in stalked barnacles. However, recent research by Barazandeh et al. (2013) suggests that *P. polymerus* may also mate by spermcasting. Since 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). While the regularity of spermcasting 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).

While *P. polymerus* is the largest species of gooseneck barnacle, three similar species exist worldwide: the European stalked barnacle (*P. pollicipes*/*P. cornucopia*, coastal northwestern France south to Senegal), the Pacific goose barnacle (*P. elegans*, eastern tropical Pacific), and the goose barnacle (*P. spinosus*, New Zealand) (Lauzier 1999a). *P. polymerus* is native to North America and is most commonly found in distinctive rosette-shaped aggregations, with larger (older) individuals at the center. Gooseneck barnacles rarely live in isolation from other species, and are most commonly found co-existing with California mussels (*Mytilus californianus*) and acorn barnacles (*Semibalanus cariosus*) on a variety of rock substrates in regions of heavy surf and wave action (Lauzier 1999a) (Fig. 3). Over the last fifty years, substantial research (see (Jamieson et al. 2001)(Lauzier 1999a)(Dayton 1971)) has gone into understanding the population dynamics and competitive interactions of these communities.



Figure 2. Collecting barnacles in the intertidal zone of Clayoquot Sound. Gooseneck barnacles are found tightly interspersed with populations of California and bay mussels (*Mytilus* spp.) in rocky areas of high surf and wave activity. (Image courtesy of Ha'oom Wild Seafoods).

### Production Statistics

Gooseneck barnacles have always been a traditional source of food for the members of the Nuuchah-nulth First Nations, who have harvested them along the northwest coast of North America for millennia (DFO 2005)(T'aaq-wiihak 2014b). The first commercial fishery was established in the mid-1980s on the west coast of Vancouver Island in Barkley, Nootka, and Clayoquot Sounds (Lauzier 1999a). Originally, only nine gooseneck barnacle fishing licenses were issued by the Department of Fisheries and Oceans (DFO) in 1985. The number of participants grew rapidly over the next few years, and 467 licenses were issued in 1988 (Fig. 4). 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, 1999a); the majority of landings came from the south coast fishing areas (i.e., DFO Pacific Management Areas 23, 24, and 26). As interest in this new, lucrative fishery increased, so did the number of inexperienced harvesters. For the duration of the fishery in the 1980s and 1990s, the driving factor behind both license numbers and annual landings was demand and high market prices from Europe. In 1997, gooseneck barnacles were valued at approximately \$11.20/kg (DFO 2005).

Although the annual catches depicted in Figure 4 reflect the total reported landings from sales slips, substantial differences between sales slip landing values, logbook landing values, and the

quantity of exported gooseneck barnacles suggests that substantial (upward of 50% in some years) under-reporting of the catch occurred (Lauzier 1999b)(Lessard et al. 2003). Although a Z-6 license (fishing without a vessel) was required, for many years this fishery operated largely unregulated and with open-access (Lauzier 1999a) (Lauzier 1999b). As a result, it was closed by DFO in May 1999 as a precaution due to concerns over inadequate management, a lack of sufficient biological and ecological data, and fears of overexploitation. 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 of the impacts the fishery was having on the surrounding intertidal habitat (Lauzier 1999a, 1999b). In addition, experienced harvesters were worried about damage to the stock and ecosystem (e.g., ‘clear-cutting’ large areas of mussels and barnacles, collecting barnacles that were too small) caused by inexperienced harvesters who had entered the fishery with the incentive of a quick financial gain (Lauzier 1999a, Lessard et al. 2003).

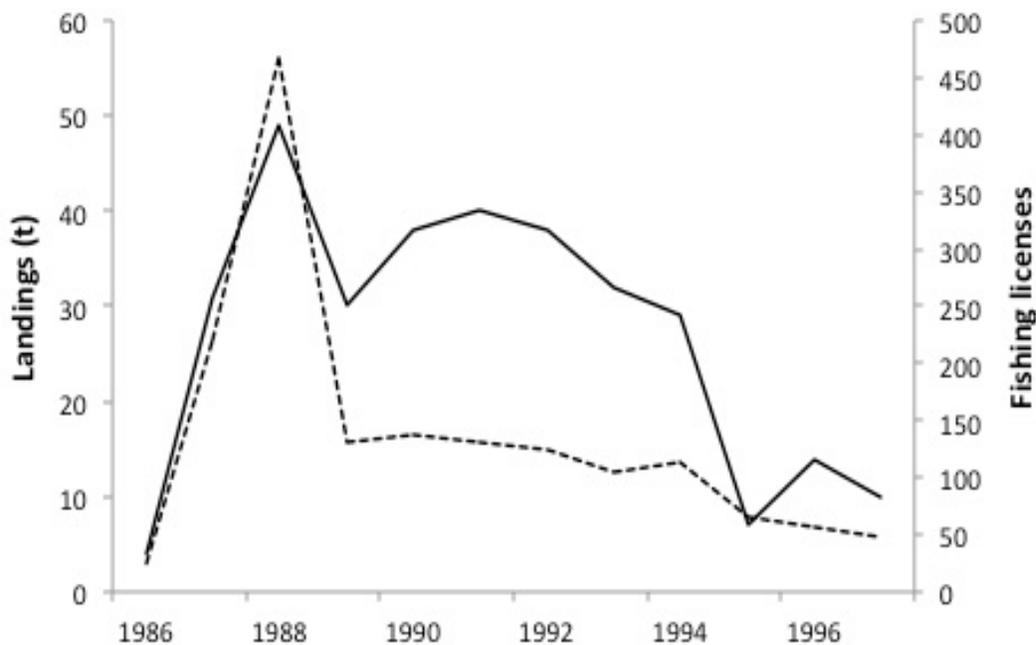


Figure 3. Total annual landings (solid line) and licenses issued (dashed line) from 1986 to 1997. (Based on data in DFO 1999.)

After the fishery closure in 1999, two experimental harvests took place—one from September 11 to December 31, 2000, the other from December 1, 2001 to March 21, 2002. Landings during these periods were very small: 1.8 t and 1.3 t respectively (DFO 2005). In both cases, DFO licensed these harvests with a variety of overarching management goals in mind. The gooseneck barnacles collected helped provide managers with information about harvesting

practices, while also providing population structure data for proposed stock assessments. At the socio-economic level, these harvests provided an income for local fishers and helped finance the costs associated with fisheries monitoring (DFO 2005).

In 2003, DFO opened an experimental commercial fishery with barnacle collection permitted in Barkley Sound, Clayoquot Sound, and Kyuquot/Checleseth (DFO 2005). The new experimental fishery management plan was developed by a local multi-sector and multi-government board called West Coast Aquatic. It was innovative in a number of ways. First, it moved from the stock being assessed as one meta-unit to assessing it on a rock-by-rock basis. Second, the assessment and management regime were created cooperatively with fishermen, and was based on their knowledge and experience. It was also one of the first to have developed a system for tracking the harvest from each rock through to end sale. Unfortunately, DFO would not provide funding to manage the fishery, so all of the science, management, and monitoring costs were covered through landings and sales. This, in addition to decreased prices in Spain, caused the fishery to close after two years (Day 2012). Although unsuccessful economically, the new management and science strategy, experience, and information provided managers and fishers with a solid foundation for future fisheries.

A limited commercial gooseneck barnacle fishery re-opened most recently in September 2013. In addition to providing employment and income for Nuuchahnulth fishers, two key underlying goals of this fishery were to test market demand for this product, and to properly train new barnacle fishers (T'aaq-wiihak 2014a). This fishery is currently composed of 48 gooseneck barnacle collection sites (i.e., rocks) in Clayoquot Sound, which is located along the South Coast of Vancouver Island in DFO Pacific Fisheries Management Area 24 (T'aaq-wiihak 2014a).

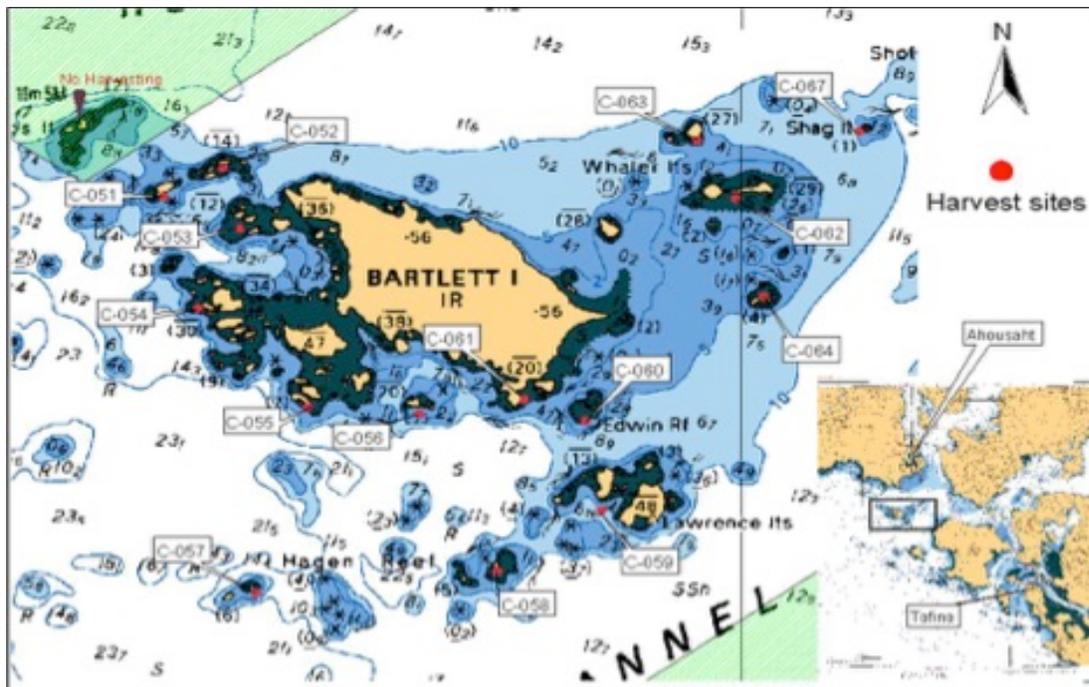


Figure 4. Designated barnacle harvest sites near Bartlett Island. A total of 48 rocks (not all shown) throughout Clayoquot Sound have been assessed and provided with a site-specific TAC. Collection in all BC Parks, including Flores Vargas Island Parks (light green), is prohibited. (Image courtesy of Alex Gagne, T'aaq-wiihak Fisheries Implementation Coordinator.)

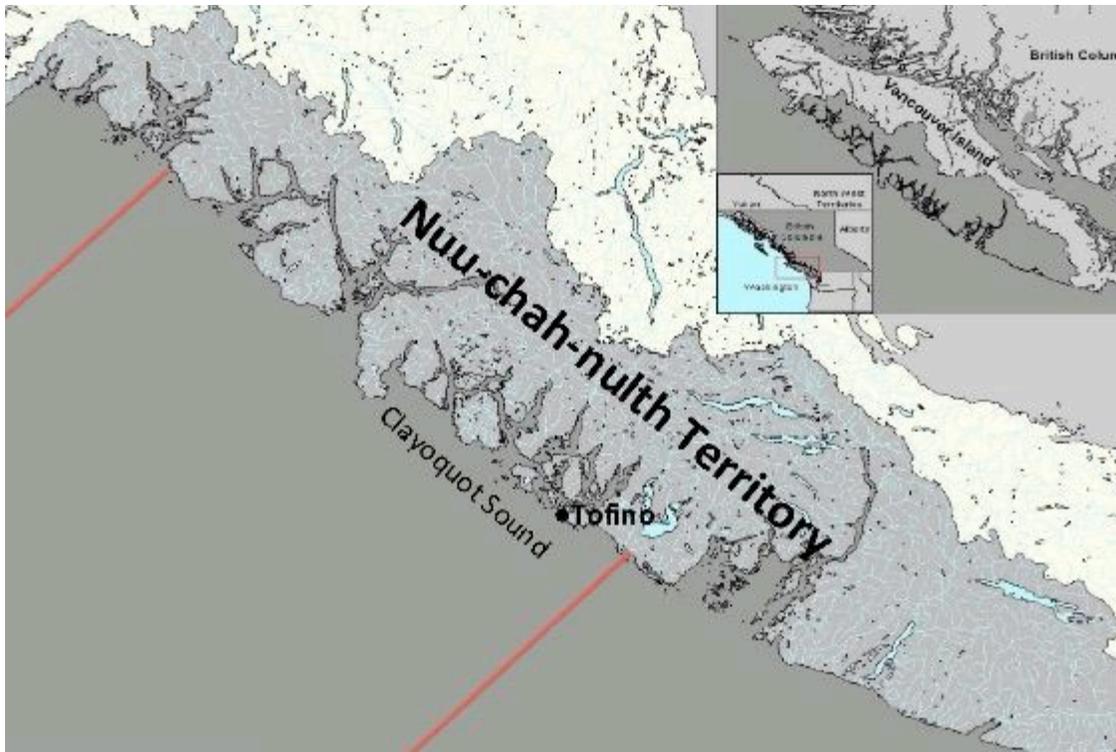


Figure 5. T'aaq-wiihak Fishing Area (area bounded by red). Territory of the 14 Nuuchahnulth First Nations extends 300 km along the west coast of Vancouver Island in British Columbia. The collection of gooseneck barnacles by Nuuchahnulth fishers occurs exclusively at 48 rock sites in Clayoquot Sound and all barnacles are landed in the town of Tofino. (Map courtesy of Alex Gagne, T'aaq-wiihak Fisheries Implementation Coordinator).

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 (T'aaq-wiihak 2014a). Collection of gooseneck barnacles still occurs exclusively by hand gathering, with the help of a modified vehicle leaf spring tool called a goose gun (Fig. 6). All mechanical devices and power tools, as well as collection by diving, are prohibited (DFO 2005); (T'aaq-wiihak 2014b). Given the fragility of these organisms and the difficulties pertaining to keeping them in marketable condition post-harvest, barnacle harvesters only collect them once an order has been placed (T'aaq-wiihak 2014a). Presently, the take of marketable barnacles for this fishery (i.e., CPUE) ranges from 9-15 kg·hr<sup>-1</sup> and the standard order size is 45-90 kg.

As part of the revised management structure, strict landing protocols are now in place (see Criterion 3) and landing data from 2013 to 2014 are accurate. Presently, the primary management focuses are ensuring fisher safety and maintaining stock sustainability with ongoing market demand. For the four months in 2013 in which the fishery was open, 0.38 t

(846.3 lbs) were harvested; the catch in 2014 (February to September) was 1.4 t (3,131.7 lbs) (unpublished raw data, provided by Alex Gagne, T'aaq-wiihak Fisheries Implementation Coordinator). DFO licensed the fishery to land up to 6,000 lbs (2.7 t) from October 2014 through to March 2015; however, poor weather conditions prevented any further landings in 2014 (T'aaq-wiihak 2014c). At present, the fishery is very small, with only four groups of 2-3 individuals, each collecting barnacles from the 48 designated harvest rocks (Alex Gagne, pers. comm.). 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 (T'aaq-wiihak 2014b). Given these ecological and biological parameters, only a very 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.

On January 30, 2014, the Supreme Court of British Columbia upheld a previous decision from November 3, 2009 (*Ahousaht Nation v. Canada*) dismissing a second appeal from Canada, and affirming the aboriginal right of the five aforementioned Nuu-chah-nulth 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).

While improving data and assessment outputs is of primary ecological concern, additional focus is being placed on ensuring the long-term economic viability of this fishery for both fishers and buyers (T'aaq-wiihak, 2014c).



Figure 6. 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) non-target organisms while carefully removing barnacles without damaging their peduncles (since this makes them unmarketable). (Image courtesy of Ha’oom Wild Seafoods.)

### **Importance to the US/North American Market**

Gooseneck barnacles have been gathered and consumed by the Nuu-chah-nulth First Nations for centuries. Although previously shipped abroad to Europe, growing interest from upscale markets in North America has resulted in approximately 75% of the current Nuu-chah-nulth harvest being sent to the United States—primarily to Seattle, New York, Los Angeles, and Las Vegas (Alex Gagne, pers. comm.). And while gooseneck barnacles remain popular overseas, the remainder of the Nuu-chah-nulth catch is sold domestically. On average, gooseneck barnacles currently fetch about \$US 9-12/kg, with a maximum price of \$US 22/kg.

### **Common and Market Names**

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

### **Primary Product Forms**

Once collected, gooseneck barnacles will degrade rapidly if not properly transported and packaged. Additionally, these organisms are very fragile, and can be easily damaged in the shipping process. While it is possible to freeze this species, they often lose much of their texture and flavor when thawed, resulting in a less valuable product. As such, gooseneck barnacles from the Nuu-chah-nulth fishery are always sold as a fresh product (Alex Gagne, pers. comm.). 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, they are typically boiled or sautéed and served on their own as well as in soups, chowders, salads, or other seafood dishes. Depending on the meal, they can also be served barbequed or smoked.

There are negligible risks of paralytic shellfish poisoning (PSP) with this species since they are crustaceans (not bivalves) and the amount of toxin they accumulate is unlikely to reach levels that pose a threat to human health (Sharpe 1981 *in* Lauzier 1999a); (Alex Gagne, pers. comm.).

## **Assessment**

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Criteria for Fisheries, available at <http://www.seafoodwatch.org>.

### **Criterion 1: Stock for which you want a recommendation**

*This criterion evaluates the impact of fishing mortality on the species, given its current abundance. The inherent vulnerability to fishing rating influences how abundance is scored, when abundance is unknown. 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.*

#### **Criterion 1 Summary**

<b>GOOSENECK BARNACLE</b>				
<b>Region / Method</b>	<b>Inherent Vulnerability</b>	<b>Abundance</b>	<b>Fishing Mortality</b>	<b>Subscore</b>
<b>British Columbia Northeast Pacific Hand collected</b>	1.00:High	5.00:Very Low Concern	5.00:Very Low Concern	<b>Green (5.000)</b>

#### **Criterion 1 Assessment**

##### **GOOSENECK BARNACLE**

##### **Factor 1.1 - Inherent Vulnerability**

###### *Scoring Guidelines*

- *Low—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing).*
- *Medium—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).*

- *High—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make it particularly vulnerable to fishing, (e.g., long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator). Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling, aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.*

### British Columbia Northeast Pacific, Hand Collected

#### High

Using the Seafood Watch PSA productivity attributes, this species receives an inherent vulnerability score of 1.75 (High).

#### Rationale

Although gooseneck barnacles have a low age at maturity (1-3 years), their maximum age is still unknown. Based on calculations by Bernard (1988), they probably live to around 12 years; an earlier estimate suggests they could live up to 20 years old. Unlike many invertebrates, gooseneck barnacles are live bearers, internally brooding egg lamellae within their mantle cavity while they develop (Lauzier 1999a)(Lewis and Chia 1981). After roughly 25 days, barnacles release free-swimming cyprid larvae, which then undergo six naupliar stages and spend approximately 42 days in the plankton before settling (Lewis 1975). Lewis (1975) suggests barnacle dispersal capabilities of 185 to 930 km (based on current velocities of 5 to 26  $\text{cm}\cdot\text{s}^{-1}$ , and Rivera et al. (2013) estimated the dispersal of larval gooseneck barnacles along the Cantabrian Coast of northern Spain to be limited to 13-56 km (current velocities of 0.5 to 4.5  $\text{cm}\cdot\text{s}^{-1}$ ) due to variations in annual upwelling activity. Despite the information available from these studies, dispersal of *P. polymerus* along Vancouver Island is not well known. Thompson et al. (1989) discusses the multiple circulation systems off the west coast of Vancouver Island, and current velocities in this part of the Pacific Ocean range from 10  $\text{cm}\cdot\text{s}^{-1}$  (offshore Alaska Current) to 50  $\text{cm}\cdot\text{s}^{-1}$  (Vancouver Island Coastal Current). Barnacle larvae most readily attach to the stalks of larger, mature gooseneck and acorn barnacles, before forming peduncular extensions that re-attach to the rocky substrate (Hoffman 1989). Populations of gooseneck barnacles are 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 1999b) (Jamieson et al. 2001). In addition, gooseneck barnacles reproduce through pseudo-copulation. As a sessile organism, this restricts mating activity between individuals that live in close proximity (Lewis and Chia 1981). Although Barazandeh et al. (2013) have suggested spermcasting behavior in this species, its prevalence within this population and the associated implications of this fertilization mechanism are not yet fully understood. As such, maintaining a tightly aggregated community appears to be essential for the overall health and fecundity of the stock. All of these characteristics contribute to a high inherent vulnerability

to fishing.

## Factor 1.2 - Abundance

### Scoring Guidelines

- *5 (Very Low Concern)—Strong evidence exists that the population is above target abundance level (e.g., biomass at maximum sustainable yield, BMSY) or near virgin biomass.*
- *4 (Low Concern)—Population may be below target abundance level, but it is considered not overfished.*
- *3 (Moderate Concern) —Abundance level is unknown and the species has a low or medium inherent vulnerability to fishing.*
- *2 (High Concern)—Population is overfished, depleted, or a species of concern, OR abundance is unknown and the species has a high inherent vulnerability to fishing.*
- *1 (Very High Concern)—Population is listed as threatened or endangered.*

### British Columbia Northeast Pacific, Hand Collected

#### Very Low Concern

Stock is at or very near its historic high or virgin biomass.

#### Rationale

Three independent survey methods—GIS mapping, Local Ecological Knowledge (LEK) surveys (from 2003-2005 and 2014), and GPS polygon mapping—resulted in an estimated marketable biomass of 19.9-24 t (43,800-52,833 lbs) available in the area outside of BC Parks. [\[1\]](#) (For detailed descriptions of each survey method, please see the Appendix.) Assuming a conservative biomass density of 2.7 kg/m<sup>2</sup> (Bernard 1988), GIS analysis determined the total gooseneck barnacle biomass in Clayoquot Sound to be 2,858 t (6.29 x 10<sup>6</sup> lbs) in 2014 (T'aaq-wiihak 2014a). While there are no biomass estimates for the population during the initial fishery (1980s-1990s), only 112 t were taken from the Clayoquot Sound region over the 15 year period in which the fishery was open (Lauzier 1999a). Given that the current population has had over two decades to recover from this depletion, the current biomass ( $B_{\text{current}}$ ) of the population is likely near virgin stock biomass ( $B_0$ ). Despite this high aggregate abundance, genetic mixing in Clayoquot Sound is unknown and Lauzier (1999b) suggests that overfishing is more likely to occur if the gooseneck fishery is managed as a meta-population instead of as a collection of smaller individual stocks (i.e., rocks). As such, a precautionary harvest threshold of 0.03-0.07 $B_0$  is applied to each rock, based on its individual available harvestable biomass from the stock assessment (T'aaq-wiihak 2014a). A rock is closed to fishing for a minimum of six months once the harvest threshold has been reached and it can only be re-opened after a full re-assessment (T'aaq-wiihak 2014a). No rocks have been closed so far, thus  $B_{\text{current}} \geq .93B_0$  at each site. By preventing overexploitation at every rock, this precautionary approach precludes the need for a critical reference point ( $B_{\text{crit}}$ ) for the fishery as a whole.

[1] Not all rocks have been surveyed with all methods, but all rocks have been surveyed with at least one method.

### Factor 1.3 - Fishing Mortality

#### Scoring Guidelines

- *5 (Very Low Concern)—Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY), OR fishery does not target species and its contribution to the mortality of species is negligible ( $\leq 5\%$  of a sustainable level of fishing mortality).*
- *3.67 (Low Concern)—Probable (>50%) chance that fishing mortality is at or below a sustainable level, but some uncertainty exists, OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible, OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught).*
- *2.33 (Moderate Concern)—Fishing mortality is fluctuating around sustainable levels, OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery and, if species is depleted, reasonable management is in place.*
- *1 (High Concern)—Overfishing is occurring, but management is in place to curtail overfishing, OR fishing mortality is unknown, species is depleted, and no management is in place.*
- *0 (Critical)—Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

#### British Columbia Northeast Pacific, Hand Collected

##### Very Low Concern

Highly likely that fishing mortality is at or below a sustainable level that will allow population to maintain current level or rebuild if depleted, and a large proportion of population is protected.

##### Rationale

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 barnacles 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 2003-2005 (DFO 2005). Today, gooseneck barnacle collection is localized to specific sites in Clayoquot Sound, and prohibited in 72% of the T'aaq-wiihak Fishing Area due to spatial closures (see Criterion 4). At present, only 48 rocks have been designated as harvest sites.

At each harvest site, most barnacles (i.e., over 90%) are non-marketable due to their size or appearance, and the exposed nature of the barnacle habitat enables fishers to be highly selective of the individuals they collect. Harvesters aim to collect barnacles that can be removed without wounding the barnacles (since torn peduncles make them unmarketable). Barnacles that are directly affixed to a rock substrate typically are usually wounded during collection, so harvesters do not attempt to pry barnacles directly off the rock substrate. This creates another inherently limiting factor to harvest from each of the rocks.

## **Criterion 2: Impacts on Other Species**

All main retained and bycatch species in the fishery are evaluated in the same way as the species under assessment were evaluated in Criterion 1. 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 ghostfishing. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard rate score (ranges from 0-1), which evaluates the amount of non-retained catch (discards) and bait use relative to the retained catch. 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.

### **Criterion 2 Summary**

<b>Gooseneck Barnacle: British Columbia Northeast Pacific, Hand Collected</b>					
<b>Subscore:</b>	<b>5.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>5.000</b>
<b>Species</b>	<b>Inherent Vulnerability</b>	<b>Abundance</b>	<b>Fishing Mortality</b>	<b>Subscore</b>	
<b>GOOSENECK BARNACLE</b>	High	5.00: Very Low Concern	5.00: Very Low Concern	<b>5.000</b>	

Given that harvesters have specific marketable size and shape requirements, individual barnacles can be assessed prior to their removal, thus making this a highly selective fishery. Once pried off the rocks, harvesters must 'clean' the clumps of barnacles/mussels (i.e., the individual barnacles are gently detached from the affixed mussels/smaller barnacles). This process requires a high amount of attention and care and is quite time-consuming. Thus, it also serves as an additional incentive for harvesters to only remove the smallest amount of discards and to target the barnacles of market size. If larger clumps are removed, more time is required to clean the marketable barnacles. As such, this creates a disincentive to 'clear-cutting' (clearing off a swatch of barnacles and surrounding matrix) as more time will be required to clean the marketable barnacles and there is a higher risk of damage to the barnacles from increased handling.

Nonetheless, due to the tight structure of the intertidal ecosystem (i.e., many species in close proximity), the incidental take of non-target organisms cannot be avoided in some cases. Since barnacles are typically removed in clumps (to minimize total damage to the bed), the majority

of bycatch are juvenile barnacles, which attach themselves to the peduncles of larger mature individuals. Two types of mussel species, California sea mussels (*Mytilus californianus*) and blue mussels (*M. edulis*), are also taken in cases where they are tightly attached to a clump of harvestable barnacles. Since none of these species can re-attach to the substrate after they have been removed, bycatch mortality is 100%. Given the small area in which the barnacle fishery operates relative to the range of these species and the fact 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. For this reason they are not assessed any further in this assessment.

## Criterion 2 Assessment

### Factor 2.4 - Discard Rate

#### British Columbia/Northeast Pacific, Hand Collected

< 20%

Given the high selectivity of this fishery, discards are likely well below 20%.

#### Detailed Rationale

No discard information specific to the T'aaq-wiihak gooseneck barnacle fishery (or similar fisheries in Spain) is currently available. Unlike many hand collection fisheries that target individual organisms, barnacles are collected in clumps of adults and juveniles. As such, some bycatch and discards are unavoidable since gooseneck barnacles with damaged peduncles are unmarketable; incidentally harvested barnacles of an undesirable size are also discarded. Nonetheless, visual observation of barnacles acts as a direct selectivity method to reduce bycatch of non-target mussels and juvenile barnacles, and the spring leaf tool is used in such a way as to limit harm to the surrounding invertebrate matrix (T'aaq-wiihak 2014a). Although the discard rate for hand collection fisheries around the world is typically 0%–1% (Kelleher 2005), the discard rate for the T'aaq-wiihak fishery is probably slightly higher, yet still below 20%.

## **Criterion 3: Management effectiveness**

*Management is separated into management of retained species (harvest strategy) and management of non-retained species (bycatch strategy).*

*The final score for this criterion is the geometric mean of the two scores. 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 or either the Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern = Red or High Concern*  
*Rating is Critical if either or both of Harvest Strategy (Factor 3.1) and Bycatch Management Strategy (Factor 3.2) ratings are Critical.*

### **Criterion 3 Summary**

<b>Region / Method</b>	<b>Management of Retained Species</b>	<b>Management of Non-Retained Species</b>	<b>Overall Recommendation</b>
<b>British Columbia Northeast Pacific Hand Collected</b>	4.000	All Species Retained	Green(4.000)

### **Factor 3.1: Harvest Strategy**

#### Scoring Guidelines

*Seven subfactors are evaluated: Management Strategy, Recovery of Species of Concern, Scientific Research/Monitoring, Following of Scientific Advice, Enforcement of Regulations, Management Track Record, and Inclusion of Stakeholders. Each is rated as 'ineffective,' 'moderately effective,' or 'highly effective.'*

- *5 (Very Low Concern)—Rated as 'highly effective' for all seven subfactors considered.*
- *4 (Low Concern)—Management Strategy and Recovery of Species of Concern rated 'highly effective' and all other subfactors rated at least 'moderately effective.'*
- *3 (Moderate Concern)—All subfactors rated at least 'moderately effective.'*
- *2 (High Concern)—At minimum, meets standards for 'moderately effective' for Management Strategy and Recovery of Species of Concern, but at least one other subfactor rated 'ineffective.'*
- *1 (Very High Concern)—Management exists, but Management Strategy and/or Recovery of Species of Concern rated 'ineffective.'*

- *0 (Critical)—No management exists when there is a clear need for management (i.e., fishery catches threatened, endangered, or high concern species), OR there is a high level of illegal, unregulated, and unreported fishing occurring.*

### Factor 3.1 Summary

Factor 3.1: Management of fishing impacts on retained species							
Region / Method	Strategy	Recovery	Research	Advice	Enforce	Track	Inclusion
British Columbia Northeast Pacific Hand Collected	Highly Effective	N/A	Highly Effective	Highly Effective	Highly Effective	Moderately Effective	Highly Effective

#### Subfactor 3.1.1 – 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? To achieve a ‘highly effective’ rating, there must be appropriate management goals, and evidence that the measures in place have been successful at maintaining/rebuilding species.*

#### British Columbia Northeast Pacific, Hand Collected

##### Highly Effective

The fishery has highly appropriate strategy and goals (described in detail in the *2014-2015 T’aaq-wiihak Goose Barnacle Harvest Plan*), and there is evidence that the strategy is being implemented successfully.

##### Rationale

The gooseneck barnacle fishery is a year-round limited entry fishery; only fishers from the Ahousaht, ʔiihʔatis/cʔiinaxʔint, Hesquiaht, Mowachaht/Muchalaht, and Tla-o-qui-aht Nations are permitted to harvest this species. The fishery is currently co-managed by the Canadian Department of Fisheries and Oceans (DFO) and the Nuuchah-nulth First Nations, and current management objectives are clearly defined in the *2014-2015 T’aaq-wiihak Goose Barnacle Harvest Plan* (T’aaq-wiihak 2014b). The DFO has set a landing quota of 1,000 lbs (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. No licenses are issued for this fishery. Instead, the Nation’s traditional leadership (the Ha’wiih) designates fishers to participate. Within this system, capacity is limited through a list of available fishers. When an order comes in, the fisher at the top of the rotation is permitted to go out and collect the desired amount of barnacles. Once a fisher completes an order successfully, (s)he goes to the bottom of the list and the next fisher on the list gets the next order. Rock-specific quotas are based on precautionary estimates of site abundance (see Factor 1.2) 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 (for specifics, see Factor 3.1.4), one of the primary management goals is filling in data gaps

pertaining to this species, both ecologically and biologically (see Factor 3.1.3). Other goals of the fishery pertain to ensuring fisher 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 barnacles for long-term fisher job security. Although few fishers participate in the fishery at present, overcapacity (and thus overexploitation) should ultimately be limited by 1) the location of the fishery (i.e., it is only permitted in certain regions of the T'aaq-wiihak Fishing Area) and 2) the number of individuals designated to participate in the fishery.

### **Subfactor 3.1.2 – Recovery of Species of Concern**

*Considerations: When needed, are recovery strategies/management measures in place to rebuild overfished/threatened/ endangered species or to limit fishery's impact on these species and what is their likelihood of success? To achieve a rating of 'highly effective,' rebuilding strategies that have a high likelihood of success in an appropriate timeframe must be in place when needed, as well as measures to minimize mortality for any overfished/threatened/endangered species.*

#### **British Columbia Northeast Pacific, Hand Collected**

**N/A**

There are currently no overfished, depleted, endangered or threatened species targeted or retained by the fishery.

### **Subfactor 3.1.3 – Scientific Research and Monitoring**

*Considerations: How much and what types of data are collected to evaluate the health of the population and the fishery's impact on the species? To achieve a 'highly effective' rating, population assessments must be conducted regularly and they must be robust enough to reliably determine the population status.*

#### **British Columbia Northeast Pacific, Hand Collected**

**Highly 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.

#### **Rationale**

No stock assessment for this fishery was conducted for the commercial fishery when it was open in the 1980s/90s. However, after the closure of the fishery in 1999, two experimental harvests took place in

conjunction with stock and habitat assessment projects (DFO 2005). These initial assessments used Local Ecological Knowledge (LEK) information but were more regional in nature and did not seek to identify site-specific population structure. The 2014 stock assessment has built on this original methodology by incorporating more LEK data, as well as two additional site survey techniques (see Appendix) to provide estimates of site-specific population biomass and structure. Landings data for each harvest rock have been effectively collected since the re-opening of the fishery in 2013, and ongoing work between Nuuchahnulth managers and members of DFO aims to further develop an appropriate monitoring program that includes both retained and discarded catches (T'aaq-wiihak 2014b). Since there is currently little information on the recovery dynamics of a harvested rock site, harvesters have begun selecting INDEX sites where various small patches will be harvested (to varying degrees) so that recovery rate can be observed and reported. This work will help fill in knowledge gaps pertaining specifically to the growth rates of gooseneck barnacles on the west coast of Vancouver Island (Alex Gagne, pers. comm.). Presently, this fishery is also on the Canadian Science Advisory Secretariat (CSAS) list for 2015-2016, which will result in additional external review of this new stock assessment methodology.

### **Subfactor 3.1.4 – Management Record of Following Scientific Advice**

*Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g. do they set catch limits at recommended levels)? A 'highly effective' rating is given if managers nearly always follow scientific advice.*

#### **British Columbia Northeast Pacific, Hand Collected**

##### **Highly Effective**

All management decisions and protocols appear to be heavily based on scientific research and advice.

##### **Rationale**

Starting with the experimental gooseneck fisheries in the early 2000s, the main focus of the re-establishment of a commercial gooseneck barnacle fishery has been to ensure its long-term ecological sustainability. All 48 rocks in the fishery have undergone assessment, using at least one biomass estimation method, and all TACs are precautionary since they are based on the lowest of the three separately calculated harvestable biomass outputs from the stock assessment (Alex Gagne, pers. comm.). Furthermore, fishers collected only two-thirds of the quota set for the 2013/14 (March-October) season. Weather plays a vital role in the barnacle harvest process, and poor conditions in the fall resulted in few fishing opportunities in the latter part of 2014. As of January 2015, only 514.4 lbs (0.23 t) of an allocated 6,000 lbs (2.72 t) of barnacles had been collected for the 2014/15 season (Alex Gagne, pers. comm.).

### Subfactor 3.1.5 – Enforcement of Management Regulations

*Considerations: Do fishers 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.*

#### British Columbia Northeast Pacific, Hand Collected

##### Highly Effective

Regulations and agreed voluntary arrangements 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 the fishery operates outside of designated BC Provincial Park reserves. To date, all landings have been under the seasonally allocated quota for the region, and no rocks have been closed (i.e., no site’s individual harvest threshold has been exceeded).

##### Rationale

To prevent overfishing and ensure proper catch reporting, landings are strictly monitored through several harvesting protocols; improper adherence to these protocols or evidence of unsustainable harvesting practices could result in suspension of the harvester from the fishery (T’aaq-wiihak 2014a). All gooseneck barnacles harvested may only be taken from the 48 designated collection rocks, logged at the time of collection (i.e., site and amount removed), and subsequently landed at one of two designated landing sites in Tofino. Here, the catch is validated by a designated T’aaq-wiihak monitor on-site using a dockside weight verification system (T’aaq-wiihak 2014a)(T’aaq-wiihak 2014b). Due to safety consideration, permission to fish from the Ha’wiih is granted only to fishers who have experience and know how to harvest. If a harvester breaks the rules (e.g., knowingly takes barnacles from a closed area, sells any barnacles illegally, etc.) the Ha’wiih can revoke the permission to fish (‘permission to fish’ is the Nuu-chah-nulth word *T’aaq-wiihak*). Since the fishery is based entirely on external demand, the number of participants is limited because with more fishers in the fishery, there are fewer orders for each fisher. Additionally, harvesters have strong incentives to adhere to regulations to protect their privilege to fish and their spot in the rotation. Ongoing efforts are also being made to better understand the impacts of this fishery on the ecosystem (T’aaq-wiihak 2014a)(T’aaq-wiihak 2014b). One of the most important measures to ensure the fishery has minimal impacts on the habitat is the prohibition of destructive ‘clear-cutting’ behavior (i.e., removal of large, indiscriminate clumps of barnacles and other species on a rock site); harvesters are not allowed to remove clusters of marketable barnacles larger than 0.25 m<sup>2</sup>, and must leave as much of the surrounding mussel and barnacle matrix as possible. To further prevent clear-cutting (which was a concern pertaining to novice harvesters in the 1980s/90s barnacle fishery), all new fishers must be trained and supervised by an experienced harvester prior to their participation in the fishery (T’aaq-wiihak 2015c).

### Subfactor 3.1.6 – Management Track Record

*Considerations: Does management have a history of successfully maintaining populations at sustainable levels or a history of failing to maintain populations at sustainable levels? A Highly Effective rating is given if measures enacted by management have been shown to result in the long-term maintenance of species overtime.*

#### British Columbia Northeast Pacific, Hand Collected

##### Moderately Effective

Although the current management structure and harvest plan appear to focus heavily on ensuring the sustainability of the gooseneck barnacle stock, the fishery is still too new to evaluate the long-term effectiveness of these strategies.

### Subfactor 3.1.7 – 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 and includes stakeholder input.*

#### British Columbia Northeast Pacific, Hand Collected

##### Highly Effective

The management process is transparent and includes input from a variety of local and provincial stakeholders.

##### Rationale

The T’aaq-wiihak gooseneck barnacle fishery is co-managed by the Nuu-chah-nulth First 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 on a monthly basis. Catch monitoring and enforcement is primarily the responsibility of Nuu-chah-nulth fisheries managers, although The Nations and DFO also have a joint enforcement committee where issues pertaining to enforcement and compliance can be jointly discussed (Alex Gagne, pers. comm.). Given the current size of the fishery, non-compliance 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. Experienced Nuu-chah-nulth fishers are invaluable to the management process as they conduct ongoing LEK surveys for the stock assessments and provide training and mentorship for new gooseneck barnacle fishers (T’aaq-wiihak 2014b)(T’aaq-wiihak 2015c). At the local level, the municipal government of Tofino

(where all gooseneck barnacles are landed) has shown continued support for the fishery (despite the fact there is currently no local market)(Bailey 2014)(Carmichael 2013)(T'aaq-wiihak 2015c)(T'aaq-wiihak, 2014c). Some funding for the fishery was provided through a grant from the Investment in Agricultural Foundation (IAF) under the Province of BC's 'Buy Local' Grant and BC Parks (Ministry of the Environment), which co-manages the marine reserve areas within the Nuu-chah-nulth territory (including the T'aaq-wiihak Fishing Area). Since 1995, Parks Canada personnel have been collaborating with members of the Nuu-chah-nulth First Nations to “achieve long-term conservation and sustainable use of natural and cultural resources within Pacific Rim National Park Reserve” (Parks Canada 2012). To date, these efforts have included developing the Park’s first Management Plan (Parks Canada 2010), improving the Visitor Center site, protecting and developing recovery plans for the 40 identified ‘Species At Risk’ within the Park, and day-to-day beach and visitor monitoring (Parks Canada 2012).

## **Bycatch Strategy**

<b>Factor 3.2: Management of fishing impacts on bycatch species</b>						
<b>Region / Method</b>	<b>All Kept</b>	<b>Critical</b>	<b>Strategy</b>	<b>Research</b>	<b>Advice</b>	<b>Enforce</b>
<b>British Columbia Northeast Pacific Hand Collected</b>	Yes	N/A	N/A	N/A	N/A	N/A

As there are no main species identified in Criterion 2, no bycatch management assessment is necessary.

## **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 (plus the mitigation of gear impacts score) and the ecosystem-based fishery management 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 cannot be Critical for Criterion 4.*

### **Criterion 4 Summary**

<b>Region / Method</b>	<b>Gear Type and Substrate</b>	<b>Mitigation of Gear Impacts</b>	<b>EBFM</b>	<b>Overall Recomm.</b>
<b>British Columbia Northeast Pacific Hand Collected</b>	5.00:None	0.00:Not Applicable	5.00:Very Low Concern	<b>Green (5.000)</b>

### **Justification of Ranking**

#### **Factor 4.1 – Impact of Fishing Gear on the Habitat/Substrate**

##### *Scoring Guidelines*

- *5 (None)—Fishing gear does not contact the bottom*
- *4 (Very Low)—Vertical line gear*
- *3 (Low)—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. Bottom seine on resilient mud/sand habitats. Midwater trawl that is known to contact bottom occasionally)*
- *2 (Moderate)—Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Bottom seine except on mud/sand*
- *1 (High)—Hydraulic clam dredge. Dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 (Very High)—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.*

#### British Columbia Northeast Pacific, Hand Collected

##### 5 (None)

Barnacles and mussels are habitat forming species, so potential impacts to habitat include direct harvest through walking over these and other intertidal invertebrates. However, the fishery is limited to a few people over a small area of the intertidal habitat available to these habitat-forming species, and so Seafood Watch has rated this fishery as having no significant impacts on habitat. Due to 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.

##### Rationale

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 (see Fig. 5 above). The thickness of this multi-species matrix ranges from 3 to 30 cm (depending on the site), with harvestable gooseneck barnacles close to the top (Alex Gagne, pers. comm.). As a result, harvesters are able to remove marketable barnacles without contacting the underlying rock substrate.

#### Factor 4.2 – Mitigation of Gear Impacts

##### Scoring Guidelines

- *+1 (Strong Mitigation)—Examples include large proportion of habitat protected from fishing (>50%) with gear, fishing intensity low/limited, gear specifically modified to reduce damage to seafloor and modifications shown to be effective at reducing damage, or an effective combination of ‘moderate’ mitigation measures.*
- *+0.5 (Moderate Mitigation)—20% of habitat protected from fishing with gear or other measures in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing.*
- *+0.25 (Low Mitigation)—A few measures are in place (e.g., vulnerable habitats protected but other habitats not protected); there are some limits on fishing effort/intensity, but not actively being reduced.*
- *0 (No Mitigation)—No effective measures are in place to limit gear impacts on habitats.*

#### British Columbia Northeast Pacific, Hand Collected

##### Not Applicable

### Factor 4.3 – Ecosystem-Based Fisheries Management

#### Scoring Guidelines

- *5 (Very Low Concern)—Substantial efforts have been made to protect species’ ecological roles and ensure fishing practices do not have negative ecological effects (e.g., large proportion of fishery area is protected with marine reserves, and abundance is maintained at sufficient levels to provide food to predators).*
- *4 (Low Concern)—Studies are underway to assess the ecological role of species and measures are in place to protect the ecological role of any species that plays an exceptionally large role in the ecosystem. Measures are in place to minimize potentially negative ecological effect if hatchery supplementation or fish aggregating devices (FADs) are used.*
- *3 (Moderate Concern)—Fishery does not catch species that play an exceptionally large role in the ecosystem, or if it does, studies are underway to determine how to protect the ecological role of these species, OR negative ecological effects from hatchery supplementation or FADs are possible and management is not place to mitigate these impacts.*
- *2 (High Concern)—Fishery catches species that play an exceptionally large role in the ecosystem and no efforts are being made to incorporate their ecological role into management.*
- *1 (Very High Concern)—Use of hatchery supplementation or fish aggregating devices (FADs) in the fishery is having serious negative ecological or genetic consequences, OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.*

#### British Columbia Northeast Pacific, Hand Collected

##### Very 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.

##### Rationale

The fishery for gooseneck barnacles falls within a clearly defined coastal region in Clayoquot Sound along the west coast of Vancouver Island (i.e., within the T’aaq-wiihak Fishing Area, Fig. 1). As previously discussed (see Criterion 1), only specific sites within this area are available to fishers. Although the barnacle fishery is open year-round, over 70% of the T’aaq-wiihak Fishing Area is located in BC Park Territory. As such, these regions have been voluntarily designated as no-take reserves (T’aaq-wiihak 2014a). The largest of the protected regions is Pacific Rim National Park Reserve of Canada, a terrestrial

and marine reserve that encompasses 511 km<sup>2</sup> of land along the west coast of Vancouver Island. The collection of gooseneck barnacles, at any time or location, is prohibited within the boundaries of this national park (in Clayoquot Sound, the park extends along Long Beach). Other areas where barnacle harvest is indefinitely prohibited include: Cleland Island (BC Ecological Reserve), Vargas Island (BC Provincial Park), Echachis Island (recreational and First Nations closure), and Flores Island (BC Provincial Park) (DFO 2005) (Alex Gagne, pers. comm.). Combined with site-specific TACs and other conservative fishery harvest strategies and monitoring efforts (see Criterion 3), these spatial closures help protect regional populations of gooseneck barnacles and other intertidal species while allowing for recruitment and dispersal to occur naturally throughout the region. 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 west coast of Vancouver Island. Pacific Rim National Park is home to abundant temperate rainforest species, including (but not limited to): black bears, wolves, cougars, blacktail deer, endemic marmots, several shorebirds, bald eagles, COSEWIC threatened dromedary jumping-slugs, a variety of old growth conifers and mosses, as well as giant kelp, various shellfishes, river otters, grey whales, and (occasionally) IUCN Critically Endangered leatherback sea turtles (Parks Canada 2010)(BCCSN 2015).

## **Acknowledgements**

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

Seafood Watch® would like to thank Andrew Day of the Vancouver Aquarium, Alex Gagne of the T'aaq-wiihak, and two anonymous reviewers for graciously reviewing this report for scientific accuracy.

## **References**

- Bailey, A. 2014 (26 February). Tofino shows support for T'aaq-wiihak fisheries. Westerly News. Retrieved on 18 December 2014 from: <http://www.westerlynews.ca/local-news/tofino-shows-support-for-t-aaq-wiihak-fisheries-1.884822>
- Barazandeh, M., Davis, C.S., Neufeld, C.J., Coltman, D.W., Palmer, A.R. 2013. Something Darwin didn't know about barnacles: spermcast mating in a common stalked species. *Proceedings of the Royal Society B* 280(1754): 20122919.
- Barnes, H., Reese, E.S. 1960. The behavior of the stalked intertidal barnacle *Pollicipes polymerus* J.B., Sowerby, with special references to its ecology and distribution. *Journal of Animal Ecology* 29: 169-185.
- BCCSN. 2015. Sightings stories: The Best of 2014. Wild Whales: B.C. Cetacean Sightings Network. Retrieved on 23 January 2015 from <http://wildwhales.org/2015/01/cetacean-stories-the-best-of-2014>
- Bernard, F.R. 1988. Potential fishery for the Gooseneck Barnacle *Pollicipes polymerus* (Sowerby, 1833) in British Columbia. *Fisheries Research* 6: 287-298.
- Carmichael, J. 2013 (September 5). First Nations to market niche sustainable fishery efforts. Westerly News. Retrieved from: <http://www.westerlynews.ca/first-nations-to-market-niche-sustainable-fishery-efforts-1.641779>
- Day, A. 2012. 2003-2005 Experimental Goose Barnacle Fishery Review. 40 pp.
- Dayton, P.K. 1971. Competition, disturbance, and community organization: the provision and subsequent utilization of space in a rocky intertidal community. *Ecological Monographs* 41(4): 351-389.
- Fisheries and Oceans Canada. 2005. West Coast Vancouver Island Goose Barnacle Experimental Fishery Guidelines Harvest Plan. Fisheries and Oceans Canada and West Coast Vancouver Island Aquatic Management Board. 62 pp.
- Fisheries and Oceans Canada. 1999. Fisheries and Oceans Pacific Region Stock Status Report C6-06. Fisheries and Oceans Canada. 3 pp
- Gagne, A. T'aaq-wiihak Fisheries Implementation Coordinator. Correspondence between 15 Dec 2014 and 12 Feb 2015.
- Hoffman, D.L. 1989. Settlement and recruitment patterns of a pedunculate barnacle, *Pollicipes polymerus* Sowerby, off La Jolla, California. *Journal of Experimental Biology*. 125: 83-98.
- Jamieson, G.S., Dixon, S., Lauzier, R. 2001. Initial evaluation of community structure in goose barnacle (*Pollicipes polymerus*) and sea mussel (*Mytilus californianus*) beds off the west coast of Vancouver Island, British Columbia. Canadian Science Advisory Secretariat Research Document 2001/124, Fisheries and Oceans Canada. Ottawa, Canada. 59 pp.

- Kelleher, K. 2005. Discards in the world's marine fisheries: An update. FAO Fisheries Technical Paper No. 470. Fisheries and Agriculture Organization of the United Nations. Rome, Italy. 131p.
- Kirchner, M. 2010. The Aboriginal Right to Sell Fish: Ahousaht Nation et al. v. Canada. Prepared for Pacific Business Law Institute Local Government Conference (4 March 2010). 31 pp.
- Lauzier, R.B. 1999a. A review of the biology and fisheries of the Goose Barnacle (*Pollicipes polymerus* Sowerby, 1833). Canadian Stock Assessment Secretariat Research Document 99/111, Fisheries and Oceans Canada. Ottawa, Canada. 30 pp.
- Lauzier, R.B. 1999b. Framework for Goose Barnacle (*Pollicipes polymerus* Sowerby, 1833) fishery in waters off the west coast of Canada. Canadian Stock Assessment Secretariat Research Document 99/198, Fisheries and Oceans Canada. Ottawa, Canada. 24 pp.
- Lessard, J., Osborne, J., Lauzier, R., Jamieson, G., Harbo, R. 2003. Applying local and scientific knowledge to the establishment of a sustainable fishery: the west coast Vancouver Island goose barnacle fishery experience. pp. 36-43. In: Haggan, N., Brignall, C., Wood, L. (eds.) Putting Fishers' Knowledge to Work Conference Proceedings (27-30 August 2001). Fisheries Centre Research Reports 11(1). Fisheries Centre, University of British Columbia [ISSN 1198-6727].
- Lewis, C.A. 1975. Development of the Gooseneck barnacle, *Pollicipes pollymerus* (Cirripedia: Lepadomorpha): Fertilization through settlement. *Marine Biology* 32: 141-153.
- Lewis, C.A., Chia, F-S. 1981. Growth, fecundity and reproductive biology in the pedunculated cirriped *Pollicipes polymerus* at San Juan Island, Washington. *Canadian Journal of Zoology* 59: 893-901
- Parks Canada. 2012. Pacific Rim National Park Reserve of Canada: Our First Nations Partners. Retrieved on 23 January 2015 from: <http://www.pc.gc.ca/eng/pn-np/bc/pacificrim/natcul/natcul5/natcul5d.aspx>.
- Parks Canada. 2010. Pacific Rim National Park Reserve of Canada Management Plan. Parks Canada. xii + 70 pp.
- Rivera, A., Weidberg, N., Pardiñas, A. F., González-Gil, R., García-Flórez, L., and Acuña, J. L. 2013. Role of Upwelling on Larval Dispersal and Productivity of Gooseneck Barnacle Populations in the Cantabrian Sea: Management Implications. *PLoS ONE* 8(11): e78482. doi:10.1371/journal.pone.0078482
- T'aaq-wiihak. 2014c. "Gooseneck Barnacle Subcommittee Meeting". PowerPoint presentation from meeting held in Port Alberni, 23 October 2014 (obtained on 17 December 2014 from Alex Gagne, T'aaq-wiihak Fisheries Implementation Coordinator).
- T'aaq-wiihak. 2014a. Ca?inwa (Gooseneck Barnacle) Assessment and Management Framework 2014-2015 (draft document obtained on 17 December 2014 from Alex Gagne, T'aaq-wiihak Fisheries Implementation Coordinator). 20 pp.
- T'aaq-wiihak. 2014b. Goose Barnacle Plan (2014-2015). 13 pp.

Thomson, R.E., B.M. Hickey, and P.H. LeBlond. 1989. The Vancouver Island Coastal Current: Fisheries barrier and Conduit. In Beamish, R., McFarlane, G. (eds.) Effects of ocean variability on recruitment and an evaluation of parameters used in stock assessment models, Special Publication of Fisheries and Aquatic Sciences, Report 108, p.265-296

Yusa, Y., Takemura, M., Sawada, K., Yamaguchi, S. 2013. Diverse, Continuous, and Plastic Sexual Systems in Barnacles. *Integrative and Comparative Biology* 53(4): 701-712.