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Executive Summary

What needs to be done in order to adequately protect Howe Sound’s glass sponge reefs? Monitoring of fishing closures in Howe Sound is currently insufficient to properly enforce fishing closures. Thus, increased funding will be required to properly monitor current and future glass sponge reef fishing closures. Further, the mining company Burnco is proposing a mine at McNab creek, on the west shore of Howe Sound. Since glass sponges are extremely sensitive to sedimentation and sedimentation from the mine is inevitable, the amount of sediment that could reach the nearest glass sponges and the sediment tolerance of these sponges must be determined. Dr. Leys, from the University of Alberta, is currently researching sediment tolerance of glass sponge reefs to help answer these questions. Burnco’s project should be put on hold until further results are found. I also recommend that boat rental companies be held liable when anchors from their boats damage glass sponge reefs, that a smartphone app be created to help recreational boaters keep their anchors out of glass sponge reefs and that further efforts to educate the public on glass sponge reefs be made. This study was suggested by community partners from Ken Melamed from the Green Party of Canada and Ruth Simons from the Future of Howe Sound Society. A literature review and interviews with experts were conducted in order to answer this question and provide recommendations for future policymaking. Glass sponge reefs are a Jurassic formation believed extinct until the 1980s when they were discovered off the coast of British Columbia. Since then, smaller glass sponge reefs and gardens continue to be discovered. Glass sponge reefs provide valuable ecosystems services such as water filtration and purification and endangered rockfish habitat. They may also sequester carbon. Glass sponge gardens host even greater biodiversity than glass sponge reefs and serve as nurseries for endangered rockfish. As research on glass sponges has progressed, new formations have been discovered, damage to reefs has been observed and industrial projects have been proposed near reef locations. Ensuring protection of these formations has become pressing. In Howe Sound there are two glass sponge reefs currently protected through fishing closures assigned by Canada’s Department of Fisheries and Oceans (DFO). One other reef in Howe Sound will soon gain protection since the province of British Columbia will increase the size of Halkett Bay Marine Provincial Park. Yet many other glass sponge reefs and gardens in Howe Sound still lack protection. Some glass sponge reefs are indirectly protected because they happen to be located in Rockfish Conservations Areas. The Canadian Parks and Wilderness Society (CPAWS) would like to establish Marine Protected Areas (MPAs) for glass sponge reefs in Howe Sound; however neither of these options will protect glass sponges from all types of fishing gear. DFO fishing closures will be required to achieve this.
Definitions

<table>
<thead>
<tr>
<th>MPA</th>
<th>Marine Protected Area</th>
<th>Designated by the Department of Fisheries and Oceans on behalf of government. Natural resource extraction is prohibited.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCA</td>
<td>Rockfish Conservation Area</td>
<td>Areas where certain types of fishing are prohibited to allow rockfish stocks to recover from their endangered state.</td>
</tr>
<tr>
<td>DFO</td>
<td>Department of Fisheries and Oceans</td>
<td>Responsible for implementation of fishing closures and MPAs</td>
</tr>
</tbody>
</table>

Figure 1: Juvenile Rockfish hiding in Cloud Sponge on Bioherm, courtesy of Adam Taylor

Introduction

My research for the Green Party of Canada and the Future of Howe Sound Society aims to answer the question, What needs to be done to adequately protect Howe Sound’s glass sponge reefs?

Glass sponge reefs are unique formations dating from the Jurassic era and believed extinct until live ones were discovered off the coast of British Columbia in the 1980’s (Leys, 2007). These formations provide habitat to a wealth of species, filter and
purify water and may even sequester carbon (Kahn et al., 2015). They also have very delicate skeletons that can easily be damaged by fishing gear and appear to sometimes stop filter feeding to avoid being clogged in conditions of high sediment load (ibid). Thus, it is critical that glass sponges be adequately protected in order to preserve these unique formations and the ecosystem services they provide.

The need for protection of these rare formations is especially urgent in Howe Sound where damage to reefs has been documented and industrial projects have been proposed (Marliave, 2016; Dennison and Clayton, 2016; Bodtker, 2016; Woodfibre LNG, 2014; Golder Associates Ltd., 2011). This paper attempts to answer the research question using literature and interviews with experts. It should be used to inform future policy decisions concerning glass sponge protection in Howe Sound.

**Methods**

I first conducted a literature review on glass sponges, Howe Sound, gravel mines, liquefied natural gas, value of ecosystems and effects of terminal construction on benthic communities abroad. After reviewing the literature, I set up interviews with experts Drs. Jeffrey Burton Marliave and Karin Bodtker from the Vancouver Aquarium and Glen Dennison and Lena Clayton from Marine Life Sanctuaries Society. Dr. Marliave helped me understand threats to Howe Sound’s glass sponges and the difference between sponge reefs and gardens. Dr. Karin Bodtker described different forms of marine protection. Glen Dennison and Lena Clayton shared their first hand knowledge of diving in Howe Sound and discovering glass sponges. They made me aware of more threats to glass sponges and shared original ideas about protecting the formations. After these interviews I attended a talk organized by CPAWS with Dr. Leys from the University of Alberta, Dr. Kim Conway from the Geological survey of Canada, Dr. Krautter, German paleoecologist and Dr. Leys’ graduate student Lauren Law as speakers. I sought clarification on specific points during the question and answer session. Finally, I compiled a list of recommendations on how best to protect Howe Sound’s glass sponge formations.

**Background Information**

**Glass Sponge Reefs**

Glass sponge reefs date back from the Jurassic era, and were thought to have gone extinct thousands of years ago. It is only in the 1980’s that live reefs were discovered in Hecate Strait, British Columbia. Following this discovery, several small reefs were found in the Strait of Georgia and Howe Sound. To this day, citizen scientists continue to discover glass sponges in Howe Sound.

Glass sponge reefs consist of mud and dead glass sponge sediment layers, on top of which live glass sponges grow. Glass sponge gardens are a cluster of sponges that grow in a rocky areas. It is important to note the distinction between these two
types of glass sponge formation. The reefs are important to marine ecosystems because of the structural habitat they create and the biodiversity they host. Rockfish are endangered on the Pacific coast, but glass sponge reefs provide them with shelter (Cook, Conway & Burd, 2008; Kahn, Yahel, Chu, Tunnicliffe & Leys, 2015). Glass sponge reefs are used as habitat by endangered mature rockfish, crustaceans and many other marine species (Marliave, 2016; Dennison and Clayton 2016). It should however be noted that glass sponge gardens host greater biodiversity than glass sponge reef because they are less muddy and thus less conducive to predators like prawns and crabs (Marliave, 2016; Dennison and Clayton, 2016). Many species find safety in glass sponge gardens, including juvenile rockfish, who use them as nurseries (Marliave, 2016; Dennison and Clayton, 2016).

Glass sponges have delicate silica skeletons that are easily fractured by direct contact with anchors, bottom trawling, prawns traps and other fishing gear (Tompkins-MacDonald & Leys, 2008; Chu, 2010; Cook, Conway & Burd, 2008; Kahn, Yahel, Chu, Tunnicliffe & Leys, 2015; Marliave, 2016; Dennison and Clayton, 2016; Bodtker, 2016). Conway and Manfred experienced this first hand when they returned to an exact glass sponge reef location a few years after they had previously visited, and found a flat ocean bottom with trawl marks and evidence of broken sponge reef. Some of Howe Sound’s glass sponge reefs have also been identified as damaged to varying degrees.

Glass sponges are filter feeders. They pump water into themselves, eat the bacteria in the water and pump out cleaner filtered water and ammonium (Tompkins-MacDonald & Leys, 2008; Chu, 2010; 2008; Kahn, Yahel, Chu, Tunnicliffe & Leys, 2015). Glass sponges thus provide the valuable ecosystem service of purifying ocean water (Cardinale et al. 2012). There is also evidence that glass sponges may act as a carbon sink (Kahn, Yahel, Chu, Tunnicliffe & Leys, 2015). Further, Leys’ study found that glass sponges are unable to control the amount of sediment they take in because their glass skeletons cannot contract efficiently (Tompkins-MacDonald & Leys, 2008).
Thus, to avoid getting clogged with sediment, they shut down and stop feeding temporarily when the water column above them contains high sediment levels (Tompkins-MacDonald & Leys, 2008). The glass sponge’s threshold for tolerance to sediments is unknown (Leys, 2016, personal communication). Research in this area is currently ongoing; however, extremely high sediment levels are predicted to smother glass sponges altogether.

It should also be noted that glass sponges cannot tolerate ocean temperatures over 10ºC (Marliave, 2016), and that no research has found chemicals or toxins to affect glass sponges thus far.

**Howe Sound**

Howe Sound is a body of water that borders on multiple municipalities and First Nations territory. Cold ocean water upwells into Howe Sound from the Salish Sea, while
the Squamish river feeds into the sound from the coastal mountains. Howe Sound is currently recovering from severe contamination caused by two pulp mills at Port Mellon and the old Woodfibre site, as well as Britannia copper mine near Britannia beach (Levings et al., 2004). Toxic effluent from Britannia mine impaired sand dollar fertilization and killed midge larva and marine amphipods, resulting in a food shortage for salmon fry (ibid). These effects disrupted the function and structure of intertidal ecosystems and resulted in low abundance of species (ibid). Meanwhile, the pulp mills in Howe Sound increased oxygen demand, toxic effluent and bleaching agents in the Sound, smothering many intertidal organisms (Bard, 1998). Before one of the Howe Sound mills shut down and the other upgraded its waste treatment, these pulp mills were found to be the most environmentally detrimental pulp mills in British Columbia (Bard, 1998). There is hope that marine life is recovering because of recent marine mammal sightings; however, biologists warn that recovery is still ongoing and that the increase in marine mammals is only a sign that herring are beginning to return to the area, not that the area has fully recovered from pollution.

**Marine Protected Areas**

MPAs are designated by DFO on behalf of government, with the purpose of “protecting sensitive habitat” (Bodtker, 2016). Establishing an MPA involves research on the area of interest. The current process of establishing MPAs involves a collaboration between DFO, Parks Canada, Environment Canada and First Nations, and all proposed MPAs require approval of the Minister of Fisheries in order to be implemented (Bodtker, 2016). It should be noted that MPAs do not necessarily involve fishing closures. Fishing closures are implemented separately from MPAs, though DFO has jurisdiction over both these designations (Bodtker, 2016).

**Burnco Gravel Mine Proposal**

In 2011, Burnco Rock Products Ltd. put forward a proposal for a mine that would be located at McNab creek, on the west shore of Howe Sound. The proposal claims that the mine would be located on a past industrial site and that Burnco would restore and monitor the site, turning the gravel pit into an artificial lake at the end of the mine’s life. Burnco further explained that no chemical processing would take place and that the only processing would be physical crushing of gravel (Golder Associates Ltd., 2011). Burnco argues that having a gravel mine at McNab creek would have a positive environmental impact, because instead of shipping gravel from Port McNeil to Burnaby, Burnco would be able to ship it from McNab creek. This route would be much shorter, causing less fossil fuel emissions from shipping and less disturbance to wildlife due to a shorter shipping route (Golder Associates Ltd., 2011). In their updated 2015 proposal Burnco proposed to shorten the mine’s life to 16 years and remove 1.5 million tons of gravel per year rather than 1.6 million tons (BURNCO Rock Products Ltd., 2016).
Woodfibre Liquefied Natural Gas

Woodfibre LNG has proposed a Liquefied Natural Gas (LNG) storage and marine carrier transfer facility 7km southwest of Squamish on the west side of Howe Sound (Woodfibre LNG). Over two million metric tons of LNG per year would be transported out of Howe Sound, and the LNG would arrive at the facility through an expansion of Fortis BC’s gas transmission system (Woodfibre LNG). The LNG cooling facility would take in seawater from Howe Sound for cooling purposes and pump it back into the sound, chlorinated and warmer than it was previously. The project has recently undergone provincial and federal environmental impact assessment (Woodfibre LNG). The Squamish Nation has given conditional approval to the Woodfibre LNG facility, which would be located on their traditional territory; however, they require a list of other conditions to be met by Woodfibre LNG, Fortis BC and the Provincial government before the project can begin. While the last 40 years of LNG shipping have supposedly had excellent safety records, 158 LNG shipping accidents are on record (Bubbico & Di Cave, 2009; Ikealumba & Wu, 2014).

Results

Glass Sponge Locations and Current Forms of Protection

The only glass sponge reefs in Howe Sound that are currently protected by DFO fishing closures are located in the Queen Charlotte Channel and near the Defence Islands (Fig.6). British Columbia’s provincial government has recently announced that it will extend the boundaries of Halkett Bay Marine Provincial Park, which will extend protection to the glass sponge reef and garden off of Halkett Point. This will allow for three of Howe Sound’s glass sponge reefs to be protected from direct contact with fishing equipment.

Other glass sponge reefs and gardens in Howe Sound still remain unprotected, and it should be noted that some of the protected sponge reefs in Howe Sound are damaged and in less of a pristine state than some of the unprotected reefs.

Meanwhile, in an attempt to manage endangered rockfish stocks and prevent their extinction, rockfish conservation areas (RCAs) were created in many parts of coastal British Columbia. Some of these RCAs are located in Howe Sound. Since rockfish use glass sponge formations as habitat and nurseries, many glass sponges happen to fall inside areas that have been labelled RCAs and are thus indirectly protected this way. RCAs do not provide full protection to glass sponges though. They prevent certain kinds of fishing and bottom trawling, but still allow anchoring and certain types of fishing, including prawn and crab traps.
Figure 6: Strait of Georgia Sponge Reef Closures from "Fisheries and Oceans Canada" (2015)
Threats to Glass Sponges

The greatest threat to Howe Sound’s fragile glass sponges is physical contact with gear. There are still unprotected glass sponge formations in Howe Sound, and currently protected sponges are still at risk of being damaged by recreational boat anchors and illegal fishing activities. Dr. Marliave identified prawn traps as a very serious risk to glass sponges, including already protected ones. Some prawn fishers have been found to go right up to the edge of glass sponge reefs and put down their traps near the reefs (Marliave interview, 2016). Because of the nature of the ocean, it is impossible to be certain of the exact landing location of a prawn trap when it hits the bottom of Howe Sound, and often traps intended to land off the edge of a reef actually end up hitting the reef and breaking off some of the delicate glass sponges (Marliave interview 2016). Dr. Marliave has observed glass sponge formations that have been damaged this way in Howe Sound. In cases where the glass sponge formation is not protected, this is allowed. In other cases where the glass sponge reef is protected, prawn fishers may not be complying with the 150 meter buffer around the reefs. In either case, glass sponges are being damaged. This points to the need for unprotected glass sponge reefs and gardens to gain protection and for protected areas already in place to be better enforced.

CPAWS has made it one of their goals to protect Howe Sound’s glass sponge reefs through one large or multiple small Marine Protected Areas. This would be helpful in protecting the glass sponges, but it should be noted that an MPA alone does not necessarily prohibit all harmful fishing activities.

MPAs and fishing closures will not, however, solve the threat of recreational boat users from unintentionally putting their anchors down into glass sponge formations. According to Dennison and Clayton recreational boaters and the public are often unaware of glass sponges and the threat their anchors pose to them. Further, they are of the opinion that some boat rental companies do not provide sufficient information to customers. Ideally, customers should be given updated maps and employees should show customers the locations of protected glass sponge reefs on the maps before customers get out on the water. Yet this exchange does not always take place when boats are rented.

Burnco’s proposed gravel mine poses the next greatest threat to Howe Sound’s glass sponges, after the threat of direct contact with fishing and boating gear. As discovered by Dr. Leys, glass sponges stop filter feeding when the water around them contains too much sediment. They do this in an attempt not to become clogged. High volumes of sediment threaten to smother glass sponge reefs and gardens, while lower amounts of sediment may also damage the sponge formations by clogging them or preventing them from feeding. The next phase of Dr. Leys’ research will attempt to find glass sponges’ threshold for sediment tolerance. Until this research is complete, it is unclear how sediment from Burnco’s proposed mine could affect glass sponge
formations in Howe Sound. However, the experts I consulted agree that sedimentation from the proposed mine into Howe Sound would be inevitable during heavy winter rainfalls, which are characteristic of coastal British Columbia. Further, the experts consulted agree that there are glass sponge formations very near McNab creek, the proposed mine location. Thus, Burnco’s proposal must be considered a potential threat to glass sponges, at least until further research is conducted.

Construction of an LNG cooling facility in Howe Sound must be considered in looking at threats to glass sponges. No research has been published on the effects of LNG terminal construction on glass sponges; however, construction of an LNG facility in Italy was found to disturb nearby sediment and cause marginal chemical contamination, which had a minor effect on benthic communities, including certain sponge species (Trabucco et al., 2015). Experts cannot provide a definite answer, but most agree that construction of a terminal would not have a significant impact on Howe Sound’s glass sponges because they are not directly adjacent to the proposed area for the terminal. While there has been concern about the effects of warm, chlorinated water being pumped into Howe Sound from the LNG cooling facility, Dr. Marliave is confident in the ocean water’s ability to regulate itself. Further, he explained that cold water comes into Howe Sound from the Strait of Georgia at deeper levels in the water column, while warmer water at Howe Sound’s surface flows out towards the Strait of Georgia. As a result, glass sponge reefs at the bottom of Howe Sound are continually getting cold water from the Strait of Georgia and should not be affected by warmer water at the surface of Howe Sound. Dr. Marliave anticipates that water from the proposed LNG cooling facility would cool back down to the regular temperature of Howe Sound by the time it could reach glass sponge formations. There is currently no evidence that chlorine or chemicals would impact glass sponges; however, it should be noted that no research has been done on this topic.

Climate change may pose a future threat to Howe Sound’s glass sponges, because they do not survive in waters above 10ºC (Marliave, 2016). Temperatures at the bottom of Howe Sound are not currently in danger of exceeding this limit, so this threat should be noted but is not of immediate concern.

Spills, fires and explosions have already been recorded in the short history of LNG transportation (Ikealumba & Wu, 2014); however, experts agree that these events likely pose no risk to glass sponge formations, which are located far below the surface of Howe Sound. In the event of an LNG spill, fire or explosion, it is likely that the surface of the ocean would react with the gas in a way that would prevent any impact from reaching glass sponge reefs on the ocean floor (Karin Bodtker, 2016).

Dennison and Clayton brought up LNG tanker propeller wash as a possible threat for glass sponge reefs and gardens. There is concern that the powerful propellers of large LNG tankers could move Howe Sound waters with such force that the impact could reach glass sponges and damage them. Given the size of Howe Sound and the
locations of glass sponges, Dr. Marliave predicts that propeller wash will likely not harm the sound’s glass sponges. It should be noted that this is a prediction by an expert, but has not been tested. This is because LNG tankers have never before come into such proximity of this type of sponge, which is only present off the coast of British Columbia.

Recommendations

To address the threat of direct contact with fishing gear to glass sponges, it is recommended that new fishing closures be implemented to protect the glass sponge reefs and gardens that are currently unprotected in Howe Sound. Since fishing closures are under the jurisdiction of DFO, their cooperation will be required to put in place further closures.

These areas closed to fishing could also be turned into MPAs; however, MPAs on their own would not be enough to protect glass sponges, since they do not necessarily prevent all types of fishing that are harmful to glass sponges. Since DFO has jurisdiction over both MPAs and fishing closures, it should be feasible to give MPA status to any glass sponge fishing closures in Howe Sound.

While RCAs are helpful in protecting glass sponges within their limits from certain types of direct contact fishing, they do not prohibit certain other types of damaging fishing, such as prawn traps, from fracturing glass sponges. Thus RCAs are not sufficient in protecting glass sponge reefs and gardens, and are not interchangeable with glass sponge fishing closures.

According to Dr. Marliave, current enforcement of fishing closures is limited by government funding. Thus, increased government funding is recommended to properly monitor and enforce current and future fishing closures.

It is further recommended to increase public awareness about glass sponge reefs and create tools to help the public protect them. Dennison and Clayton suggest creating a user-friendly smartphone app that shows glass sponge locations on a map and allows boaters to see when their boat is directly above glass sponges. This simple, accessible tool could allow boaters to take responsibility and avoid harming glass sponges with their anchors. It is recommended that this smartphone app be developed and be free of charge to users.

To prevent glass sponge damage from rented boats, Dennison and Clayton suggest that boat rental companies be held liable for any damage caused by their boats. It is recommended that Dennison and Clayton’s idea be put in place as an incentive for boat rental companies to properly inform their customers about glass sponge locations and protection.

To address the knowledge gap of sediment tolerance in glass sponges and the volume of sediment that could reach the glass sponges nearest to McNab creek in the event of sedimentation, it is recommended that further research by Leys’ and her team be funded. Burnco’s mine project should be postponed until further research is complete.
Conclusion

Glass sponge reefs are of great value because they are a unique Jurassic formation, previously thought to be extinct. British Columbia's coast is home to the only known live glass sponge reefs in the world and Howe Sound's glass sponge reefs are the only ones shallow enough for divers to access. Glass sponges provide valuable ecosystem services such as purifying water and possibly sequestering carbon. Glass sponge reefs and gardens provide habitat and nurseries, respectively, for endangered rockfish. They also host a wealth of marine biodiversity. Howe Sound's glass sponge reefs are built of brittle silica and are thus extremely vulnerable to contact with anchors and fishing gear. They may also be threatened by high levels of sediment in the water around them.

Thus, glass sponge reefs require protection. Three glass sponge reefs in Howe Sound are currently protected by DFO fishing closures or inclusion in a Provincial Marine Park, however these protected areas require better monitoring. Furthermore, other glass sponge formations in Howe Sound remain unprotected and are in need of fishing closures. Finally, Burnco’s proposed gravel mine at McNab creek may pose a threat to glass sponges. Thus, further research is required to determine how much sedimentation from the proposed mine could reach the nearest glass sponge formation and what the sediment tolerance of these glass sponges would be.

Acknowledgements

Dr. Jeffrey Burton Marliave, Karin Bodtker, Glen Dennison and Lena Clayton contributed valuable findings to this report during in person interviews. Dr. Jeffrey Burton Marliave, Vice President at the Vancouver Aquarium, contributed a wealth of first
hand knowledge regarding Howe Sound’s glass sponges and insight on possible threats to glass sponges. Karin Bodtker, at the Vancouver Aquarium, contributed to my understanding of Howe Sound and Marine Protected Areas. Glen Dennison and Lena Clayton, from Marine Life Sanctuaries Society, also contributed first hand knowledge of Howe Sound glass sponge reefs from diving and discovering many of them. A special thanks also to Diane Reid and Adam Taylor who allowed me to use their photographs in this report. CPAWS hosted a presentation on glass sponge reefs with guest speakers Dr. Kim Conway, Dr. Manfred Krautter, Dr. Leys and graduate student Lauren Law, which helped confirm findings from interviews and fill in any final gaps in my knowledge. With all the experts on glass sponges in the room, I was able to confirm exactly how far science has come and the next steps that need to be taken in terms of glass sponge research. I also wish to thank Ken Melamed from the Green Party of Canada and Ruth Simons, executive director of the Future of Howe Sound Society, for entrusting me with this research. Thank you also to my professor, Dr. David Brownstein who supported me throughout the project.
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