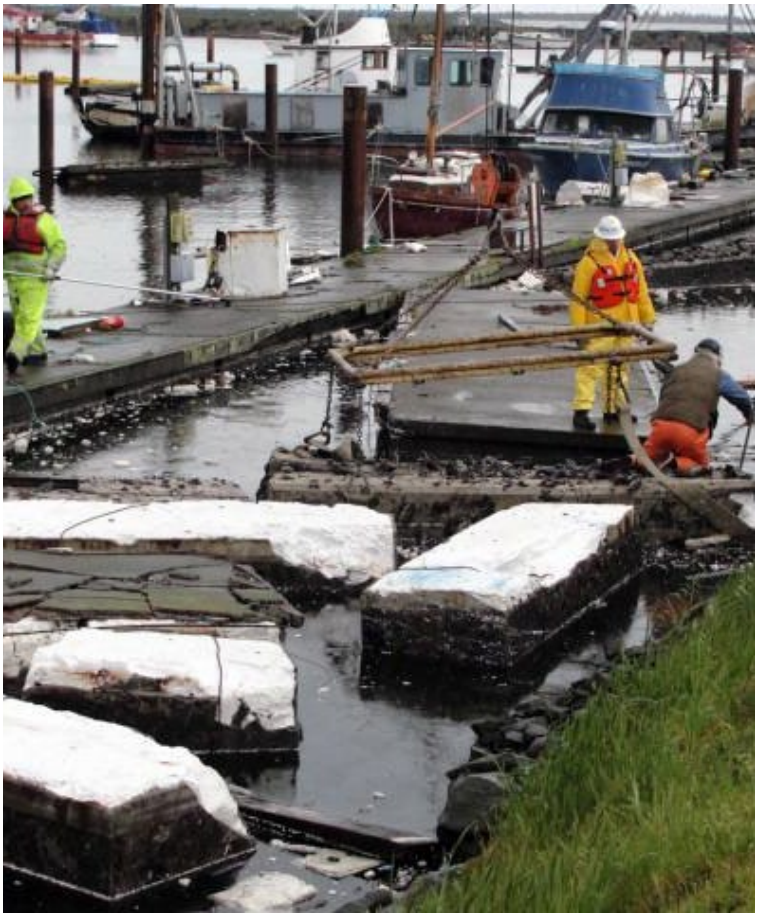
The Polystyrene Problem:

A Scholarly Report



Report in partnership with the Lasqueti Island Shoreline Debris Initiative

Ocean Leaders:

Elsa Camins

Max Miner

Kate Mussett

FISH507

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Introduction

For the last half decade, single use plastics have been the topic of ocean conservation discussions internationally. During this time, the public bore witness to the sweeping effects of social media and globalization of both place-based and international issues. Our focus was kept steadily on plastic bags floating through the open ocean, turtles being suffocated by straws, and marine organisms' intestines being filled with microplastics. The same cannot be said for other matters of marine pollution, including but not limited to the ongoing use of polystyrene as floatation devices for docks and wharves on Canada's coasts. Polystyrene has long been the enemy of waste management agencies, given its unwillingness to break down or be recycled. However, the experiences of communities and individuals living on the shores of British Columbia's inland waters can attest that polystyrene does seem to have a favored environment for breakdown and degradation: marine environments. As polystyrene continues to be the preferred material for docks both old and new, so too does the pollution of this destructive substance within the Salish Sea.

Communities across British Columbia's Southern Gulf Islands have been experiencing the ongoing effects of this pollution as it ends up on their shores. In the case of Lasqueti Island, a small community of approximately 360 permanent and seasonal individuals in the Strait of Georgia of Vancouver Islands east coast, polystyrene accumulates constantly on their beaches in startling quantities. Following the establishment of the Lasqueti Island Shoreline Debris Initiative, as well as the British Columbia Marine Debris Working Group, and many more between British Columbia's Southern and Central coastline, public awareness and engagement activities to gain traction similar to that of the single use straw failed to gain public interest. Working groups and community volunteer initiatives have struggled to have their concerns taken seriously within the context of marine protection and both provincial and federal responsibilities towards plastics and polystyrene pollution.

The context of this report proposes potential solutions for moving forward in removing the use of polystyrene in docks and wharves from marine ecosystems and waterways by first bringing forward a discussion around ecological implications of polystyrene use within the context of docks in the Salish Sea. This outline will aid in illuminating the efficacy of some solutions over others, as well as articulating the risks of continued use. We will then endeavor to untangle the complicated web that is marine jurisdiction in Canada, in order to uncover the specific roles and responsibilities of each governing body within the scope of polystyrene pollution and dock

floatation degradation. This discourse will outline the need for First Nations based legislation and marine spatial planning, in order to adhere to the knowledge, values, and histories of these lands stewards, as well as to continue bridging socio-cultural divides between Indigenous and colonial governments. Given the related concerns in other contexts, similar considerations have been made by communities in Washington State, the province of Ontario, and beyond to move forward with different methods of removing or encapsulating polystyrene. Here will discuss how these plans came into fruition, how they have worked, and how the province of British Columbia as well as the Canadian government can take on related trajectories towards greater change. In all, this report will serve as the foundation for a policy and recommendations brief that will be circulated to other marine pollution working groups, the province of British Columbia, as well as First Nations governments whose territories are affected by this ongoing issue. It is our hope that this report and subsequent briefing will aid in building a framework for change in Salish Sea polystyrene pollution mitigation and reduction.

Implications of Polystyrene in the Marine Environment

History and Production in Docks

Polystyrene is a synthetic thermoplastic polymer of styrene, a hydrocarbon monomer. It is one of the oldest plastics, first isolated in 1839 from the resin of *Liquidambar orientalis*, the Turkish sweetgum tree. Although originally isolated from plant material, styrene produced today is derived from ethylbenzene, a product of the petrochemical industry (NCBI 2022). Over 99% of all petroleum-derived ethylbenzene is used in polystyrene production. As of 2019, global polystyrene production reached a peak of approximately 15.6 billion kg (Fernandez 2021).Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) are the two primary types of polystyrene foam (PS). Both EPS and XPS are created via a manufacturing process that treats unexpanded polystyrene with “blowing agents”, causing the polystyrene to expand (turning its composition to 95% air) and making it good for insulation and floating. Chemical additives and external coatings to change its material properties, such as making it more durable and resistant to the environment. The high buoyancy, resistance to decomposition, low water absorption, and extremely low cost of EPS contributes to its utility in aquatic applications; these same three factors are the cornerstones of polystyrene pollution’s intractability as an environmental issue.

But what is the difference between EPS and XPS? Both materials are made of attached cells, but in the case of XPS it is a hard foam, which means that it doesn't contain the open network of space between the expanded beads like EPS, providing more stiffness and more water resistance. For these reasons, it is usually recommended to use XPS for docks, rather than EPS. EPS was developed for commercial use in the late 1940s, and by the late 1960s had begun to be used as a cheap, lightweight replacement for a variety of products, from cups and packaging to holiday decorations. By the mid-20th century, EPS was the primary material used for dock floats in both freshwater and marine environments, and various constituencies had begun to voice concerns about its effects on aquatic systems.

The use of Polystyrene for docks and aquaculture started to become more popular between the 1960s and 1970s, especially for recreational docks and fisheries as for its low cost and its characteristics (already mentioned before). And already from the 1970s, polystyrene pollution in seawater and fish was started to be observed (Carpenter & Smith, 1972). For the aquaculture industry the used expanded Polystyrene floats can be of 40 to 70 L in size usually. While for docks the styrofoam buoys can be of more than 200L in size (*Jang M., 2016)*. When not encapsulated the life expectancy of polystyrene foam is short - about 20 years for EPS. This short life span necessitates frequent replacement. Encapsulation with a layer of plastic, metal, or other protective material can increase life expectancy by a factor of three to four times when compared to exposed EPS (EPS Industry Alliance, 2021). In South Korea, research on Polystyrene buoy production, use, and retrieval found that around 70%, are lost or thrown away as waste, making styrofoam one of the main types of beached marine debris (Jang, M. et al., 2016). Furthermore, the recovered buoys usually have low recycling rate, given the high transportation cost due to increased waterlogging, as when this happens their weight increases (Ragan, 2007). Therefore, a lot of the recycling programs for polystyrene docks have had little success.

How Expanded Polystyrene breaks down and enters the Salish Sea:

Due to its structure, EPS is easily broken up compared to other types of polymers, depending on the environmental conditions it is found in. In terms of marine structures, one example is when the polystyrene flotations for docks can break free, where whole pieces float away in the ocean. In this case, the polystyrene either ends up washing on a beach and can be retrieved, or it can break into many fine pieces and disperse throughout the marine environment (beaches, water column, the ocean floor, and ingested by animals). Additionally, marine life can often cause the breaking down of polystyrene. For example, crustaceans and other animals can

get attached to the non-encapsulated polystyrene float that is submerged under the water, so that when predators come to eat them, the float is damaged and causes dispersal of small pieces into the water.

Marine crustacean bores are a main contributor to marine polystyrene degradation.s. These isopods create densely clustered colonies that perforate the submerged surface of the polystyrene and reduce its functionality. These colonies usually are created between the first 60mm of the surface, and when different generations have colonized the same area, eventually all these colonies create an interconnected network (Davidson, T. M., 2012). Leading the polystyrene to be weaker and more susceptible to breakage. However, as they are filter feeders, it is believed that there is no consumption of the excavated material. From the boring process of polystyrene by crustaceans and all the other processes, small particles of plastic or microplastics (<5mm) (Styrofoam in this case) are created and released to the environment. Like other microplastics, when released it can have great harmful effects on marine organisms.

Figure 1. Photo of a burrowed polystyrene dock at Sewell Horseshoe Bay (Photo by Donald Gordon)

Some species involved in the boring process of polystyrene are: *S. quoianum*, *S. terebrans*, and *S. peruvianum*. The non-encapsulated floats are the ones more vulnerable to isopods burrowing. The frequency of non-encapsulated polystyrene getting burrowed is about 43.5%, while damaged encapsulated expanded polystyrene is 30.4% (Davidson, T. M., 2012). Non-encapsulated polystyrene can also be affected by abiotic or weather conditions, such as photodegradation, or also called “breakdown by light”. The continual exposure to sunlight affects the outer layer of the plastic, leading to discoloration and turning it into a more fragile substance.

With this process, the polystyrene becomes thinner and is able to break down in a few years. However, if polystyrene was to be protected from the light via encapsulation,, this process wouldn't happen and this material would last longer. Additionally , it can be affected by waves, changes in sea level, wind and ice. In the case of EPS, it can be more affected by ice, as the interstitial gaps between the expanded beads are open to the environment, water can go in and during winter convert to ice, causing the EPS to break into pieces (Turner, A., 2020). And finally passing boat traffic can also help with the breaking of the PS.

Ecological Effects on Marine Life and Aquatic Health:

Polystyrene and the chemicals incorporated during manufacture present a handful of negative ecological effects on marine life and aquatic health, which can end up posing a risk for public health. When it is left in the marine environment to break down, it remains there for hundreds to thousands of years in normal ocean conditions. Being toxic for humans, wildlife and marine life, food supply, and the environment. Actually, the U.S. Environmental Protection Agency (EPA) and the International Agency for Research on Cancer as a possible human carcinogen.

Microplastics can affect marine life in three main ways; first, they can facilitate the spread of non-native species to different locations, as they create a surface where organisms can attach and use as transportation. Furthermore, it can work as a potential source of hazardous substances for attached organisms. Some examples of organisms that you can find attached are: sponges, microalgae, or bryozoans. When the Polystyrene breaks from the burrowing, the pieces of PS disperse with these animals and help them to invade and colonize new areas, making them easier to be invasive species (Davidson, T. M., 2012). And helping with the dispersal to new docks. Not only they can help to disperse invasive species, but also, they can transport the containing chemicals from a contaminated area to a remote uncontaminated one, expanding the contamination. When they get colonized in the marine environment by biofilm and other organisms, it makes them weigh more and sometimes sink (Gregory, 2009). ending on the bottom of the ocean, where they might interact with benthic and pelagic organisms.

Second, the ingestion of these particles can also lead to different physical problems, for example, if they accumulate in an organism. The accumulation can lead to intestinal obstructions, stomach ulcers, and to a false indication of satiation. All this can affect their growth and survival, however, it's still not clear all the actual effects that can cause. PS foam has been found in the stomachs of fish, marine mammals, sea turtles and marine birds (Savoca, et al., 2021). And if the size of the microplastics is small enough it can transfer to outside the gut and end up in other

tissues, being this process called translocation. Microplastic fragments released from the floats from aquacultures can be ingested by the farmed fish and be transferred to humans. Moreover, zooplankton can also ingest PS passively while eating phytoplankton. And selective filter feeders like copepods (Cole et al., 2015), oysters (Sussarellu, et al., 2016) and mussels might also be ingesting PS from the suspended water.

Finally, as microplastics degrade and interact with the environment they can start accumulating toxic substances from the environment and become toxic. Some of the common toxic substances that they can get adhered to are Persistent Organic Pollutants (POPs) (Davidson, T. M., 2012). POPs have a higher affinity for plastics and can accumulate in high concentrations; when the marine fauna ingests the plastics they can absorb these chemicals and bioaccumulate through the trophic levels. This can lead to an issue for humans too when consuming fish (Bastlova, T. & Podlutsky, A., 1996).

Polystyrene can also absorb fuel and oil, which can make the styrofoam docks catch on fire. As well as being an environmental risk if this dock floats away or breaks into pieces, dispersion the fuel or oil to other non-contaminated areas. Furthermore, they can bioaccumulate heavy metals. Microplastics can also leach the toxic additives added during their manufacturing production to the environment, which some of them are known to be endocrine-disrupting chemicals (like styrenes), possibly affecting the reproduction and development of marine organisms (Cole et al., 2015). The can also can cause lung tumors, affect the liver and create genotoxicity. Some of the chemicals added are antioxidants, plasticizers, UV stabilizers, flame retardants, etc. (*Jang M., 2016)*. The released polystyrene foam can become a hazard to boat traffic and end up washing up on the beaches, affecting their aesthetics and quality. Polystyrene microbeads pose a barrier for communities and shoreline clean up crews through mixing with sand, leading to smaller pieces that are even more difficult to detect. In some areas, up to 70% if the plastics found in beach sand is polystyrene (Zbyszewski, M., et al., 2014). Larger polystyrene pieces are similarly challenging due to the failure of industry and government to take responsibility for proper disposal and clearing of polystyrene from British Columbia’s shores.

Figure 2: Pieces of Polystyrene foam that has washed in the coast at Cape Rogers Curtis, Bowen Island (Photo by Donald Gordon)

British Columbia Marine Debris Today

Due to its high buoyancy and fragmentability, EPS tends to collect in high abundance near point pollution sources and in areas where land shape, wind, and ocean currents concentrate debris. One such location is Lasqueti Island. Lasqueti's location in the center of the northern Strait of Georgia, exposed to tidal and wind-driven surface currents, leads to the accumulation of massive volumes of marine debris on the island's beaches. The majority of this debris is composed of polystyrene foam, both in microplastic fragments and in large, intact dock-float blocks (fig. 3). After years of informal cleanups, in 2016 the residents of Lasqueti Island began annual, organized, citizen-led efforts to clean up the marine debris accumulating on their beaches. They were not alone - in the past decade, multiple community-led organizations focused on beach cleanups and marine debris reduction have been created. These organizations have loosely coalesced into the British Columbia Marine Debris Working Group (MDWG). During the COVID-

19 pandemic, the BC MDWG was involved in the BC Marine Debris Removal Initiative, which successfully removed 327 tonnes of plastic waste from BC beaches. Despite these accomplishments, **there is increasing recognition that cleanups (the burden of which often falls on local communities) are a temporary fix, and that legislative and regulatory action is needed if the issue of marine debris in BC waterways is to be permanently addressed.**

Figure 3. Examples of fragmented and whole-block polystyrene debris from the beaches of Lasqueti Island

In 2019, the BC Provincial Government, under the leadership of Parliamentary Secretary Sheila Malcolmson, met with interested parties in order to "fully understand the gaps, barriers, and opportunities" related to marine debris pollution. A summary of the results of the Province's work, which included input from coastal governments, Indigenous First Nations, industry interests, NGOs, and citizen organizations, was published in February of 2020 (BC MECCS 2020). **Polystyrene foam pollution in marine environments was the only issue that was selected as a problem of primary concern by all 5 categories of interest groups.** Additionally, the most widely agreed-upon solutions to the issue were "planning and interjurisdictional cooperation", "disposal and recycling options", and "province-funded programs". In the following sections, we will (1) summarize the literature on the ecological impacts of polystyrene, (2) discuss the legal and jurisdictional framework around marine debris in BC, and (3) outline how the issue of polystyrene pollution from dock floats has been addressed in other jurisdictions.

Jurisdictional Responsibilities and Marine Law

Marine Jurisdiction in British Columbia

All levels of government are responsible for coastal protection in British Columbia (West Coast Environmental Law, 2020). That being said, untangling the web that is marine jurisdiction in British Columbia involves a deep understanding not only of the United Nations Convention on the Law of the Sea (UNCLOS), but also the complex and overlapping inner workings of Canadian federal, provincial, and First Nations government structures (Hewson et al., 2020). Before ascending into the legal concerns brought forward by the Lasqueti Island Shoreline Debris Initiative, also known as the 'search for a smoking gun', we must first understand who is responsible, and why. By starting from the highest legislative power, ie. the United Nations, and working towards the lower levels, ie. local government and community working groups, we can garner a better understanding of this layered affair. According to the United Nations Convention on the Law of the Sea (UNCLOS), each state's jurisdictional power is divided into sections from internal or inland waters, to territorial sea and beyond, each with decreasing power as nautical mileage increases towards the high seas (Hewson et al., 2020). The figure below depicts this breakdown:

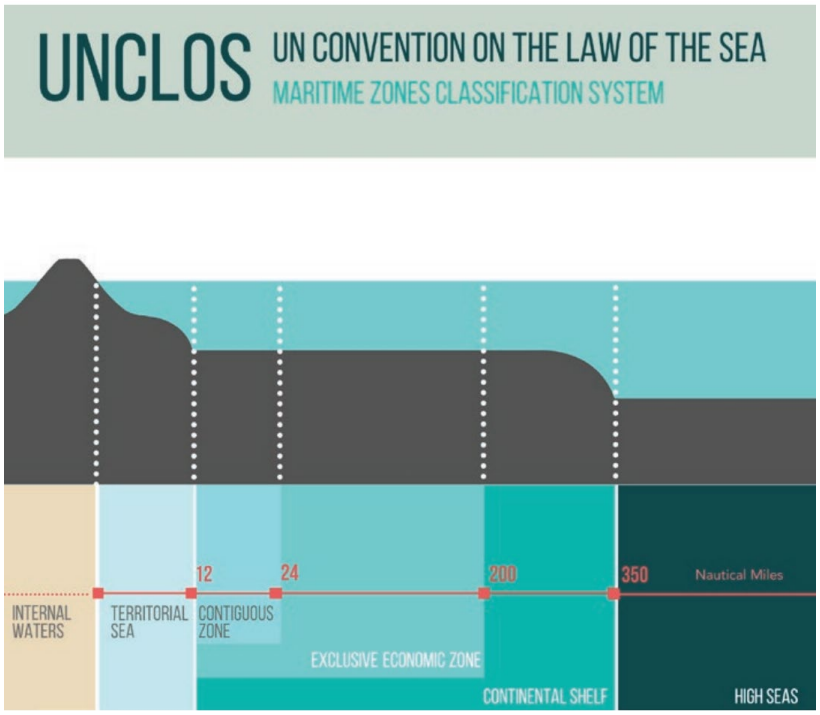

Figure 4: United Nations Convention on the Law of the Sea Jurisdictional Breakdown (Hewson et al., 2020)

As shown above, UNCLOS Maritime Classification System includes six major zones, all of which are governed by one or jurisdictional body. The table below breaks down the specific governing bodies that hold control or responsibility over these areas;

	International	*Federal*	*Provincial*	*Municipal*	*Indigenous*	*Local*
Internal Waters	X	X	X	X	X	X
Territorial Sea	X	X			X	
Contiguous Zone	X	X			X	
Exclusive Economic Zone (EEZ)		X				
High Seas	X					

Table 1: Jurisdictional responsibility across marine zones

Beyond UNCLOS separation of maritime jurisdiction, Canada's constitution further convolutes matters through further division of state jurisdiction between provinces, Indigenous governments, and local authorities. British Columbia's inland waters compose all waters between the Province's mainland and island territory These inland waters were under the jurisdiction of the federal government until June 1981, when the Declaration of the Strait of Juan de Fuca turned these responsibilities over to the Province (Finkle and Lucas, 1990). This decision came at the same time as the introduction of UNCLOS, and their subsequent Maritime Classification System, which outlined Canada's right to exploit resources in their Exclusive Economic Zone (EEZ), but not to own the waters or subsurface lands (Finkle and Lucas, 1990). This decision can be seen to have had profound effects on the ongoing marine pollution debate, as neither the federal nor provincial government holds ownership or associated responsibilities to waterways classified as EEZs.

The jurisdictional area of particular relevance to our report is the foreshore, which encompasses the land between low and high water marks and "is an area of special jurisdictional complexity" (Hewson et al., 2020, p. 29). The foreshore has been the site of much debate and legal negligence within the context of pollution and marine protection. Foreshore Crown title

belongs in majority to the province except in specific, limited circumstances such as federal docks or First Nations reserve lands (West Coast Environmental Law, 2020). In most cases, legislation around use of foreshore areas is enacted in case by case scenarios, such as shellfish and aquaculture operations policies or dock building materials and use. These policies often do not adhere to broad coastal protection objectives, nor do they require cumulative effects or impacts assessments prior to implementation (Hewson et al., 2020). Due to this disorderly conduct, foreshore administration is often thrown together in a manner concerned only within the specific circumstances at hand. This indolence is cause for great concern, especially in the context of the high level of anthropogenic activity within the foreshore area. Further complications arise given that foreshore areas are often fish habitat, which falls under federal jurisdiction, as well as often holding cultural and/or archeological significance to First Nations, resulting in the need for Heritage Act permits for altering or building on land (Hewson et al., 2020).

Given these conflicts, decisions by one level of government in an area of jurisdiction allocated to another level of government brings action to a standstill. This can be exemplified in the case of the Canada-Newfoundland and Labrador Joint Petroleum Board, where calls were put out for offshore oil and gas development bids in a federally regulated marine protected area (MPA), Northeast Newfoundland Slope Marine Refuge (Hewson et al., 2020). Given that this MPA counts towards national conservation goals, the federal government is responsible for maintaining its protection, while also upholding its positionality within the Petroleum Board. Further, given its collaborative nature, the federal government alone cannot remove the call for bids, resulting in multifaceted conflict. These sorts of disputes often occur between Indigenous governments and the federal government within the context of commercial fisheries closures, rights to fishing, and take allowance (West Coast Environmental Law, 2020).

These governmental and jurisdictional incompatibilities create multidimensional difficulties in making change, especially within the context of marine pollution. Throughout the course of this discussion, it can be seen that ultimately the province holds majority responsibility for mitigating the effects of polystyrene pollution, as well as for moving towards a polystyrene-free future. Furthermore, this will inevitably require cooperation from all levels of government, or cooperative federalism, in order to achieve success in the eyes of all stakeholders and rights holders. In the subsequent sections, we will unpack the ways in which this may occur.

Collaborative Efforts in Marine Protection and Ocean Pollution Reduction

Within the context of this conversation, it is important first to reference the UNCLOS ocean protection responsibilities, including Article 192, which states that “States have the obligation to protect and preserve the marine environment”, and Article 194, which ”requires that states take all necessary measures to protect and preserve rare or fragile ecosystems, including endangered or fragile habitats.” (Hewson et al., 2020).

Interjurisdictional marine protection often occurs through the implementation of conservation areas, including marine protected areas and provincial and national parks such as the SGaan Kinghlas-Bowie Seamount Marine Protected Area in Haida territory (Hewson et al., 2020). In that case and many others, successful implementation of a protected area depended on intergovernmental collaboration that took into account the values and concerns of all parties. Succes collaboration between Indigenous and colonial governments in BC is often made more difficult by the historical and ongoing oppression and genocide of Indigenous peoples. First Nations governance precludes Canada’s constitution and operates according to their own laws, values, and traditions. The resistance that occurs when First Nations governments or communities attempt to implement protection or conservation actions are often due to deep ceded and colonially rooted power struggles, as well as disparate management objectives often related to natural resource extraction. While sovereign governance over land and resources is often not granted to First Nations, collaborative efforts have seen some success in the aforementioned Marine Protected Area in Haida territory, as well as in some national parks and co-managed commercial fisheries (Hewson et al., 2020).

In 2011, the BC Provincial Government and 17 First Nations from the North and Central BC Coast formalized a Marine Protection Plan Initiative, or MaPP(Diggon et al., 2021). This partnership began with a “nested planning process” in which First Nations contributed concerns and values around marine protection in order to create a more equitable and respectful process. The nested planning process produced the following co-created goals: the identification of objectives and strategies for moving towards healthier oceans, an increase in the strength of marine economies, and improved cultural and social outcomes (Diggon et al., 2020).

Due to overlapping and non-contiguous territorial claims in this region, management units or subregions were established based on geography, politics, and socio-economic alignments (Diggon et al., 2021). The process was then placed within the context of provincial jurisdiction, which included community and economic well being, tourism, aquaculture, log handling, cultural and historical resources, and marine protection (Diggon et al., 2021). In all, this Marine Protection

Plan within the North and Central Coast context laid the groundwork for future Indigenous and provincial government collaborative work, which allows for effective and actionable communication on shared goals. Furthermore, this type of Marine Protection Plan would be well suited for the Southern Coast region and has the potential to support attempts by community working groups, First Nations governments, and local governments to reduce polystyrene pollution in the Salish Sea.

These concerns are well heard across regional and international levels of government as concern around marine debris continues (Sandborn et al., 2021). Within the larger context of marine debris, a key aspect in potential future solutions is appropriate disposal of products at the end of their life through better waste management initiatives (Sandborn et al., 2021). As discussed in previous sections, better waste management alone cannot address the complex associated with use of polystyrene in docks and marine systems. Therefore, the focus must be on reducing polystyrene inputs to the marine environments. Effective tools for making change within this space include awareness campaigns, rebalancing of financial burdens of cleanup, and use of alternative materials. Awareness campaigns attempt to influence behavior and apply pressure to provincial and federal governmental bodies, but often fail due to their focus on influencing individual behavior (Sanborn et al., 2021). Additionally, the larger marine debris removal initiatives often posit a “polluter pays” form of mitigation, or extended producer responsibility programs. However neither of these avenues remove polystyrene from the shores of Lasqueti Island and other Salish Sea coastal communities. Therefore, it is necessary to explore polystyrene alternatives, the establishment of legislation banning polystyrene use in docks, or a combination of both.

Polystyrene: Legal Responsibilities

Responsibilities fall on all levels of government, but local and Indigenous governments/groups are often met with barriers built and controlled by the federal and provincial government. Given the need for inter-jurisdictional cooperation when implementing policy on marine protected areas and environmental protection, all parties need to be invested in order to make change. Indigenous and local communities have expressed interest and demanded change in polystyrene and plastics pollution, therefore it falls to the province of British Columbia and Canadian federal government to make change. This can be seen as a case of negligence given the known effects of polystyrene pollution in the Salish Sea. The legal responsibilities around polystyrene pollution fall to all levels of government based on declarations from the United Nations, such as the Crown’s requirement to fulfill duties under the United Nations Declaration on

the Rights of Indigenous Peoples (UNDRIP), as well as constitutional duties, both of which outline a call to protect marine areas (Hewson et al., 2020).

Case Studies in Polystyrene Policy

The issue of expanded polystyrene foam pollution in aquatic environments has been recognized, debated, and legislated for decades. Oregon State became the first subnational governmental body in North America to ban unprotected EPS in aquatic environments over 30 years ago, in January of 1992. British Columbia lags behind Oregon, Washington, Ontario and other Canadian and American regions in its failure to address polystyrene pollution in either marine or freshwater environments. Municipal and regional legislation around preventing EPS pollution has increased greatly in the past decade. In this section, we present a summary review of how the EPS dock float issue has been addressed in subnational jurisdictions in the United States and Canada.

Case Studies

Jurisdiction: State of Washington

Overview: Bill 2013-5546 mandated the encapsulation of dock flotation materials in marine and freshwater environments. The timing of the bill coincided with an increase in public concern around marine debris pollution following the 2011 Japanese Tsunami.
Legislation : *SENATE BILL 5546: An Act relating to floatation devices on state-owned aquatic lands and in state waters.* (WSL 2013-5546)
Date: 4 Feb, 2013
Effect: Mandated encapsulation of polystyrene foam in floats installed on state-owned aquatic lands.

Details: WA Senate Bill 5546 amended WAC 220-660-140 (*Residential and public recreational docks, piers, ramps, floats, watercraft lifts, and buoys in freshwater areas*) (WAC 220-660-150) and WAC 220-660-380 (*Residential and public recreational docks, piers, ramps, floats, watercraft lifts, and buoys in saltwater areas*) (WAC 220-660-380) to include language mandating encapsulation of flotation material in new dock construction. In contrast to lifecycle replacement of polystyrene floats mandated by other regu lations outlined below, the Washington legislation included an explicit timeline for replacement of legacy unencapsulated dock floats that had been installed before bill passage. Dock owners were given less than two years to replace any existing unencapsulated float.

The 2013 Washington State legislation was the product of several decades of campaigning by environmental and citizen activist groups. After years of little legislative progress, the issue of marine debris, including styrofoam, was brought into the public eye in the aftermath of the 2011 Tohoku earthquake and subsequent tsunami that devastated the east coast of Japan (Hickney 2013) . Debris from the 2011 event began to wash up on the west coast of North America in 2012, and was disproportionatel y composed of styrofoam fragments (30% of total debris, as compared to 5% of total debris pre-tsunami) (Rosen 2013). The volume of tsunami debris peaked in 2013, and included many documented cases of dock floats and even entire docks washing up on the shores of the Pacific Northwest. While not directly referenced in Bill 2013 -5546, this increase in public awareness around marine polystyrene pollution likely played a role in the timing of the bill, and may have contributed to the lack of public opposition i n Washington compared to similar legislation in other jurisdictions. A search of news archives

from 2011-2015 using various combinations of the keywords "washington state" "styrofoam" "polystyrene" "styrofoam" "dock" "float" and "legislation" returned no relevant results other than digital archives of the bill itself.

Jurisdiction: State of Oregon

Overview: An early bill mandating encapsulation of dock materials has failed to prevent polystyrene dock floats from fragmenting, and attempts to ban the use of polystyrene completely are ongoing.
Legislation: *Oregon State Marine Board Rules 250-010-0700 to 0715 (OAR 250-010-0700-0715)*
Date: January 1, 1992 (Increased restrictions in 2019)
Effect: Mandated encapsulation of all polystyrene floats in aquatic environments.

Details:

> *"Polystyrene foam is deadly to marine life. It floats on ocean surfaces, breaks up into pellets resembling food, and is consumed… There is no such thing as 'safe' polystyrene foam. Don't use it." Spilyay tymoo, Newspaper of the Confederated Tribes of the Warm Springs Reservation, Warm Springs, Oregon, (Spilyay tymoo 1990)*

Oregon State was the first State or Province in North America to ban unencapsulated EPS in January of 1992, after decades of opposition to the use of polystyrene and recognition of its impacts on Oregon's aquatic environments. The measure met with mixed success, and in 2019 the existing regulations were strengthened to include more durable and thicker encapsulation requirements. Despite the regulations mandating encapsulation, Oregon continues to struggle with expanded polystyrene pollution in the State's aquatic systems, including news accounts of the decomposition of dock float encapsulation materials resulting in the release of large amounts of fragmented and whole float debris (Del Savio 2021). In 2021, an attempt to enact a complete ban on the use of polystyrene foam in food service packaging and dock floats failed to pass the State legislature.

Jurisdiction: Province of Ontario

Overview: In 2021, after significant pressure from activist groups, the Province of Ontario passed legislation mandating encapsulation of newly-installed polystyrene floats. The legislation was the least-detailed of any discussed here, consisting of only two sentences. No timeline for replacement or explicit guidelines for encapsulation materials were provided.
Legislation: *Bill 228: Keeping Polystyrene Out of Ontario's Lakes and Rivers Act, 2021* (S.O. 2021)
Date: 20 May, 2021
Effect: Mandate encapsulation of all polystyrene floats in aquatic environments.

Details: After years of advocacy from residents, the Province of Ontario banned the sale, construction, or installation of unencapsulated polystyrene in 2021. The Bill, introduced by MPP Norman Miller, was the result of years of advocacy by a number of local organizations, including the Georgian Bay Association and Federation of Ontario Cottagers' Associations. The GBA had previously led shoreline debris cleanup efforts along the shores of the Great Lakes and, similar to cleanups in BC, had reported polystyrene to compose approximately 95% of all debris collected.

Under the current legislation, use of encapsulated polystyrene foam is still permissible. Of o rganizations that submitted written statements during the legislative process, 28 of 30 supported the Bill. The legislation took effect immediately with no grace period. It did not mandate immediate or lifecycle replacement of existing polystyrene docks or floats, but did require the encapsulation of any EPS used in repairs to existing docks.

While celebrated locally, the wording of the legislation is minimal: 3 sentences mandating undefined "encapsulation" of dock float polystyrene, with no mandate to replace existing unencapsulated floats. Effects of legislation are yet to be determined.

Jurisdiction: City of San Francisco

Overview: A complete local ban on the use of polystyrene, encapsulated or unencapsulated, in aquatic systems. Limited in scope: city jurisdiction includes only waterways controlled by the city which, in California, does not include marine docks over State-owned tidelands.
Legislation: *Ordinance 14016: Amendment to theEnvironment Code- Food Service and Packaging Waste Reductio (SFBoS 2016)*
Date: 29 July, 2016
Effect: Complete ban on all polystyrene in aquatic systems, including encapsulated EPS.

Details: At time of enactment in 2016, the San Francisco ordinance was the broadest ban on polystyrene foam in North America. The ordinance strengthened a 2007 ban on styrofoa m food service items such as cups, plates, and take-out containers. The political and local pressure behind the strengthening of the ordinance was a direct result of the initial ban's failure to address EPS pollution in the city's waterways; during the ord inance drafting process, the San Francisco Board of Supervisors specifically cited the "contribution of polystyrene foam to plastic pollution in waterways" as a guiding rationale. Dock floats, though not the main focus of the legislation, were included under the umbrella of the comprehensive ban. In practice, the impact on the use of polystyrene dock floats is limited, as the State- owned marine waters of San Francisco's coast are outside the jurisdiction of the city. However, the ordinance does apply to city-owned docks, as well as docks in canals and freshwater environments with the city limits.

Jurisdiction: Pender Harbor, British Columbia

Overview: After a controversial multi -decade consultation process, the Province of BC and the Shíshálh First Nation agreed to a comprehensive management plan for Pender Harbor. While the Shíshálh FN Best Management Practice for Marine Docks recommends no usage of polystyrene floats, the final compromise agreement for Pender Harbor required only encapsulation of polystyrene and lifecycle replacement of existing unprotected floats.
Legislation: Pender Harbor Dock Management Plan (BCMFLNRORD 2018)
Date: 4 April, 2018. Updated March 2021.
Effect: Mandated encapsulation of float in new dock installation, lifecycle replacement of unencapsulated floats

Details: The land and waters that comprise the convoluted coastline of what is today known as Pender Harbor are located wit hin the traditional territory of the Shíshálh First Nation. Pender Harbor is the location of Kalpilin, one of the four main historical Shíshálh settlements. As a result, it is an area of ongoing and historical significance to the

Nation, as well as the location of significant archeological, environmental and cultural resources. It has also seen heavy residential and commercial development over the 20th and 21st centuries as a destination for vacation and recreation. This development has included the often-unregulated installation of hundreds of residential and dozens of commercial docks. After decades of confusion, inaction, and lack of government regulation, a moratorium was placed on new dock construction while the Shíshálh and the Provincial Government negotiated a management plan for the Harbor. The *Pender Harbor Dock Management Plan*, released in 2018 after 15 years of negotiations, is described by the province as follows:

> *"(the PHDMP) defines requirements for dock design and construction, and further identifies three zones where additional requirements or restrictions apply. The plan aims to minimize impacts to marine resources, protect archaeological resources, address impacts of dock development and advance collaborative management between the shíshálh Nation and the province."*

In June of 2018, shortly after the Management Plan was released, the Shíshálh FN published the *Shíshálh Nation Best Management Practices for Marine Docks*, (Shíshálh 2018) which provides guidance for responsible dock construction in Shíshálh territory. The BMP recommends complete elimination of expanded polystyrene floats in new dock construction, stating:

> *"The use of Styrofoam to keep docks afloat is prohibited for new construction and repairs. Styrofoam floats on existing docks that are showing evidence of breakdown should be replaced using an alternative material."*

Despite the recommendation of complete prohibition of polystyrene floats, the language of the final Pender Harbor Dock Management Plan permits the use of encapsulated polystyrene dock floats in new dock construction within the management area. No timeline was set for replacement of existing unencapsulated floats, although a general lifecycle replacement was implemented (*"Styrofoam floats on existing docks that are showing evidence of breakdown must be replaced using an alternative material"*). Unlike the Oregon and Washington legislation discussed above, no explicit guidelines for composition or thickness of encapsulation were outlined, except that the polystyrene must be "fully enclosed in a solid, molded shell".

The PHDMP was controversial at time of enactment, mainly as a result of its restrictions on dock installation in culturally and environmentally sensitive areas. Opposition coalesced around several groups formed in opposition to the plan, with backlash including Freedom of Information requests, pressure on local MPs, pamphletting campaigns, articles in local media and yard signs bearing the message "*This is our land, not Sechelt land*" (Shore 2018a, Shore 2018b, Hager 2018, PHDMPWG 2019). This local opposition may, in part, explain the discrepancies between the best-practice polystyrene prohibition outlined in the SFN's Best Practices for Marine Docks and the less strict encapsulation requirement outlined in the final PHDMP.

Conclusion

Polystyrene has been a popular option for dock flotations since the mid-20th century for its inexpensiveness and for its flotation and moisture resistance qualities. However, from the early stages its risk of pollution started to be evident, and after all these years of non-encapsulated Polystyrene use it has been observed its great risk for the whole environment. Different processes that have been observed, biotics and abiotics, intervene in the process of breaking down the Polystyrene in the environment when it's not protected.

From all that has been mentioned in this report and from all the research done, it is clear that action needs to be taken, as non-encapsulated polystyrene foam is dangerous for marine life, as well it could end up impacting the humans too. There have been studies that demonstrate the impact that when Polystyrene foam blocks break into pieces, these pieces can negatively affect marine wildlife, physically as well as chemically. However, the full extent of the impacts of the polystyrene contamination is still to be known.

Given Canada's complex jurisdictional format, pinning down a smoking gun for marine polystyrene pollution is no simple task. Various calls to action have surfaced over the last decade; from United Nations declarations, to federal, provincial, and First Nations government policies, to local and community group cries for help, such as those from the Lasqueti Island Shoreline Debris Initiative. No matter the source of policy or legislation, it comes down to the fact that the Canadian federal government is ultimately responsible for overseeing the success of provincial legislation and responsible action for polystyrene pollution in the Salish Sea. Given the federal declaration of all waters between provincial islands and mainland as 'internal waters', it falls to the province to respond to all calls to action from local community groups to international governing bodies. In the case of polystyrene, the province of British Columbia is ultimately legally responsible for past, present, and future pollution mitigation.

In the case of the Lasqueti Island Shoreline Debris Initiative, the best way forward is to establish a position within ongoing conversations around coastal marine protection strategies, such as in the case of MaPP, or the Marine Protection Plan, between the Province of British Columbia and 17 Central and North Coast First Nations. This will provide opportunities for local voices to be heard, and for real steps to be taken towards ensuring a polystyrene-free future for the residents of Lasqueti Island, the multitude of other communities on various islands encompassing BC's inland waters, and future generations throughout the Salish Sea.

To sum up, the several impacts to the environment and the risk that implies has made clear the need to keep Polystyrene out of the water. Following these concerns, some regions of the world, like Washington State in the U.S., have already started taking measures to decrease the amount of Polystyrene leaked to the water, for example putting in place regulations on the docks and the encapsulation of Polystyrene. However, British Columbia is still to take this step forward to the protection of the environment, overcoming the possible opposition that might find from the dock owners.

Appendix: Recommendations Table

This table will facilitate information gathered within the context of our scholarly report into the policy briefing our team will create to circulate within Marine Debris working groups across the Southern Coast.

Recommendation	**Type**	***Description and/or Action***
Encapsulation of polystyrene dock floatation devices	Ecological	Encapsulation of Polystyrene foam reduces the pollution impact to the environment. In reducing the amount of leakage of Polystyrene to the water through prolonged life of the material, risk to marine fauna decreases. Polystyrene can be encapsulated in cement, wood, or plastic in the marine environment.
Implementation of alternative materials for dock floatation	Ecological	1. Modular and pontoon docks made with high density Polyethylene (HDPE), which can be filled with either air or XPS 2. Pontoon-based docks made with steel pontoons. 3. Mycelium “Styrofoam”, currently used in packaging with potential to expand to use in docks
Awareness raising	Local Action	Ultimately, the province of British Columbia is responsible for mitigation of and protection against polystyrene pollution and use in the Salish Sea; raising awareness is a necessity in moving towards a polystyrene-free future.
Collaboration with Indigenous governments	Jurisdictional (Provincial, Federal)	Cooperative legislation with Indigenous peoples creates an avenue for marine protection that values the shared goals and concerns of local, Indigenous, and provincial government s.
Implementation of Marine Protection Plan	Jurisdictional (Provincial, Federal, Local)	Implementing a marine protection plan for the Southern Coast of British Columbia inspired by that co-created by Central and North Coast First Nations and the province of British Columbia is the best and most effective first step towards reducing polystyrene

		pollution.
Collaboration with local governments and working groups	Local Action, Jurisdictional (Provincial)	Legislation is more effective when tied to an event or incident that raises public awareness of the issue
Effective timeline implementation for polystyrene replacement	Ecological, Jurisdictional (Provincial, Federal)	Timelines for replacement (example: two years, in the Washington State legislation) are more effective than lifecycle replacement mandates, which are harder to define and enforce.
Increased research on polystyrene alternatives	Ecological, Jurisdictional, Academic, Local Action	In order to achieve multi-sector goals of replacement and prolonged use of dock flotation in the marine, it is essential to increase research on the efficacy, life span, and effects of various polystyrene alternatives.

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